Amount of Minutes Played Does Not Contribute to Anterior Cruciate Ligament Injury in National Basketball Association Athletes

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abstract

There is limited information on the potential risk factors for sustaining an anterior cruciate ligament (ACL) tear in National Basketball Association (NBA) athletes. This study evaluated 83 NBA players who sustained an ACL injury between 1984 and 2015 to determine the influence of minutes played on injury risk. Minutes played in the injury game, during the season, and over their career were assessed, along with the ability to return to play, player efficiency rating, and playing time after return. Athletes in the NBA played significantly fewer minutes before sustaining an ACL injury (17.1 minutes) than their average minutes per game that season (23.5 minutes; $P<.01$) or over their career (24.0 minutes; $P<.01$). One-third of all injuries occurred during the first quarter of the season (preseason to November). There was a 95% rate of return (78 players) to NBA competition the season following ACL injury. Players who were drafted as lottery picks (draft pick 1 to 15) or those who were starters played significantly more minutes the season following injury than those who were not (both $P<.01$). Players who returned to play had decreased player efficiency ratings when compared with matched controls. This study found that minutes played in a single NBA game did not contribute to the risk of sustaining an ACL injury. Although there was a high rate of return to NBA competition the season following injury, those who were elite athletes played more minutes per game than those who were not. Athletes who returned to play sustained a decrease in player efficiency ratings compared with similar athletes without ACL injury. [*Orthopedics*. 201x; xx(x):xx-xx.]

Anterior cruciate ligament (ACL) tears are one of the most common injuries during athletic play.[1] Athletes are predisposed to ACL tears by performing torque-producing activities such as cutting, jumping, and landing.[2,3] Altered landing mechanics in fatigued athletes have been reported to contribute to the risk of ACL tear.[4] These studies suggest that large ground reaction forces, anterior tibial shear force, valgus knee moments, and external knee flexion increase ACL loading during landing. A more extended knee during landing also exacerbates shear forces on the ACL, while a more flexed knee decreases these forces.[5]

Although previous studies have documented high return to play (RTP) rates following ACL reconstruction (63%-86%), the literature discussing potential etiologies of these tears in professional athletes

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Table 1

Demographic Data of the NBA Players With ACL Tears

Characteristic	Value
Players, No.	83
ACL tears, No.	83
Age, mean±SD, y	25.7±3.5
Body mass index, mean±SD, kg/m^2	26.9±2.2
Knee, No.	
Right	35
Left	48
Experience in NBA prior to ACL tear, mean±SD, y	3.9±3.1
Position, No.	
Point guard	21
Shooting guard	15
Small forward	12
Power forward	20
Center	15
Starter, No.	43
Reserve, No.	40
Draft pick, No.	
1 to 15	38
16 to undrafted	45
ACL tear timing, No.	
In-season game	42
First quarter	13 (31.0%)
Second quarter	5 (11.9%)
Third quarter	12 (28.6%)
Fourth quarter	11 (26.2%)
Overtime	1 (2.3%)
Preseason basketball	11
Off-season basketball	7
In-season practice	6

Abbreviations: ACL, anterior cruciate ligament; NBA, National Basketball Association.

involved in cutting sports is limited.[6-8] Fatigue in athletes has been shown to alter muscular activity and biomechanics. These alterations can lead to landing with a more straight leg, increasing an athlete's susceptibility to ACL tears. However, it is unknown if the amount of minutes played contributes to fatigue or the risk of ACL injury in athletes.

The purpose of this study was to determine if the amount of minutes played contributed to the risk of sustaining an ACL tear in National Basketball Association (NBA) athletes. The hypothesis was that NBA players would be more likely to sustain an ACL rupture when playing a higher number of minutes than their season or career averages.

Materials and Methods

Players in the NBA who sustained an ACL tear and underwent reconstruction between 1984 and 2015 were evaluated. Players were identified through NBA team websites, publicly available Internet injury reports, player profiles, biographies, and press releases. This methodology is similar to that of previous studies reporting outcomes for NBA athletes.[6,9] Validation of an ACL tear was confirmed by documentation in one of the above sources and correlation to an absence of statistics for that player following the injury. Any NBA player who played at least 1 game prior to sustaining an acute ACL tear was included. Players who sustained multiligamentous knee injuries were excluded.

