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ORIGINAL ARTICLE

Impact of Knee Injuries on Post-retirement Pain and Quality of Life: A Cross-Sectional Survey of Professional Basketball Players

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Abstract *Background:* Professional basketball players are at increased risk for knee injuries. Epidemiologic data exist on the prevalence of such injuries in players in the National Basketball Association (NBA), but little is known about how these injuries affect athletes before after retirement. *Questions/Purposes:* The goals of this study were to evaluate the rates and characteristics of knee injury before and during NBA players' careers and how those injuries correspond to knee injury, pain, or surgery, as well as quality of life, after retirement. *Methods:* A cross-sectional survey study was performed. The survey instrument was designed with the aid of a multidisciplinary focus group. Data collected included patient demographics; length of professional career; injuries before, during, and after the athletes' NBA careers; and post-retirement quality of life, assessed using the EQ-5D and Tegner Activity Scale. The survey was distributed electronically to 900 retired NBA athletes. Descriptive statistics were used to present means and proportions, and multiple regression analysis was performed to assess for potential factors correlated to injury. *Results:* One hundred eight retired NBA players participated (a response rate of 12%). Almost a third (32.4%) sustained a knee injury before starting their NBA career; 51 (47.2%) sustained knee injury during professional play in the NBA, and nearly two-thirds of those players (62.7%) needed surgery. Among those who reported knee injuries during their NBA career, a majority had knee pain that continued until retirement (72.5%). Two-thirds (67%) reported having knee pain currently (at the time of the survey). More than a third (34.0%) underwent knee surgery after retirement, which included nine total knee arthroplasties (8.3%). *Conclusion:* A majority of retired NBA athletes in our study had knee pain, and many needed operative management during and after their NBA careers. NBA players score lower on quality-of-life measures than average North American men of similar age. Further research is needed to elucidate the best strategies for recognizing and treating knee injuries in these athletes.

Keywords NBA · knee injury · professional athlete · basketball

Level of Evidence: Level III: Cross-sectional Survey Study

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Introduction

Professional basketball players are at increased risk for injury, both acute and chronic, as a result of repetitive stresses on the musculoskeletal system [5, 10]. Such stresses are placed on joints and ligaments at myriad points throughout the course of a player's career, from off-season workouts to practices to games. In athletes competing in the National Basketball Association (NBA), the risk of acute and chronic musculoskeletal injuries is associated with repetitive overhead motions; crowded and high-contact play below the net; and repetitive running, pivoting, and jumping on a hardwood court surface [9]. The knee is the most commonly injured body part among NBA athletes, accounting for as many as 20% of all injuries [5].

Some studies have been conducted on the post-retirement impact of injuries sustained during the playing

careers of professional soccer and football players. Arliani et al. identified early osteoarthritis and reduced quality of life among retired professional soccer players [1]. The significant impact of concussion after retirement has been well-documented in professional football players, as well [13]. Few studies are available, however, on the nature and post-retirement impact of injuries sustained in the NBA, the treatment of these injuries (operative versus nonoperative), or the prevalence of risk factors that may predispose athletes to such injuries.

To date, no comprehensive study has been performed on the impact of knee injury in NBA players. An understanding of the relationship between knee injury and a player's decision to retire, as well as the impact on post-retirement life, is crucial for professional basketball players and for physicians who are providing them comprehensive care. The purpose of our study was to evaluate the epidemiology of knee injuries during the careers of professional basketball players and the impact of injury on post-retirement quality of life. Our hypothesis was that knee injury in NBA players would result in continued disability and significantly affect post-retirement quality of life.

Methods

We used a cross-sectional survey study design to evaluate the connection between pre- and post-career knee injury and later disability and quality of life.

Instrument Development

We developed a survey to be administered to retired NBA players. We created a focus group consisting of sports medicine fellowship–trained orthopedic surgeons, team physicians who manage sports injuries, and a statistician to determine areas to be evaluated. We reviewed other orthopedic surveys and consulted with athletic trainers involved with the NBA to ensure that our questionnaire was comprehensive and appropriate. In deciding which questions to include, we used a sample-to-redundancy strategy, adding to the number of surgeons and athletic trainers whom we asked for suggestions until no new items or themes emerged. Questions captured data on demographics, injuries before and during respondents' NBA careers, and current quality of life and musculoskeletal health (Online Resource 1).

