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Impact of Patellar Tendinopathy on Player Performance in the National Basketball Association

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Investigation performed at Henry Ford Hospital, Detroit, Michigan, USA

Background: The extent to which patellar tendinopathy affects National Basketball Association (NBA) athletes has not been thoroughly elucidated.

Purpose: To assess the impact patellar tendinopathy has on workload, player performance, and career longevity in NBA athletes.

Study Design: Cohort study; Level of evidence, 3.

Methods: NBA players diagnosed with patellar tendinopathy between the 2000-2001 and 2018-2019 seasons were identified through publicly available data. Characteristics, return to play (RTP), player statistics, and workload data were compiled. The season of diagnosis was set as the index year, and the statistical analysis compared post- versus preindex data acutely and in the long term, both within the injured cohort and with a matched healthy NBA control cohort.

Results: A total of 46 NBA athletes were included in the tendinopathy group; all 46 players returned to the NBA after their diagnosis. Compared with controls, the tendinopathy cohort had longer careers (10.50 ± 4.32 vs 7.18 ± 5.28 seasons; $P < .001$) and played more seasons after return from injury (4.26 ± 2.46 vs 2.58 ± 3.07 seasons; $P = .001$). Risk factors for patellar tendinopathy included increased workload before injury (games started, 45.83 ± 28.67 vs 25.01 ± 29.77; $P < .001$) and time played during the season (1951.21 ± 702.09 vs 1153.54 ± 851.05 minutes; $P < .001$) and during games (28.71 ± 6.81 vs 19.88 ± 9.36 minutes per game; $P < .001$). Players with increased productivity as measured by player efficiency rating (PER) were more likely to develop patellar tendinopathy compared with healthy controls (15.65 ± 4.30 vs 12.76 ± 5.27; $P = .003$). When comparing metrics from 1 year preinjury, there was a decrease in games started at 1 year postinjury (−12.42 ± 32.38 starts; $P = .028$) and total time played (−461.53 ± 751.42 minutes; $P = .001$); however, PER at 1 and 3 years after injury was unaffected compared with corresponding preinjury statistics.

Conclusion: NBA players with a higher PER and significantly more playing time were more likely to be diagnosed with patellar tendinopathy. Player performance was not affected by the diagnosis of patellar tendinopathy, and athletes were able to RTP without any impact on career longevity.

Keywords: National Basketball Association; patellar tendinopathy; performance; return to sport; basketball

Patellar tendinopathy is a debilitating knee injury that can affect athletes of all levels. Often referred to as "jumper's knee," patellar tendinopathy appears to have the highest prevalence in sports emphasizing explosive eccentric contractions.[18,34] Patellar tendinopathy is believed to result from a combination of inflammatory and degenerative processes caused by repetitive microtraumas associated with constant jumping.[1,10] Because of the explosive nature of the sport, National Basketball Association (NBA) athletes are at an increased risk of patellar tendinopathy. Studies have shown that extensor mechanism injuries are the second most common orthopaedic injury in NBA players and account for roughly 11.9% of all orthopaedic injuries.[6] While patellar tendinopathy is endemic in NBA athletes, little is known about the effects on performance after return to play (RTP) from injury.

Symptomatic patellar tendinopathy classically presents as localized pain at the junction of the patella and patellar tendon; however, this can also occur at the patellar tendon and the tibial insertion.[25] Because of varying levels of symptomatology and response to therapy, several different therapeutic options are used to treat patellar tendinopathy. Nonsurgical methods consist of physical therapy focused on eccentric exercise, activity modification, physical modalities (patellar strapping, sports taping), therapeutic ultrasound, laser therapy, shock wave therapy, and trials of injections (platelet-rich plasma, steroids, and cell-based therapies) for refractory cases.[2,10,33] Eccentric exercise is

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thought to aid in patellar tendon remodeling to re-equip the joint for high stress sport and has the highest rate of symptom improvement in recent reviews.[9,10] Cases recalcitrant to conservative treatment are candidates for surgical intervention, which has been shown to achieve symptomatic relief in up to 57% of patients (95% CI, 52%-62%)[9]; arthroscopic shaving specifically has reported up to 80% patient satisfaction.[29] Optimal care is extremely important for professional athletes, as lower extremity injuries have been shown to decrease player utilization and productivity in both NBA and amateur basketball.[4,15] Surgical options have been shown to require a longer RTP duration, lower success rates, and a higher complication profile compared with nonoperative modalities.

