

# Knee Injuries and Associated Risk Factors in National Basketball Association Athletes



Sailesh V. Tummala, M.D., Landon Morikawa, B.S., Joseph Brinkman, M.D.,  
Tom J. Crijns, M.D., Kostas Economopoulos, M.D., and Anikar Chhabra, M.D., M.S.

**Purpose:** To determine structural knee injury rates and to identify risk factors and the number of games missed associated with these injuries in National Basketball Association (NBA) players from the 2015 to 2020 seasons. **Methods:** Publicly available player records of active NBA players between the 2015 and 2020 seasons (excluding the shortened 2019 season) were reviewed to identify players with a knee injury associated with missing one or more games. Player demographics, anthropometric measurements, statistics, injury characteristics, and history of other lower-extremity injuries were recorded. We sought factors associated with having a structural knee injury in bivariate analysis and multivariable logistic regression. Negative binomial regression was conducted to evaluate factors associated with the total number of games missed. **Results:** Two hundred twelve players (of 1,011, 21%) sustained a structural knee injury. Accounting for potential confounders, having a structural knee injury was associated with more minutes per game played (odds ratio [OR] 1.1; 95% confidence interval [CI] 1.0-1.2;  $P = .002$ ), a greater usage rate (OR 1.1; 95% CI 1.0-1.2;  $P = .004$ ), and a lower player efficiency rating (OR 0.94; 95% CI 0.89-1.0;  $P = .041$ ). A greater number of missed games was associated with more minutes per game (regression coefficient [RC] 0.065; 0.028-0.10;  $P = .001$ ), fewer points per game (RC  $-0.078$ ;  $-0.14$  to  $-0.017$ ;  $P = .013$ ), and greater usage rate (RC 0.032; 0.0040-0.060;  $P = .025$ ). **Conclusions:** Structural knee injuries occurred in 21% of players in this study with an overall rate of 5.42 injuries per 1,000 game exposures. Significant risk factors associated with injury were minutes per game, usage rate, and true shooting percentage. Player efficiency was significantly associated with a decreased risk of injury. Increased minutes per game and usage rate were significantly associated with a longer duration of game loss. **Level of Evidence:** Level IV, case series.

Among athletes in major sports, basketball players are at a relatively greater risk of injury secondary to repetitive musculoskeletal stresses, particularly pivoting, jumping, and change of direction.<sup>1</sup> Knee injuries are among the most common in basketball players at the high school,<sup>2</sup> collegiate,<sup>3</sup> and professional levels.<sup>4</sup> These injuries have been shown to have a negative impact on player performance upon return to play and

may account for more than one-fourth of games lost due to injury in professional athletes.<sup>5</sup>

As compared with the high school and collegiate athletes, players in the National Basketball Association (NBA) compete on a longer court, for a longer season, at an older age, and with an overall increased physical toll related to movement change and activity workload.<sup>4,6</sup> These physiologic stresses place professional athletes with a unique risk profile for injury. There is limited comprehensive data regarding injury pattern, rates, and risk in this population.

Previous studies have evaluated knee injuries in professional basketball players.<sup>4,5,7</sup> An analysis of 70,420 NBA game exposures reported that the lower extremity was the most commonly injured body area and that knee injuries accounted for 19.1% of all injuries.<sup>7</sup> Similarly, a separate 10-year analysis of 1,094 NBA athletes found that patellofemoral and knee injuries were second only to ankle injuries in frequency and comprised 9.4% and 4.4% of all injuries, respectively.<sup>5</sup> It also has been reported that patellofemoral inflammation is the most significant injury in regard to days lost from competition.<sup>4</sup> Analysis of demographic

From the Department of Orthopaedic Surgery, Mayo Clinic, Phoenix, Arizona (S.V.T., J.B., K.E., A.C.); and John A Burns School of Medicine, Honolulu, Hawaii (L.M.); and University of Texas, Austin, Texas (T.J.C.), U.S.A.