Pretesting and Validity Assessments

To ensure face validity, the survey was pretested with an independent pair of orthopedic surgeons, as well as a former professional basketball player, to determine whether the survey as a whole appeared to address injuries relevant to play in the NBA and their possible impact on musculoskeletal health at the time of survey completion. Content validity was ensured through expert review of the question content and focus by surgeons specializing in managing injuries in professional- and elite-level basketball players. Sections refined after this feedback was received were related to demographics; time spent playing in the NBA; player position; and injuries and surgical interventions before, during, and after players' NBA careers. A focus was placed on common injuries affecting the shoulder, hip, and knee. Additionally, comments related to the content, ease of understanding, comprehensiveness, and time required for completion of the survey were assessed and used to refine the survey. The final questionnaire, consisting of 61 items, framed responses using both Likert and nominal scales. In addition, Tegner Activity Scale [4] and EQ-5D [8] assessments were incorporated into the survey.

Questionnaire Dissemination and Administration

The survey was sent by email to all members of the National Basketball Players Association (NBPA), which is the labor union representing NBA players. The survey was administered through the *S*urveyMonkey® electronic survey platform from April 1, 2017, to June 26, 2017. The survey was open only to players who had played in the NBA and were retired at the time of the survey. Electronic restrictions were in place to ensure that only one response per computer was possible and that multiple responses were not obtained from the same individual. The NBPA sent out three reminder emails to all members to maximize player response rate. The survey was distributed to a total of 900 former NBA players.

Statistical Analysis

All responses were organized and analyzed in the SurveyMonkey platform; statistical analysis was carried out in consultation with a statistician. Summary statistics were calculated as dichotomous or categorical variables and presented as percentages. Multiple regression analysis was performed to assess for factors possibly correlating injury before and during professional basketball play to current quality of life. We performed χ^2 tests to compare proportions. A p value of less than 0.05 was considered to be significant.

Consent was obtained from players electronically before they completed the survey. To maintain privacy, all data were collected anonymously without identifiers. This study was approved by the institutional review board at the University of Michigan Medical School.

Results

One hundred eight retired NBA players participated in the survey, for a response rate of 12%. Of those who started the survey, 93% completed it in its entirety. A majority (72.2%) were over the age of 55 years (range, 35 to 55 or older); 68% of respondents had played in the NBA between 5 and 14 years (range, 0 to 19 years), and 79% of respondents had also played in another professional league (such as EuroLeague or the National Basketball League of Canada). More than 56% of respondents identified as "black or African American." All playing positions were represented, with center being the most common (28.7%) and shooting guards the least common (13.9%) (Table 1).

Table 1 Demographics

Player characteristics	Number (%) $N = 108$
Age in years	
35–39	2 (1.9)
40–44	8 (7.4)
45–49	10 (9.3)
50–54	10 (9.3)
55+	78 (72.2)
Years in the NBA	
0–4	27 (25.0)
5–9	34 (31.5)
10–14	39 (36.1)
15–19	8 (7.1)
Years in other professional league	
0–4	56 (51.9)
5–9	18 (16.7)
10–14	9 (8.3)
15–19	2 (1.9)
N/A	23 (21.3)
Primary playing position	
Center	31 (28.7)
Power forward	25 (23.2)
Small forward	19 (17.6)
Point guard	19 (16.7)
Shooting guard	15 (13.9)

NBA National Basketball Association, *N/A* not applicable

Injury Before NBA Play

Table 2 provides details of player injuries suffered before professional (NBA) play. Approximately one-third (32.4%) of players identified a significant injury having occurred before professional (NBA) play that had resulted in lost time or surgery. Among those reporting injuries before their time in the NBA, the ankle and knee were the most commonly injured (n = 17 of 35 for each). Of those reporting knee injury, 82% (n = 14 of 17) required surgical intervention, and cartilage or meniscal injury was most commonly reported (52.9%; n = 9 of 17). One athlete had undergone anterior cruciate ligament (ACL) reconstruction before starting his NBA career.

Injury During NBA Play

Table 3 shows characteristics of knee injury during players' NBA careers. Nearly half of all respondents (47.2%; n = 51 of 108) reported sustaining knee injury during professional play in the NBA. Athletes who had sustained a knee injury before starting their professional career were significantly more likely to report knee pain or injury while in the NBA (70.6% vs. 43.8%; $\chi^2 = 10.6$; $p < 0.01$). The most common knee injuries during athletes' NBA careers were cartilage and meniscus injuries, reported by 80.4% (n = 41) of those who had knee injuries. Overall, from the total sample, one in five athletes (20.4%; n = 22 of 108) received intra-articular knee corticosteroid injection while playing in the NBA. More than one-third (38.0%) of the 108 respondents missed playing time because of knee injuries, with nearly a fifth (19.4%) of those who sustained knee injuries having missed 21 or more games. Among those who reported knee injuries during their NBA career, most (72.5%) stated that their knee continued to bother them until retirement, and 29.4% retired from the NBA because of their knee problems.