Although patellar tendinopathy continues to burden NBA athletes, there is a paucity in the literature regarding the contributions of workload on patellar tendinopathy and the implications on performance. Therefore, the aim of this study was to report on the effects of patellar tendinopathy on NBA athlete performance and utilization through publicly available data. We hypothesized that players who suffered from patellar tendinopathy would see a significant decline in player utilization and performance upon return to sport as compared with preinjury status. Furthermore, we hypothesized that these reductions in workload and performance would be greater than the natural decline of healthy matched control athletes, therefore resulting in reduced career longevity in players who were diagnosed with patellar tendinopathy.

METHODS

All instances of patellar tendinopathy sustained by NBA athletes and diagnosed by team physicians from the 2000-2001 season to the 2018-2019 season were collected from publicly available injury reports, press releases, personal websites, and game summaries using methods validated by previous studies.[8,14,19-22] Each documented case of patellar tendinopathy was verified by at least 2 sources, and the dates of injury were cross-referenced with game statistics to ensure accurate RTP data. Players were included if they never had any reported injury in the ipsilateral extremity. Additionally, players must have sustained the injury while on an active NBA roster during in-season play. If a player suffered recurring tendinopathy injuries in the same season, only the first instance was recorded, and the player was included in the longitudinal analysis. Players were excluded if they suffered from patellar tendinopathy while not playing in the NBA or if they participated in leagues outside of the NBA (eg, EuroLeague, NBA Developmental League, or Chinese Basketball Association) after RTP. Players were also excluded if they had a history of lower extremity surgery on either leg before their management of patellar tendinopathy, as their data could not be attributed strictly to the management of patellar tendinopathy. Finally, players who did not have a full season of data and/or did not RTP for a full season were not included in the RTP analysis.

Control players, matched by age, body mass index, position, year, and NBA seasons played, were those who did not sustain a documented knee injury during our study's period of interest. The control group served as baseline to compare performance before and after the diagnosis of patellar tendinopathy. This method for selecting a control group is similar to what has been performed in previous literature.[7,8,13,14,19,20,22] For each instance of patellar tendinopathy, the year in which the injury occurred was recorded as the index year. After selecting the index year, the following information was collected: primary position, height, weight, date of injury, season of injury, age at injury, date of RTP, number of years active in the NBA before the injury, and number of years active in the NBA after the injury. In addition, performance data were collected in the 3 years before and after their injury. These data included total games player, games started, minutes played, minutes played per game, and player efficiency rating (PER). PER was developed to quantify the overall performance of an NBA athlete in a standardized fashion.[26] The formula assigns weighted positive value to statistics such as 2-point field goals made, 3-point field goals made, assists, offensive and defensive rebounds, steals, free throws made, and blocks, while assigning a weighted negative value to turnovers, missed 2- and 3-point field goal attempts, and missed free throws. The metric then factors in minutes played, team pace, and mean player performance in the league over the previous 15 seasons. The date of RTP was identified as the date of the first competitive exposure (ie, game) after injury.

Statistical Analysis

All continuous data were presented as a mean ± standard deviation and all categorical data were reported as column percentages. In a univariate 2-group comparison,

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Ethical approval was not sought for the present study.

TABLE 1
Demographic Comparison Between the Control and Patellar Tendinopathy Cohorts[a]

	Control (n = 121)	Tendinopathy (n = 46)	*P* Value
Age, y	25.30 ± 4.47	26.24 ± 3.97	.212
Height, in	78.70 ± 4.04	78.33 ± 2.85	.502
Weight, lbs	214.61 ± 28.64	218.43 ± 23.11	.419
Position, % of players			.060
Point guard	21	26	
Shooting guard	21	11	
Small forward	16	33	
Power forward	20	20	
Center	21	11	
Seasons played			
Before index year	3.60 ± 4.51	5.26 ± 3.99	**<.001**
After index year	2.58 ± 3.07	4.26 ± 2.46	**.001**
Overall	7.18 ± 5.28	10.50 ± 4.32	**<.001**

[a]Data are presented as mean ± SD unless otherwise indicated. Bolded *P* values indicate statistically significant differences between groups ($P < .05$).