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Address correspondence to Dr. Anikar Chhabra, M.D., M.S., Department of Orthopaedic Surgery, Mayo Clinic Arizona, 5777 E. Mayo Blvd., Phoenix, AZ 85054. E-mail: [Chhabra.Anikar@mayo.edu](mailto:Chhabra.Anikar@mayo.edu)

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variables are not associated with knee injuries in these athletes. However, investigation into other possible predictive factors including anthropometric and game play information has been limited.

Epidemiology of injuries in sport and sport-specific injury patterns allow clinicians to develop targeted preventative strategy. The purposes of this study are to determine structural knee injury rates and to identify risk factors and the number of games missed associated with these injuries in NBA players from the 2015 to 2020 seasons. The authors hypothesized that increasing age, body mass index, minutes per game, usage rate, and associated lower-extremity injury would be correlated with knee injury risk and time loss.

## Methods

### Data Collection

This retrospective analysis of player records was deemed exempt after institutional review board approval. The Pro Sports Transactions ([prosportstransactions.com](http://prosportstransactions.com)) was queried 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. This database has been previously cited in numerous NBA-related studies.<sup>8-12</sup> Each injury event was verified using historical injury data available on The Sports Network ([tsn.ca](http://tsn.ca)) and Rotowire ([rotowire.com](http://rotowire.com)) and confirmed with player game logs on Basketball-Reference ([basketball-reference.com](http://basketball-reference.com)), which is sourced by Sportradar US (Sportradar AG), the official stats partner of the NBA.

Team schedules, player demographics, and player statistics were obtained from Basketball-Reference. Injury-related data from the 2019 NBA season were omitted from this study because of an abrupt league-wide suspension of the season due to the onset of the coronavirus disease 2019 pandemic.

### Measurements

Player demographics, anthropometric measurements, basketball statistics, injury characteristics, and history of other lower-extremity injuries were recorded. Advanced statistics examined included usage rate, player efficiency rating and true shooting percentage. Usage rate is an estimate of the percentage of a team's plays that a player is involved in while playing. Player efficiency rating estimated a player's per minute productivity that is per-minute and pace-adjusted with the average set at 15.<sup>13</sup> Finally, true shooting percentage considers the efficiency of all types of shots (2- and 3-point field goals) over the course of a game.

Minutes per game represents the average 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 the injury, specifically minor (1-game absence), moderate (2-10 game absence), and severe (11+ game absence). A game exposure (GE) was characterized by a single game appearance, regardless of minutes played in the contest. Follow-up duration is the time after injury a player was followed during the study period. This does 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 1,000 game exposures for each season. Continuous variables are presented as mean  $\pm$  standard deviation or as median (interquartile range), and discrete variables as the number of patients, with the percentage in parentheses. Structural Knee Injury was defined as all injury excluding soreness. We sought factors associated with having a knee injury in bivariate analysis, accounting for player demographics, 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,  $\chi^2$  tests and Fisher exact test 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 ratios (OR), regression coefficients (RC), 95% confidence intervals (95% CI), standard errors, and *P* values were reported. Alpha was set at 0.05.

## Results

### Characterization of Knee Injuries

A total of 740 knee injuries were reported, with 212 players (of 1,011, 21%) sustaining a structural knee injury. Excluding knee soreness, knee contusion was most common (0.75 per 1000 GEs) followed by inflammation (0.56 per 1000 GEs) (Table 1). Notably, anterior cruciate ligament injuries occurred at 0.09 per 1,000 GEs, cartilage injuries at 0.08 per 1,000 GE, and meniscal tears at 0.13 per 1,000 GEs.

Stratified by age, structural knee injury rate was greatest in players <20 years old (3.23/1000 GE) followed by >30 years old (3.11/1000 GE), 25 to 29 years (2.97/1000 GE), and 20 to 24 years (2.26/100 GE) and (Table 2). When looking more closely at knee injury by minutes per game, the rate was greatest in those playing >30 minutes (3.86/1000 GE), followed by 20.0 to