Two-thirds of athletes who sustained knee injuries during their NBA career required operative management (62.7%; n = 32 of 51), of whom 38.7% (n = 12 of 32) required more than one operation. Most operations were meniscal, cartilage, or loose body removal procedures (93.6%; n = 44 of 47 procedures); three athletes reported needing ACL reconstruction surgery while in the NBA. Cruciate ligament injuries were most likely to result in athletes missing an entire season (four of 10; data not shown) and had the lowest rate of return to play at the same level (0%; data not shown), although it should be noted that the latter was subjectively reported and based only on a sample of three athletes.

Among athletes with knee injuries during their NBA career, those needing operative management were significantly less likely to return to play at the same level than those who did not need knee surgery (59.4% vs. 78.9%; $\chi^2 = 9.6$; $p < 0.01$; data not shown). After adjustment for age and ethnicity, having a knee injury during NBA career had a significant impact on current activity level ($p = 0.033$).

Post-career Knee Health

Table 4 summarizes the characteristics of respondents' knee health after their NBA careers. Regarding knee-specific post-career questions, two-thirds of all respondents reported that they currently had knee pain (67%; n = 69 of 103), and nearly one-third of all athletes (30.1%) had received a corticosteroid injection in their knee since retiring from the NBA. More than one-third (34.0%; n = 35 of 103) of all respondents had undergone knee surgery since retiring from the NBA, including 14.6% who had had more than one

Table 2 Pre-NBA injury characteristics

	Number (%) $N = 108$
Respondents with injury before NBA	35 (32.4)
Location of injury[a]	
Knee	17 (15.7)
Ankle	17 (15.7)
Shoulder	4 (3.7)
Hip	4 (3.7)
Elbow	3 (2.8)
Nature of the injury[a]	
Ligament sprain	7 (6.5)
Ligament or tendon tear	9 (8.3)
Dislocation	6 (5.6)
Fracture	10 (9.3)
Meniscus or cartilage injury	10 (9.3)
Muscle tear or sprain	11 (10.2)
Back injury	5 (4.6)
Required knee surgery	14 (13.0)
Knee meniscus surgery	6 (18.8)
ACL surgery	1 (0.9)

NBA National Basketball Association, *ACL* anterior cruciate ligament
[a] Respondents could select more than one response

operation (for a total of 56 knee procedures). Among the retired athletes who had undergone knee surgery, meniscal surgery was the most common (37.5%; $n = 21$ of 56 procedures), and 26.5% had received total knee replacements ($n = 9$ of 35). There were no significant differences between those who had knee pain during their NBA career and those who did not, in terms of rates of current knee pain ($p = 0.08$), corticosteroid injection ($p = 0.07$), or post-retirement knee surgery ($p = 0.16$).

General Post-career Health

Table 5 provides details of responses to the questions regarding general health, including the Tegner Activity Scale and the EQ-5D.

At the time of the survey, the median Tegner Activity Scale level was 4, meaning "work—heavy labor." The most frequently chosen level (20.4%; $n = 22$), however, was 2: "work—light labor, walking on uneven ground possible, but impossible to hike or backpack."

On the EQ-5D, nearly one-third of retired NBA players reported having moderate to severe problems with mobility (30%; $n = 32$). More than half (51.5%) of respondents reported having some problems performing their usual activities, such as "work, study, housework, family, or leisure activities." Most respondents (88%) reported having some pain or discomfort. Nearly half (44%; $n = 44$) of those surveyed reported that they were "slightly" to "extremely" anxious or depressed. The majority (88%; $n = 88$) of respondents had no problems with self-care activities.

On the EQ-5D visual analog scale, which asks respondents to rate their current health from 0 (worst) to 100 (best), the mean (± standard deviation) score was 74.1 ± 17.1. There were no significant differences in EQ-5D responses between athletes who had a knee injury during their career and those who did not.