Demographic data (age at the time of injury, body mass index [kg/m^2], position [point guard, shooting guard, small forward, power forward, or center], side of injury [right vs left], starter status [starter vs reserve], and draft pick [picks 1 to 15 vs 16 to undrafted]) were collected and analyzed. Other variables analyzed were minutes played in the injury game, minutes per game during the injury season, minutes per game over career, quarter of injury (first, second, third, fourth, overtime, or practice), and quarter of season (preseason to November, December to January, February to March, or April to postseason). A control group of players without ACL injuries was selected to compare performance data with the authors' cohort of players who returned to play after ACL reconstruction. Each injured player was matched to a control player based on sex, age, body mass index, position, and years of experience in the NBA. The year of the ACL injury was considered the "index year" as used in previous studies.[10,11]

All analyses were done using R version 3.2.5 software (R Foundation for Statistical Computing, Vienna, Austria). A single-variable analysis for each continuous variable (performance measure) within groups was completed using a paired-samples Student's *t* test. This same test was used for the within-subjects comparison of minutes played in the injury game vs average minutes per season or career, and also for the within-subjects comparison between multiple sets of variables for subjects who returned to sport. Binary logistic regression using Fifth's penalized maximum likelihood, via the R logistics package version 1.21, was used to analyze the association between demographic factors and RTP. Minutes per game the following season, games played the following season, and seasons played after ACL tear were predicted using a simple linear regression via ordinary least squares. A 2-way analysis of variance was performed to analyze the difference in minutes, games, and seasons played before and after injury for players returning to the same team vs those who returned to a different team. A comparison of cohort players with matched controls was performed using a paired-samples Student's *t* test.

Results

Eighty-three NBA players with primary ACL tears were identified and performance data were collected. No players were excluded from the final cohort. Demographic data of the NBA players are listed in **Table 1**. On average, NBA athletes played significantly fewer minutes before sustaining an ACL injury (17.1±12.3 minutes) than their average minutes per game that season (23.5±11.1 minutes; $P<.01$) or over their career (24.0±7.3 minutes;

P<.01) (**Figure**). There was no difference in the quarter of the game in which ACL injuries occurred, with most in-game injuries (31%) occurring in the first quarter. One-third of all injuries occurred during the first quarter of the season (preseason to November).

There was a 95% rate of return (78 players) to NBA competition the season following ACL reconstruction. Athletes played fewer minutes per game after return from injury compared with prior to injury (21.6±8.5 vs 23.5±10.8 minutes, respectively; *P*=.04) (**Figure**). Players who were drafted as lottery picks (draft pick 1 to 15) or who were starters played significantly more minutes the season following injury than players who were not (both *P*<.01) (**Table 2**).

Most NBA players (70.1%) returned to the same team following ACL reconstruction. Those who returned to their prior team played more seasons than players who returned to a different team (5.4±3.5 vs 2.6±2.1 seasons, respectively; *P*<.01) (**Table 3**).

When comparing the current cohort of NBA players with 83 randomly selected control players, there were no significant differences in age, body mass index, seasons played before injury, or draft pick. The control athletes played more games and minutes per game than the case players. However, after returning from injury, the difference in playing time between case and control players remained consistent and was not significant. Players who returned to the NBA following ACL reconstruction had a decrease in player efficiency rating compared with controls (11.4±5.3 vs, 15.3±5.8 respectively; *P*<.01) (**Table 4**).