**Table 1.** Knee Injury Totals and Incidences in NBA Athletes

| Injury Type               | No. of Injuries | Injury Incidence (per 1,000 GEs) | Injury Severity Incidence (per 1,000 GEs) |          |        |
|---------------------------|-----------------|----------------------------------|---|----------|--------|
|                           |                 |                                  | Mild                                      | Moderate | Severe |
| Soreness                  | 364             | 2.67                             | 1.14                                      | 1.23     | 0.29   |
| Inflammation              | 76              | 0.56                             | 0.22                                      | 0.25     | 0.09   |
| Contusion                 | 102             | 0.75                             | 0.31                                      | 0.34     | 0.10   |
| Management/recovery/rehab | 41              | 0.30                             | 0.24                                      | 0.06     | 0.00   |
| Unspecified               | 16              | 0.12                             | 0.07                                      | 0.04     | 0.01   |
| Sprain/Strain             | 83              | 0.61                             | 0.11                                      | 0.35     | 0.15   |
| Hyperextension            | 10              | 0.07                             | 0.01                                      | 0.05     | 0.01   |
| ACL tear                  | 12              | 0.09                             | 0.01                                      | 0.01     | 0.07   |
| Meniscal tear             | 18              | 0.13                             | 0.01                                      | 0.02     | 0.10   |
| Tendon tear               | 5               | 0.04                             | 0.01                                      | 0.00     | 0.03   |
| Avulsion fracture         | 2               | 0.01                             | 0.00                                      | 0.01     | 0.01   |
| Cartilage injury          | 11              | 0.08                             | 0.01                                      | 0.02     | 0.05   |
| Total                     | 740             | 5.42                             | 2.13                                      | 2.38     | 0.91   |
| Total without soreness    | 376             | 2.75                             | 0.99                                      | 1.15     | 0.62   |

ACL, anterior cruciate ligament; GE, game exposure; NBA, National Basketball Association.

29.9 minutes (3.03/1000 GE), and 10.0 to 19.9 minutes (1.82/1000 GE).

### Risk of Structural Knee Injury

In bivariate analysis (Table 3), having a knee injury was associated with older age ( $P < .001$ ), greater weight ( $P = .042$ ), more years of experience ( $P < .001$ ), longer

**Table 2.** Structural Knee Injury Incidence by Severity, Season, Age, Minutes Per Game, and Position in NBA Athletes

|                  | No. of Injuries<br>(n = 376)* | Incidence<br>(per 1,000 GEs) |
|------------------|-------------------------------|------------------------------|
| Severity         |                               |                              |
| Minor            | 135                           | 0.99                         |
| Moderate         | 157                           | 1.15                         |
| Severe           | 84                            | 0.62                         |
| Season           |                               |                              |
| 2015             | 64                            | 2.29                         |
| 2016             | 67                            | 2.4                          |
| 2017             | 76                            | 2.73                         |
| 2018             | 60                            | 2.15                         |
| 2020             | 109                           | 4.37                         |
| Age, y           |                               |                              |
| <20              | 8                             | 3.23                         |
| 20-24            | 110                           | 2.26                         |
| 25-29            | 158                           | 2.97                         |
| ≥30              | 100                           | 3.11                         |
| Minutes per game |                               |                              |
| <10              | 17                            | 1.75                         |
| 10.0-19.9        | 79                            | 1.82                         |
| 20.0-29.9        | 153                           | 3.03                         |
| ≥30.0            | 127                           | 3.86                         |
| Position         |                               |                              |
| PG               | 79                            | 2.93                         |
| SG               | 87                            | 3.17                         |
| SF               | 56                            | 2.36                         |
| PF               | 74                            | 2.36                         |
| C                | 80                            | 2.98                         |

C, center; NBA, National Basketball Association; GE, game exposure; PF, power forward; PG, point guard; SF, small forward; SG, shoot guard.

\*Does not include soreness as injury type.

follow-up duration ( $P < .001$ ), a greater total and regular season games ( $P < .001$ ), and more minutes played ( $P < .001$ ). Performance metrics on bivariate analysis also were significantly associated with injury risk, most notably greater usage rate ( $P < .001$ ), lower player efficiency rating ( $P < .001$ ), and lower true shooting percentage ( $P < .001$ ). The percentage of players with a knee injury was greater, with more minutes per game (Fig 1) and greater usage rates (Fig 2). These graphs can be interpreted as risk of knee injury (percentage) per minutes played or usage rate over the seasons studied. All lower-extremity injuries were associated ( $P < .001$ ) with having a knee injury. All variables with  $P < .10$  were moved to multivariable logistic regression.