Table 3 Characteristics of knee injury during NBA career

	Number (%) $n = 51$[a]
Respondents with any knee injury during NBA play	51/108 (47.2)
Type of knee injury[b]	
Meniscus	21 (41.2)
Cartilage	20 (39.2)
Hamstring	9 (17.6)
Patella or quadriceps tendon	6 (11.8)
ACL/PCL	5 (9.8)
LCL/MCL	5 (9.8)
Patellar dislocation	1 (2.0)
Unspecified knee pain	13 (25.5)
Steroid injections	22 (43.1)
Surgery	
Any surgery	32 (62.7)
More than one operation	12 (23.5)
Type of surgery[b]	
Meniscus	20 (39.2)
Cartilage	10 (19.6)
Loose body removal	14 (27.5)
ACL reconstruction	3 (5.9)
Outcomes	
Games missed	
None	10 (19.6)
< 5	6 (11.8)
6–20	14 (27.5)
21–50	14 (27.5)
> 51 (entire season)	7 (13.7)
Returned to play at same level	34 (66.7)
Knee pain until retirement	37 (72.5)
Retired because of knee	15 (29.4)
Would have played longer if knee didn't hurt	28 (54.9)

NBA National Basketball Association, *ACL* anterior cruciate ligament, *PCL* posterior cruciate ligament, *LCL* lateral collateral ligament, *MCL* medial collateral ligament

[a] $n = 51$ unless otherwise specified

[b] Respondents could select more than one response

Discussion

The key findings of this survey are that two-thirds of retired NBA players reported experiencing knee pain and more than a third needed surgical intervention after retirement from professional play. Additionally, knee injuries have a significant effect on post-retirement activity levels. It is therefore important to correctly identify and treat knee injuries in professional basketball players in order to improve outcomes. In addition, long-term knee health should be discussed with all NBA athletes, given that a majority experience knee symptoms after retiring. Counseling and treatment should be provided with a view toward lifelong knee health and overall function to ensure that athletes' values are taken into account and that the desire to return to play is balanced with considerations of long-term function.

Limitations of the survey include its focus on an all-male, single-sport cohort from a top professional league, which limits its generalizability to other athlete populations. Also, given that this is a rarified population, the overall pool of possible participants is relatively small; this is reflected in the total number of participants. In addition, given that the majority of respondents were older than 55 years, there is limited generalizability of these data to younger retirees. Additionally, the age range of participants in the study population is a possible confounding variable, with older respondents reporting more symptoms or disability. Finally, the response rate was low; however, this study concerns a very specific group of athletes, and the available comparable literature is scant; consequently, our study provides novel and valuable data.

Athletes entering the NBA with a previous knee injury were significantly more likely to sustain further knee injury while in the NBA, with meniscal and cartilage injuries being most common. In addition, most of these athletes required surgical interventions during their playing career and continued to experience knee pain until retirement, suggesting that this subset of athletes may be predisposed toward a higher baseline risk of knee injury upon entry into the league. It is important that these athletes be managed and counseled appropriately in order to prevent further injury and to manage new injuries when they do arise. Kirkendall and Garrett stress the importance of education and regular patient contact in managing retired athletes with osteoarthritis [11]. The same

Table 4 Characteristics of knee health after NBA career

	Number (%) $N = 103$
Respondents with current knee pain	69 (67.0)
Steroid injection since retirement	31 (30.1)
Surgery	
Any surgery	35 (34.0)
More than one operation	15 (14.6)
Type of surgery	
Meniscus	21 (20.4)
Cartilage	11 (10.7)
Loose body removal	13 (12.6)
ACL reconstruction	2 (1.9)
Total knee arthroplasty	9 (8.7)

NBA National Basketball Association, *ACL* anterior cruciate ligament

approach may be applied from the time an athlete enters professional play until retirement.

A troubling trend in the present study was NBA athletes' reporting lower scores across all health-related quality-of-life (HRQOL) domains, as compared with population norms. The median Tegner Activity Scale score was lower than the mean score (of 6) in adults with normal knees reported by Briggs et al. in 2009 [3]. In addition, respondents were more likely to report problems in all five EQ-5D domains, as compared with the population norm in American men over 55 years of age [8], with odds ratios (ORs) ranging from 1.24 to 1.56. The most pronounced differences were in usual activities (OR = 1.56) and mobility (OR = 1.54) (Table 6). It is important to note that this is actually a conservative comparison, given that a quarter of the sample in the present study was younger than 55. A recent meta-analysis found that athletes had better HRQOL outcomes than nonathletes, and that noninjured athletes had better HRQOL outcomes than injured athletes [7]. That study, however, involved primarily high-school and collegiate athletes and did not report mean ages or sports played. Arliani et al. matched a group of retired professional soccer players with a group of healthy volunteers and found that the retired athletes had significantly worse functional scores across a number of HRQOL domains, including on the 36-item Short Form Health Survey [1]. The findings of the present study are consistent with those of Arliani et al.; despite being much more fit than the average population during their playing careers, professional NBA players fare more poorly than the average person after they retire.