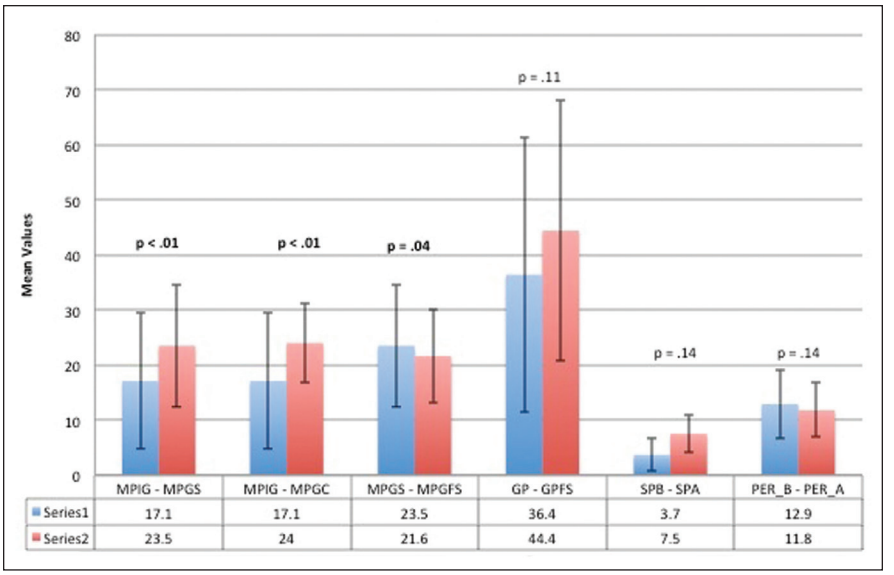

Figure: Within-subjects comparison of minutes, games, and seasons played as well as player efficiency ratings before and after anterior cruciate ligament reconstruction. Athletes played significantly fewer minutes in their injury game than during the season and over their career. Athletes played significantly fewer minutes per season following return from anterior cruciate ligament reconstruction. There was no difference in games played per season, seasons played, or player efficiency ratings before and after anterior cruciate ligament reconstruction. Players who returned from anterior cruciate ligament reconstruction had significantly lower player efficiency ratings. Abbreviations: GP, games played during injury season; GPFS, games played following season; MPGC, minutes per game over career; MPGFS, minutes per game following season; MPGS, minutes per game during injury season; MPIG, minutes played during injury game; PER_A, player efficiency rating after injury; PER_B, player efficiency rating before injury; SPA, seasons played after injury; SPB, seasons played before injury.

Table 2

Linear Regression Predicting Minutes per Game Following Index Season

Variable	Descriptive Statistics	Coefficient Estimate[a]	*P*
Age, mean±SD, y	25.5±3.2	-0.4 (0.3)	.21
Body mass index, mean±SD, kg/m^2	24.4±2.1	-0.7 (0.5)	.18
Starter, No.	38 (51.4%)	Reference	
Reserve, No.	36 (48.7%)	-9.3 (1.7)	<.01[b]
Draft pick, No.			
1 to 15	34 (46.0%)	Reference	
16 to undrafted	40 (54.0%)	-6.2 (1.9)	<.01[b]
SPB, mean±SD	3.7±2.9	0.1 (0.4)	.83

Abbreviation: SPB, seasons played before anterior cruciate ligament tear.
[a]Mean (SE).
[b]Statistically significant.

Discussion

In the authors' evaluation of 83 NBA players who sustained primary ACL tears, the results suggest that minutes played in a single game is not a factor in ACL tears for these athletes. There was a high rate of return following ACL injury, and on average, athletes played fewer minutes per game following return. However, elite players had more playing time than those who were not. When compared with matched controls, returning players had a decrease in player efficiency rating.

Table 3

Comparison of Minutes Played per Game, Games Played, Seasons Played, and Player Efficiency Ratings Between Return to Play Team

Variable	Return to Different Team	Return to Same Team	*P*
MPGS (SD)	16.2 (10.5)	26.8 (9.5)	
MPGFS (SD)	15.1 (7.7)	23.9 (7.6)	
Difference	-1.1	-2.9	.64
GP, No. (SD)	32.7 (24.3)	37.7 (25.3)	
GPFS, No. (SD)	30.7 (18.0)	49.4 (23.6)	
Difference	-2.0	+11.7	.18
SPB, No. (SD)	4.0 (3.2)	3.4 (2.8)	
SPA, No. (SD)	2.6 (2.1)	5.4 (3.5)	
Difference	-1.4	+2.0	<.01[a]
PER_B (SD)	11.0 (6.6)	13.7 (6.1)	
PER_A (SD)	9.3 (5.4)	13.2 (4.0)	
Difference	-1.7	-0.5	.56

Abbreviations: GP, games played during injury season; GPFS, games played following season; MPGFS, minutes per game following season; MPGS, minutes per game during injury season; PER_A, player efficiency rating after anterior cruciate ligament tear; PER_B, player efficiency rating before anterior cruciate ligament tear; SPA, seasons played after anterior cruciate ligament tear; SPB, seasons played before anterior cruciate ligament tear.
[a]Statistically significant.

Table 4

Summary of Player Variables Comparing Cases With Controls

	Mean±SD		
Variable	Cases	Controls	*P*
Age, y	25.7±3.5	25.6±3.2	.81
Body mass index, kg/m^2	26.9±2.2	24.6±2.2	.34
SPB, No.	3.9±3.1	3.9±2.8	.66
MPGS	24.0±10.6	27.9±8.3	.01[a]
GP, No.	35.0±24.5	66.8±17.8	<.01[a]
MPGFS	20.4±8.7	27.8±8.5	<.01[a]
GPFS, No.	43.0±24.3	68.8±15.8	<.01[a]
SPA, No.	4.4±3.4	6.3±3.4	<.01[a]
PER_B	13.3±5.5	14.5±4.3	.10
PER_A	11.4±5.3	15.3±5.8	<.01[a]

Abbreviations: GP, games played during injury season; GPFS, games played following season; MPGFS, minutes per game following season; MPGS, minutes per game during injury season; PER_A, player efficiency rating after anterior cruciate ligament tear; PER_B, player efficiency rating before anterior cruciate ligament tear; SPA, seasons played after anterior cruciate ligament tear; SPB, seasons played before anterior cruciate ligament tear.
[a]Statistically significant.