Accounting for potential confounders, in multivariable logistic regression analysis (Table 4) having a knee injury was associated with longer follow-up duration (OR 1.6; 95% CI 1.4-1.9;  $P < .001$ ), more minutes per game (OR 1.1; 95% CI 1.0-1.2;  $P = .002$ ), greater usage rate (OR 1.1; 95% CI 1.0-1.2;  $P = .004$ ), lower player efficiency rating (OR 0.94; 95% CI 0.89-1.0;  $P = 0.041$ ), greater true shooting percentage (OR 1.1; 95% CI 1.0-1.1;  $P < .001$ ), and more games missed due to injury (OR 1.1; 95% CI 1.0-1.1;  $P < .001$ ).

In multivariable negative binomial regression analysis, a greater number of missed games was associated with shorter follow-up duration (RC  $-0.10$ ; 95% CI  $-0.18$  to  $-0.019$ ;  $P = .015$ ), more minutes per game (RC 0.065; 0.028-0.10,  $P = .001$ ), greater usage rate (RC 0.032; 0.0040-0.060;  $P = .025$ ), and fewer points per game (RC  $-0.078$ ;  $-0.14$  to  $-0.017$ ;  $P = .013$ ), and any associated lower-leg injuries except calf or shin injuries ( $P > .05$ ).

### Discussion

A total of 21% (n = 212) of NBA players sustained a structural knee injury and a total of 740 injuries were

**Table 3.** Bivariate Analysis of Factors Associated With Having a Knee Injury During the Follow-up Period Among NBA Players

| Variables*                                | Knee Injury <sup>†</sup> |                   | P Value         |
|---|--------------------------|-------------------|-----------------|
|   | Yes                      | No                |                 |
| No. of players                            | 212 (21%)                | 799 (79%)         | —               |
| Age, y                                    | 26 (23-30)               | 24 (22-28)        | <b>&lt;.001</b> |
| Height, m                                 | 2.0 ± 0.087              | 2.0 ± 0.086       | .16             |
| Weight, kg <sup>‡</sup>                   | 100 ± 11                 | 98 ± 12           | <b>.042</b>     |
| Body mass index <sup>‡</sup>              | 25 ± 1.7                 | 25 ± 1.8          | .072            |
| Years of experience                       | 5 (3-9)                  | 2 (1-5)           | <b>&lt;.001</b> |
| Follow-up duration, y                     | 4 (3-5)                  | 2 (1-3)           | <b>&lt;.001</b> |
| Number of games played <sup>‡</sup>       |                          |                   |                 |
| Total                                     | 62 (41-73)               | 41 (17-61)        | <b>&lt;.001</b> |
| Regular                                   | 58 (39-68)               | 39 (16-59)        | <b>&lt;.001</b> |
| Playoffs                                  | 0 (0-6)                  | 0 (0-3)           | .20             |
| Minutes per game <sup>‡</sup>             |                          |                   |                 |
| Total                                     | 24 (18-30)               | 14 (8-20)         | <b>&lt;.001</b> |
| Regular                                   | 25 (18-30)               | 14 (9-20)         | <b>&lt;.001</b> |
| Playoffs                                  | 0 (0-19)                 | 0 (0-6)           | .080            |
| Performance metrics                       |                          |                   |                 |
| Usage rate                                | 19 (16-24)               | 17 (14-20)        | <b>&lt;.001</b> |
| Player efficiency rating                  | 14 (11-17)               | 11 (7.9-14)       | <b>&lt;.001</b> |
| True shooting percentage                  | 0.55 (0.51-0.59)         | 0.52 (0.47-0.57)  | <b>&lt;.001</b> |
| Points per game                           | 9.2 (6.1-14)             | 4.6 (2.6-7.7)     | <b>&lt;.001</b> |
| Block percentage                          | 0.40 (0.20-0.66)         | 0.20 (0.090-0.40) | <b>&lt;.001</b> |
| Total rebound percentage                  | 3.9 (2.5-5.3)            | 2.2 (1.3-3.5)     | <b>&lt;.001</b> |
| Position                                  |                          |                   | .481            |
| Point guard                               | 48 (23%)                 | 155 (19%)         |                 |
| Shooting guard                            | 42 (20%)                 | 200 (25%)         |                 |
| Small forward                             | 36 (17%)                 | 147 (18%)         |                 |
| Power forward                             | 45 (21%)                 | 156 (20%)         |                 |
| Center                                    | 41 (19%)                 | 141 (18%)         |                 |
| Games missed due to injury                | 3 (1-10)                 | 1 (0-4)           | <b>&lt;.001</b> |
| Other lower-extremity injury <sup>§</sup> | 173 (82%)                | 355 (44%)         | <b>&lt;.001</b> |
| Foot                                      | 56 (26%)                 | 73 (9.1%)         | <b>&lt;.001</b> |
| Ankle                                     | 109 (51%)                | 223 (28%)         | <b>&lt;.001</b> |
| Calf or shin                              | 68 (32%)                 | 102 (13%)         | <b>&lt;.001</b> |
| Hip, hamstring, or quadriceps             | 112 (53%)                | 176 (22%)         | <b>&lt;.001</b> |