TABLE 2
Preinjury Workload and Performance Metrics Between Cohorts[a]

	Control	Tendinopathy	*P* Value
1 year before injury			
Games started	25.01 ± 29.77	45.83 ± 28.67	**<.001**
Total minutes played	28.71 ± 6.81	19.88 ± 9.36	**<.001**
Minutes per game	63.38 ± 199.17	28.71 ± 6.81	**<.001**
PER	12.76 ± 5.27	15.65 ± 4.30	**.003**
3 years before injury			
Games started	32.71 ± 28.31	49.91 ± 26.95	**.007**
Total minutes played	29.94 ± 8.04	23.81 ± 9.08	**.009**
Minutes per game	58.93 ± 221.34	27.94 ± 8.04	.060
PER	14.07 ± 4.71	16.80 ± 5.18	**.014**

[a]Data are presented as mean ± SD. Bolded *P* values indicate statistically significant differences between groups ($P < .05$). PER, player efficiency rating.

continuous variables were evaluated with Wilcoxon rank-sum tests for nonnormal distributions and 2-sample *t* tests for normally distributed data sets. For categorical variables with cell counts >5, a univariate 2-group analysis was performed with chi-square tests. If cell count was <5, Fisher exact tests were used. Percentages of postseason statistics were calculated relative to preseason year 1 and were examined between groups utilizing Wilcoxon rank-sum tests. Statistical significance was set at $P < .05$. All analyses were performed using SAS 9.4 (SAS Institute Inc).

RESULTS

Characteristics

A total of 56 NBA athletes with patellar tendinopathy symptomatic enough to be reported to the media and/or result in missed games were identified between the 2000-2001 and 2018-2019 seasons. A total of 46 players met the inclusion criteria and were included in the final analysis. A matched cohort of players was constructed from athletes between the 2000-2001 and 2018-2019 seasons and consisted of 121 players. There was no statistically significant difference in age, height, weight, or position between the 2 cohorts (Table 1).

Five players (10.9%) required surgery after nonoperative management; information on treatment modality was not available for most athletes (n = 37; 80.4%). All 46 players (100%) returned to play from patellar tendinopathy. The mean time between the diagnosis and RTP was 60.7 ± 95.2 days (independent of treatment type), with an interquartile range of 3.8 to 70.3 days. Also, 22 players (47.8%) missed fewer than 10 days, including 9 players (19.6%) who missed only 1 or 2 days before returning to play. When compared with matched controls, athletes diagnosed with tendinopathy were found to have played more seasons before their index year (5.26 ± 3.99 vs 3.60 ± 4.51 seasons; $P < .001$), played more seasons after returning to sport (4.26 ± 2.46 vs 2.58 ± 3.07 seasons; $P = .001$), and had longer careers overall (10.50 ± 4.32 vs 7.18 ± 5.28 seasons; $P < .001$) (Table 1).

Workload and Performance: 1 Year Before Injury

At 1 year before injury, athletes with tendinopathy had significantly higher levels of in-game utilization and performance compared with controls (Table 2). The tendinopathy cohort started in significantly more games (45.83 ± 28.67 vs 25.01 ± 29.77 starts; $P < .001$) and had more playing time during the season (1951.21 ± 702.09 vs 1153.54 ± 851.05 minutes; $P < .001$) and during games (28.71 ± 6.81 vs 19.88 ± 9.36 minutes per game; $P < .001$). Athletes with tendinopathy also had a significantly higher PER before injury when compared with controls (15.65 ± 4.30 vs 12.76 ± 5.27; $P = .003$). At 3 years before the index year, the patellar tendinopathy group started in significantly more games (49.91 ± 26.95 vs 32.71 ± 28.31 starts; $P = .007$), played more during the season (2044.55 ± 611.71 vs 1607.81 ± 804.94 minutes; $P = .009$), and had a higher PER (16.80 ± 5.18 vs 14.07 ± 4.71; $P = .014$) compared with controls.

Difference in Pre- and Postinjury Workload and Performance

Table 3 shows the mean differences in workload and performance for 1 year before versus after and also 3 years before versus after the index year. In the year after RTP, the tendinopathy cohort exhibited a significant decline in games started (−12.42 ± 32.38 starts; $P = .028$), time played overall (−461.53 ± 751.42 minutes; $P = .001$), and per game (−2.35 ± 6.65 minutes per game; $P = .041$). Upon evaluation of the mean difference in performance and workload 3

TABLE 3
Mean Difference in Pre- and Postinjury Workload and Performance Metrics[a]