Recent public awareness of sport-related concussion has shed light on the mental health of professional athletes after retirement. Two recent systematic reviews found an association between sport-related concussion and post-retirement depression and other mental health symptoms [13, 15]. Interestingly, although our survey was focused on musculoskeletal injury, it included the important finding that nearly half of retired NBA players reported some level of anxiety or depression, which is higher than the age-matched population norms [8]. Although there is a dearth of high-quality research, evidence is emerging that retired professional athletes may have an elevated risk of mental illness, although recent studies suggest that there is no increase in the risk of suicide [6, 12].

Table 5 Detailed responses to HRQOL measures

EQ-5D domains and VAS

	Number (%) $N = 108$
Mobility	
No problems	45 (41.7)
Slight problems	23 (21.3)
Moderate problems	25 (23.1)
Severe problems	6 (5.6)
Unable to walk	1 (0.9)
Missing	8 (7.4)
Self-care	
No problems	88 (81.5)
Slight problems	9 (8.3)
Moderate problems	2 (1.9)
Severe problems	9 (0)
Unable to wash or dress myself	1 (0.9)
Missing	8 (7.4)
Usual activities	
No problems	48 (44.4)
Slight problems	32 (29.6)
Moderate problems	15 (13.9)
Severe problems	0 (0)
Unable to do my usual activities	4 (3.7)
Missing	9 (8.3)
Pain	
No pain	12 (11.1)
Slight pain	40 (37.0)
Moderate pain	42 (38.9)
Severe pain	4 (3.7)
Extreme pain	2 (1.9)
Missing	8 (7.4)
Anxiety or depression	
No anxiety or depression	56 (51.9)
Slight anxiety or depression	29 (26.9)
Moderate anxiety or depression	14 (13.0)
Severe anxiety or depression	1 (0.9)
Extreme anxiety or depression	0 (0)
Missing	8 (7.4)
VAS Current Health (0 to 100)	Mean 74.1 (SD 17.1)
Tegner activity scale	
Current activity level[a]	
Level 10	0 (0)
Level 9	2 (1.9)
Level 8	1 (0.9)
Level 7	5 (4.6)
Level 6	16 (14.8)
Level 5	9 (8.3)
Level 4	10 (9.3)
Level 3	16 (14.8)
Level 2	22 (20.4)
Level 1	6 (5.6)
Level 0	4 (3.7)
Missing	17 (15.7)

HRQOL health-related quality of life, *VAS* visual analog scale
[a] See Table 6 for definitions of the levels

Interestingly, one in five athletes received intra-articular corticosteroid injections in an injured knee while in the NBA. Given that most respondents were over the age of 55, this likely represents practice patterns from 20 to 30 years ago. In vivo animal studies and in vitro human studies have demonstrated a risk of cartilage thinning with the use of high-dose intra-articular corticosteroids, particularly with

Table 6 National Basketball Association sample survey responses to EQ-5D-derived questions on general health, in comparison with population norms [8]

EQ-5D domain	NBA sample (%)	Population norm (%)	Odds ratio
Mobility	55	36	1.54
Self-care	12	10	1.24
Usual activities	52	33	1.56
Pain	88	61	1.44
Anxiety or depression	44	30	1.49

repeated injections [14, 16]. Of course, this would not be a concern with single or rare injections, which is more commonly the practice in the care of professional athletes. Given the availability of newer intra-articular injections such as hyaluronic acid and platelet-rich plasma, it would be interesting to compare current practice patterns with our data [2].

A majority of retired NBA athletes have knee pain, and many required operative management both during and after their NBA career. NBA players score lower on quality-of-life measures when compared with the average North American men of similar age. Further research is needed to help elucidate the best strategies for recognizing and treating knee injuries in this group of elite athletes. Further research is needed to evaluate the post-retirement musculoskeletal and overall health of retired professional athletes, including other cross-sectional studies of retired athletes, as well as long-term prospective cohort studies. The establishment of more high-quality evidence will guide sports medicine physicians in counseling athletes during their careers and for years beyond.

Compliance with Ethical Standards

Conflict of Interest: Moin Khan, MD, MSc, FRCSC, Seper Ekhtiari, MD, Tyrrell Burrus, MD, Kim Madden, MSc, PhD, AND Joseph P. Rogowski, MSc, ATC, CSCS, declare that they have no conflicts of interest. Asheesh Bedi, MD, reports receiving personal fees from Arthrex and stock or stock options from A3 Surgical, outside the submitted work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

Informed Consent: Informed consent was obtained from survey respondents electronically before they completed the survey.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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