NBA, National Basketball Association.

\*Continuous variables presented as mean ± standard deviation or as median (interquartile range); discrete variables as the number of patients, with the percentage in parentheses. Values in bold indicate statistical significance at  $P < .05$ . All variables with  $P < .10$  were moved to multivariable analysis.

<sup>†</sup>Includes any type of structural injury (e.g., fracture, ligament sprain, strain, or rupture) and nonspecific symptoms (e.g., bruising, or effusion). Knee soreness alone was excluded from analysis. One player with a gunshot wound to the knee was excluded from analysis.

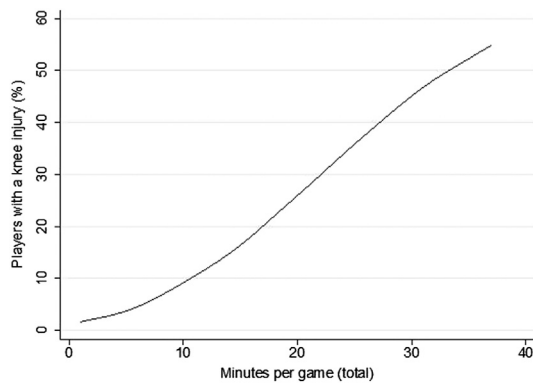
<sup>‡</sup>Only weight was moved to multivariable regression because of expected multicollinearity with body mass index; only “total number of games played” and “total minutes per game” were moved to multivariable analysis.

<sup>§</sup>Includes any type of hip, upper and lower leg, foot, or ankle injury.

reported from the 2015 to 2020 seasons, excluding the 2019 season. More minutes per game, greater usage rate, and lower player efficiency rating were significantly associated with increased risk of structural knee injury. Further, more minutes per game, greater usage rate, and associated lower-extremity injury was positively correlated with an increased number of missed games after knee injury.

Previous studies have evaluated basketball injuries at the professional,<sup>4,5,7,14</sup> collegiate,<sup>3,15</sup> and high school<sup>2</sup> levels. Drakos et al.<sup>4</sup> evaluated NBA players from 1988 to 2005 and found that knee injuries were responsible for 9% of all injuries with overall rate 1.5 injuries per 1,000 game exposures and accounting for

18.1% of games missed. This high percentage of knee injuries was also supported by Andreoli et al.,<sup>16</sup> who performed a systematic review evaluating basketball players of all levels of competition and found that 17.8% of all injuries were related to the knee. Our study found that 21% of NBA players had a structural knee injury and that the overall knee injury rate was 5.42 per 1,000 game exposures. Previous studies have suggested that there is increasing trend in overall injuries in NBA athletes.<sup>9</sup> However, this notable difference in rate can also be accounted for in that Drakos et al.<sup>4</sup> only accounted for in game injuries, separated knee and patellar injuries, and did not account for “soreness” as a type of knee injury, which accounted for



**Fig 1.** The percentage of National Basketball Association (NBA) athletes who sustained a knee injury by the minutes per game played (regular season and playoffs).