	Control	*P* Value	Tendinopathy	*P* Value
1 year before vs after				
Games played	0.30 ± 26.87	.933	−10.97 ± 17.45	**.001**
Games started	−4.02 ± 29.15	.307	−12.42 ± 32.38	**.028**
Total minutes played	−26.50 ± 865.15	.820	−461.53 ± 751.42	**.001**
Minutes per game	11.87 ± 219.30	.458	−2.35 ± 6.65	**.041**
PER	−0.80 ± 6.41	.245	−0.47 ± 3.23	.387
3 years before vs after				
Games played	−12.47 ± 25.72	**.049**	−5.64 ± 21.18	.199
Games started	−14.58 ± 34.44	.082	−11.48 ± 43.57	.200
Total minutes played	−414.89 ± 899.02	.113	−252.04 ± 1004.13	.222
Minutes per game	−3.63 ± 9.74	.222	−0.43 ± 11.19	.850
PER	−2.06 ± 5.14	.098	−0.91 ± 6.84	.734

[a]Data are presented as mean ± SD. Bolded *P* values indicate statistically significant differences between preinjury and postinjury ($P < .05$). PER, player efficiency rating.

seasons before versus 3 seasons after RTP the control cohort experienced a significant reduction in games played. There were no other significant differences on any metric in either cohort.

DISCUSSION

The present study demonstrated that NBA athletes diagnosed with patellar tendinopathy reliably return to play in the NBA (100%). Players who were more likely to develop patellar tendinopathy, on average, started in 21 more games, played 798 more minutes per season and 35 more minutes per game, and had a 3-point higher PER compared with noninjured players. Patellar tendinopathy was not found to negatively affect career longevity, as players had longer careers and played more seasons after return from injury compared with healthy controls. After return from injury, players continued to experience high workloads and performance.

The explosive nature of the NBA lends itself to a high prevalence of patellar tendinopathy. The high prevalence, combined with its nature as a chronic injury,[31] results in patellar tendinopathy being the leading cause of games missed in the NBA and the second most common orthopaedic injury seen in the NBA,[6] with up to 32% of players reporting symptoms.[5,18,28] RTP and performance after patellar tendinopathy has not been previously defined in the NBA population. Not surprisingly, our results demonstrated that every NBA athlete suffering from patellar tendinopathy returned to play. Although there is a high RTP rate, the injury can cause considerable pain and dysfunction. The mean RTP time in the current study was 60 days, although >45% of players returned in <10 days. In comparison, a retrospective analysis performed by Lang et al[16] on 30 athletes who underwent arthroscopic patellar release to treat patellar tendinopathy reported a mean RTP time of 4 months.

A prospective study performed by Gemignani et al[11] on 282 professional or semiprofessional athletes with patellar tendinopathy sought to determine the relationship between sonographic findings and prognosis. The authors defined a grading system for patellar tendinopathy ranging from 1 (involving <20% of the tendon on axial ultrasound) to 4 (representing a subtotal or a total tear). They also suggested RTP times according to percentage involvement of the tendon: grade 1 = 20 days, grade 2 (20%-50% tendon) = 40 days, grade 3 (>50% of the tendon) = 90 days. These results demonstrate that most athletes RTP after being diagnosed with patellar tendinopathy. RTP is faster with conservative management compared with operative management, and tendon involvement can be used to predict RTP in conservatively managed athletes.

Because of the high prevalence of patellar tendinopathy among jumping athletes, several studies have sought to elucidate factors that predispose athletes to the diagnosis.[18,27,32] A cross-sectional study of NBA players by Lewis[17] investigated workload in 627 athletes over 3 seasons and reported that injuries were associated with greater game load. For every 96 additional game minutes played, there was a 2.9% increase in injury (noninjured vs injured: 8.23 ± 6.76 vs 9.72 ± 7.11 accumulated game minutes [scaled per 96 minutes]; $P < .001$). Likewise, for each additional day of rest between games, injuries decreased by 16% (noninjured vs injured: 1.25 ± 1.20 vs 1.19 ± 1.06 days of rest; $P < .001$). Similar findings were reported by Teramoto et al[30] in an epidemiologic study of NBA players investigating the relationship of game frequency and injury. The authors found that playing back-to-back games (odds ratio [OR], 3.50; 95% CI, 2.31-5.39; $P < .001$), a high frequency of games over a short period of time (OR, 3.29; 95% CI, 2.03-5.50; $P < .001$), and increased minutes in a game (26.1 vs 19.5 minutes per game; $P < .001$) were associated with a higher incidence of injury. Finally, in a meta-analysis of 31 articles on patellar tendinopathy, in which 25 studies (80.6%) involved basketball and/or volleyball players and 13 studies (41.9%) focused on professional athletes, the authors found no significant association between body mass index ($P = .06$) and risk of patellar tendinopathy but a significantly greater risk of patellar tendinopathy when there was an increased volume of activity (OR, 1.50; 95%

CI, 1.11-2.02; $P < .01$). The present study established that NBA athletes with higher workloads and performance were more likely to develop patellar tendinopathy. Consistent with the evidence of these prior studies, our findings revealed that higher caliber players are inclined to play more minutes and more games, resulting in higher accumulated workload placed on their extremities. This additional workload can lead to patellar tendinopathy. Thus, there is a potential opportunity for improved injury prevention through monitoring workload within these high-caliber athletes.