In-game timing of ACL tears in the NBA has previously been evaluated by Harris et al.[6] In evaluating 58 players who sustained an ACL injury while playing in the NBA, they found no significant difference in the quarter of the game in which players were injured. However, 40% of injuries occurred in the fourth quarter. In the current study, no significant difference was found in the quarter of the game in which players were injured, but the percentages of players injured in each quarter were more evenly distributed. The larger player cohort, which was less susceptible to bias by small sample size, may explain the discrepancy in results. The study by Harris et al[6] did not analyze minutes played in the game of injury or the quarter of the season in which injury occurred. The current authors found that athletes played significantly fewer minutes in the game in which they sustained an ACL tear than during the season and over their career. They also found that a large proportion of injuries occurred in the beginning of the season. Because athletes played fewer minutes in the game of injury, amount of minutes played does not likely contribute to ACL injury risk in NBA players. The fact that ACL injuries occurred more frequently in the beginning of the NBA season and game of injury suggests the possibility of alternative factors contributing to injury risk.

Anterior cruciate ligament tears can be devastating to athletes, having the potential to jeopardize their career.[12] Previous studies have reported mixed outcomes in professional athletes following ACL reconstruction.[6,9,13,14] Kester et al[9] found a high rate of RTP (86.1%) in the NBA following ACL reconstruction in 79 players. This was associated with a decline in player efficiency ratings the year of return. In evaluating a similar cohort, Harris et al[6] also found a high rate of RTP (86%) in the NBA following ACL reconstruction; however, there was no difference in performance compared with matched controls. The current study found a similarly high rate of RTP among NBA players the season following ACL reconstruction and that players had a decline in player efficiency ratings compared with matched

controls. National Basketball Association players were also more likely to play fewer minutes per game after returning from ACL reconstruction compared with before injury; however, this was not statistically different when compared with uninjured controls. These findings suggest that ACL injury decreases the productivity of NBA athletes, potentially causing them to play fewer minutes per game after returning. The finding that starters and players who were lottery picks played more minutes per game the season after sustaining injury indicates that teams remain committed to playing their elite players even after injury. It is also possible that these players were better athletes who were more capable of returning to their previous caliber of play.

Performance of players on returning to the same team vs to a different team after ACL reconstruction was a unique aspect of this study. Players who returned to their original team played more seasons after their injury than players who returned to a new team. This could be because of the level of trust and familiarity between the player and coaching staff.

Return to play has been evaluated in other cutting sports, including professional football. Eisenstein et al[7] and Shah et al[8] reported a 62% and 63% RTP rate, respectively, for National Football League athletes following ACL reconstruction. The RTP rate in professional football is notably less than the RTP rate found in studies evaluating NBA players. This may possibly be because of the higher physical demand and increased cutting involved in football. Similar to the current results, most ACL injuries in National Football League athletes occurred in the beginning of the season[7] and elite football players were more likely to RTP.[8]

This study has potential limitations. It is possible that a number of ACL tears in NBA athletes were inadvertently omitted because of the method of searching for injured players and issues with injury reporting. However, the authors conducted multiple, separate searches to identify all possible players for inclusion. On comparison of cases and controls, the control athletes played more games and more minutes per game than the case athletes. However, after returning from injury, the difference between case and control players was not significant. Controls were identified by demographic variables only. The addition of performance data may have made cases and controls more comparable. Surgical technique, physical examinations, and rehabilitation protocols could not be assessed because of the retrospective nature of the study. These factors could have potentially affected a player's ability to return and perform thereafter. Although this study discussed many variables involved in RTP, there were likely numerous variables not reported that could have influenced a player's willingness and ability to RTP. These factors could be identified with a more comprehensive and publicly available NBA injury database.

Conclusion

This study found that minutes played in a single NBA game did not contribute to the risk of sustaining an ACL injury. However, a large proportion of injuries occurred in the first quarter of the season, indicating that conditioning may impact injury risk. Although there was a high rate of return to NBA competition the season following injury, elite athletes played more minutes per game than those who were not elite athletes. Athletes who returned to play had a decrease in player efficiency ratings compared with similar athletes without ACL injury.

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