49% ( $n = 364$ ) of all injuries in this study. Similarly, Deitch et al.<sup>7</sup> reported a rate of 2.5 knee injuries per 1,000 game exposures, which was also lower than that found in this study but only included players with 0 to 5 years of playing experience, excluding a large population.

NBA players have been shown to have an overall injury rate nearly double of their collegiate counterparts and even more disparate when compared to high school athletes.<sup>2,5,15</sup> This appears to be true regarding knee injuries as well. Zuckerman et al.<sup>3</sup> in their characterization of men's and women's NCAA basketball players found that knee injuries occurred at a rate of 2.01 per 1,000 exposures, which was nearly one half that found in our analysis. This finding is likely multifactorial but may be explained by a prolonged professional season, increased physically demanding play, older age of athletes, and enhanced injury detection and reporting.

When evaluating knee injury type, previous studies have suggested that soft-tissue inflammation and nonspecific sprains are the most common knee injury type in NBA players.<sup>4,5,7</sup> Deitch et al.<sup>7</sup> found that overuse and inflammatory conditions accounted for 22% of all injuries, and Starkey<sup>5</sup> regards patellofemoral inflammation as a "silent endemic" being the leading cause of players to miss games. In our study, we found a larger proportion of overuse pathology with soreness accounting for 49% (2.67/1,000 GEs), contusions accounting for 13% (0.75/1000 GE), and inflammation responsible for 10% (0.56/1000 GE) of all knee injuries.

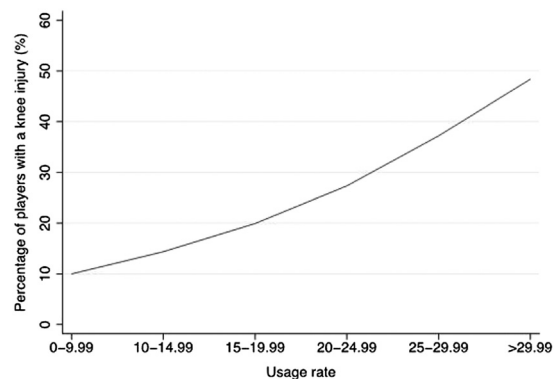
These trends across literature further highlight the implications of repetitive physiologic stress on basketball players. Previous studies have suggested these athletes change directions on average of every 2 seconds, with sudden deceleration movements generating high shear forces of the lower extremity. Notably, this induces large torque forces at the knee joint and subsequently increases injury risk.<sup>17-19</sup> These repetitive

physical stresses are combined with travel as much as 4 times a week across a 38-week season with minimal rest. Together, these factors further contribute to the physiologic burden in professional athletes and prime athletes for a greater proportion of overuse and inflammatory injury.<sup>5</sup>

The findings in this study further support the correlation with physiologic burden and knee injury risk in NBA players. Multivariable analysis not only showed a positive correlation with minutes per game and usage rate but also that these same factors were also significantly associated with increased games missed. Notably, this was significant while controlling for confounding factors of age, body mass index, and number of games played. This finding was supported by Drakos et al.,<sup>4</sup> who reported player demographic factors such as age, weight, height, or years of experience in the NBA had no correlation with injuries. It also should be noted that player efficiency rating was significantly associated with a decreased risk of injury, suggesting that more effective players may be able to mitigate knee injury risk. Contextually, this implies that a player who averages 10 more minutes per game over the course of a season has a 159% increased risk of a knee injury.

Studies evaluating knee injury risk in basketball players are scarce. Similar to the findings in this study, Teramoto et al.<sup>20</sup> found that playing more back-to-back games and games away from home was significantly associated with increased injuries. In contrast, Okoroha<sup>21</sup> found that minutes played in a single NBA game did not contribute to the risk of an anterior cruciate ligament injury but did not more closely evaluate cumulative effects of an entire season.