The effect of patellar tendinopathy on longitudinal athlete performance is important to elucidate. Seeking to investigate the role of chronic injury on performance, Khan et al[15] retrospectively reviewed 75 lower extremity bony stress injuries in NBA players. Those authors found that athlete performance, including points, assists, and blocks, was at a similar level before and after the injury. They also asserted that the only reliable predictor of postinjury performance was PER the year before injury ($\beta = 0.66$; 95% CI, 0.414-0.897). Similarly, Patel et al[24] performed a retrospective study of 79 adductor injuries in the NBA and found no difference in PER when comparing the season before versus after injury (15.8 ± 6.4 vs 15 ± 5.4; $P = .27$). Furthermore, Amin et al[3] performed a retrospective study of 43 NBA players who were treated nonoperatively for Achilles tendinopathy and concluded that injured players' field goal percentage, free throw attempts, rebounds per game, steals per game, blocks per game, and PER were not significantly affected the year after the injury when compared with a control cohort. These studies suggest that conservative management of tendon injuries has a minimal effect on athlete performance; in fact, the best predictor of player performance when returning from a nonoperative injury appears to be how well athletes played before injury.[3,15]

The present study demonstrated that athletes diagnosed with patellar tendinopathy performed at a significantly higher level, as measured by PER, 1 year before injury as compared with controls. However, in a similar manner as the above studies, the injured athletes' productivity, as measured by PER, 1 year after injury did not decrease when compared with their preinjury performance. Lastly, this study revealed that long-term performance was not affected, as PER 3 years after injury remained comparable with preinjury levels. In summary, we found that that NBA athletes with patellar tendinopathy were statistically more productive before their diagnosis as compared with controls; yet, despite the diagnosis, players with patellar tendinopathy reliably returned to their high level of preinjury productivity after returning to sport. The development of patellar tendinopathy can reasonably be attributed to increased production, leading to more playing time and increased workload. Once the injury has been identified, treated, and the player cleared to return, we found that players were able to return to their preinjury level of play.

Limitations

This study had its limitations, principally, the use of publicly available data on professional athletes, which is predisposed to selection bias because of lack of availability of players' medical records or centralized NBA archive of injuries. To address these issues, we cross-referenced injuries with reputable sources and maintained consistency with methods previously validated by other studies.[13,19,20,23,24] Previous studies have shown the incidence of patellar tendinopathy to be around one-third of elite basketball players.[6,12,18,28] This study focused on NBA athletes with patellar tendinopathy who were symptomatic enough to be reported to the media and/or result in missed games. Because of the public nature of our data, we were unable to include every player who had patellar tendinopathy, as the injury is not always reported in the NBA health record or the public sources. Therefore, we may have underestimated the true incidence of patellar tendinopathy in the NBA.

Furthermore, our study spanned 19 NBA seasons, during which treatment modalities and rehabilitation regimens have evolved. We also recognize that changes in rosters, coaches, schemes, and opponents are confounding variables as well as previous injuries or potentially undisclosed injures that occurred before a player's NBA career. We were unable to provide the severity and location of patellar tendinopathy, as this is not routinely reported in public data. This could portend differences in outcomes that, ultimately, we were not able to delineate. Similarly, we were unable to report on the impact of treatment methodology, as 80.4% of players analyzed in this study did not have their treatment disclosed. Finally, it was not possible to assess subjective pain or player satisfaction because of limited availability of this information. Future studies should focus on large randomized controlled trials to further evaluate the efficacy of different nonoperative modalities used to treat patellar tendinopathy.

CONCLUSION

All 46 NBA players diagnosed with patellar tendinopathy during 19 seasons predictably returned to play without impact on career longevity. Athletes who were statistically more productive and played in significantly more games were more likely to be diagnosed with patellar tendinopathy. Workload was decreased 1 year after returning from injury but normalized at long-term follow-up. Player performance was not affected by the diagnosis of patellar tendinopathy in our review of publicly available data.

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