These findings should be placed in context of the potential long-term implications of knee injuries in basketball players. It has been suggested that knee injuries suffered during a player's professional career can cause significant morbidity well after their career is over.<sup>1</sup> Khan et al.<sup>1</sup> showed that up to two-thirds of NBA players with knee injuries during their career



**Fig 2.** The percentage of National Basketball Association (NBA) athletes who sustained a knee injury by usage rate.

**Table 4.** Multivariable Logistic Regression Analysis of Factors Associated With Having a Knee Injury Among NBA Players

| Variables                                 | Odds Ratio (95% Confidence Interval) | Standard Error | P Value*        | Pseudo R <sup>2</sup> |
|---|--------------------------------------|----------------|-----------------|-----------------------|
| 0.27                                      | 1.0 (0.92-1.1)                       | 0.049          | .780            | 0.27                  |
| Weight, kg                                | 1.0 (0.98-1.0)                       | 0.011          | .559            |                       |
| Years of experience                       | 1.0 (0.92-1.1)                       | 0.050          | .846            |                       |
| Follow-up duration, y                     | 1.6 (1.4-1.9)                        | 0.13           | <b>&lt;.001</b> |                       |
| Number of games played (total)            | 0.99 (0.98-1.0)                      | 0.0058         | .372            |                       |
| Minutes per game (total)                  | 1.1 (1.0-1.2)                        | 0.042          | <b>.002</b>     |                       |
| Performance metrics                       |                                      |                |                 |                       |
| Usage rate                                | 1.1 (1.0-1.2)                        | 0.039          | <b>.004</b>     |                       |
| Player efficiency rating                  | 0.94 (0.89-1.0)                      | 0.028          | <b>.041</b>     |                       |
| True shooting percentage                  | 1.1 (1.0-1.1)                        | 0.017          | <b>&lt;.001</b> |                       |
| Points per game                           | 0.91 (0.80-1.0)                      | 0.058          | .135            |                       |
| Block percentage                          | 1.8 (0.87-3.6)                       | 0.64           | .118            |                       |
| Total rebound percentage                  | 0.95 (0.81-1.1)                      | 0.078          | .537            |                       |
| Games missed due to injury                | 1.1 (1.0-1.1)                        | 0.013          | <b>&lt;.001</b> |                       |
| Other lower-extremity injury <sup>†</sup> |                                      |                |                 |                       |
| Foot                                      | 1.5 (0.95-2.4)                       | 0.35           | .078            |                       |
| Ankle                                     | 0.85 (0.56-1.3)                      | 0.18           | .425            |                       |
| Calf or shin                              | 1.1 (0.74-1.8)                       | 0.25           | .537            |                       |
| Hip, hamstring, or quadriceps             | 1.1 (0.70-1.6)                       | 0.23           | .777            |                       |

NBA, National Basketball Association.

\*Values in bold indicate statistical significance,  $P < .05$ . Note: One player with a gunshot wound to the knee was excluded from analysis.

<sup>†</sup>Not having a specific foot, ankle, calf/shin, or hip/hamstring/quadriceps injury was used as a reference standard.

continued to have ongoing pain after retirement and more than one-third underwent additional surgery after finishing playing. This continues to highlight the importance of monitoring and prevention of these injuries. Further research should be targeted at the effectiveness of interventions regarding injury-prevention programs and the optimization of player usage in preventing knee injury.

### Limitations

There are several limitations to this study that should be noted. First, this analysis was limited to injuries that were reported in the media, and it is possible that minor injuries that did not lead to missed games were under-reported. Those injuries that were not reported could not be quantified or confirmed with an official team medical record. Further, injuries sustained during the offseason and subclinical injuries that did not force a player to miss a full game but potentially practice instead were excluded from this study due to an inability to verify these events. Further, game exposures as defined in this analysis did not account for minutes played in each game. Finally, given that only professional athletes were included in this study, it does decrease the generalizability to other levels of play and competition.

### Conclusions

Structural knee injuries occurred in 21% of players in this study with an overall rate of 5.42 injuries per 1,000 game exposures. Significant risk factors associated with injury were minutes per game, usage rate, and true

shooting percentage. Player efficiency was significantly associated with a decreased risk of injury. Increased minutes per game and usage rate were significantly associated with a longer duration of game loss.

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