Epidemiology and Impact of Knee Injuries in Major and Minor League Baseball Players

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Injuries among professional baseball players have been on the rise for several years.\(^1\,^2\) From 1989 to 1999, the number of disabled list (DL) reports increased 38% (266 to 367 annual reports),\(^1\) and a similar increase in injury rates was noted from the 2002 to the 2008 seasons (37%).\(^2\) These injuries have important implications for future injury risk and time away from play. Identifying these injuries and determining correlates and risk factors is important for targeted prevention efforts.

Several studies have explored the prevalence of upper extremity injuries in professional and collegiate baseball players;\(^2\,^4\) however, detailed epidemiology of knee injuries in Major League Baseball (MLB) and Minor League Baseball (MiLB) players is lacking. Much more is known about the prevalence, treatment, and outcomes of knee injuries in other professional sporting organizations, such as the National Basketball Association (NBA), National Football League (NFL), and National Hockey League (NHL).\(^4\,^12\) A recent meta-analysis exploring injuries in professional athletes found that studies on lower extremity injuries comprised approximately 12% of the literature reporting injuries in MLB players.\(^4\) In other professional leagues, publications on lower extremity injuries comprise approximately 56% of the sports medicine literature in the NFL, 54% in the NBA, and 62% in the NHL.\(^4\) Since few studies have investigated lower extremity injuries among professional baseball players, there is an opportunity for additional research to guide evidence-based prevention strategies.

A better understanding of the nature of these injuries is one of the first steps towards developing targeted injury prevention programs and treatment algorithms. The study of injury epidemiology among professional baseball players has been aided by the creation of an injury tracking system initiated by the MLB, its minor league affiliates, and the Major League Baseball Players Association.\(^5\,^13\,^14\) This surveillance system allows for the tracking of medical histories and injuries to players as they move across major and minor league organizations. Similar systems have been utilized in the National Collegiate Athletic Association and other professional sports organizations.\(^3\,^15\,^17\) A unique advantage of the MLB surveillance system is the required participation of all major and minor league teams, which allows for investigation of the entire population of players rather than simply a sample of players from select teams. This system has propelled an effort to identify injury patterns as a means of
developing appropriate targets for potential preventative measures.

The purpose of this descriptive epidemiologic study is to better understand the distribution and characteristics of knee injuries in these elite athletes by reporting on all knee injuries occurring over a span of 4 seasons (2011-2014). Additionally, this study seeks to characterize the impact of these injuries by analyzing the time required for return to play and the treatments rendered (surgical and nonsurgical).

Materials and Methods

After approval from the Johns Hopkins Bloomberg School of Public Health Institutional Review Board, detailed data regarding knee injuries in both MLB and MiLB baseball players were extracted from the de-identified MLB Health and Injury Tracking System (HITS). The HITS database is a centralized database that contains data on injuries from an electronic medical record (EMR). All players provided consent to have their data included in this EMR. HITS system captures injuries reported by the athletic trainers for all professional baseball players from 30 MLB clubs and their 230 minor league affiliates. Additional details on this population of professional baseball players have been published elsewhere. Only injuries that result in time out of play (≥1 day missed) are included in the database, and they are logged with basic information such as region of the body, diagnosis, date, player position, activity leading to injury, and general treatment. Any injury that affects participation in any aspect of baseball-related activity (eg, game, practice, warm-up, conditioning, weight training) is captured in HITS.

All baseball-related knee injuries occurring during the 2011-2014 seasons that resulted in time out of sport were included in the study. These injuries were identified based on the Sports Medicine Diagnostic Coding System (SMDCS) to capture injuries by diagnostic groups. Knee injuries were included if they occurred during spring training, regular season, or postseason play. Offseason injuries were not included. Injury events that were classified as “season-ending” were not included in the analysis of days missed because many of these players may not have been cleared to play until the beginning of the following season. To determine the proportion of knee injuries during the study period, all injuries were included for comparative purposes (subdivided based on 30 anatomic regions or types).

For each knee injury, a number of variables were analyzed, including diagnosis, level of play (MLB vs. MiLB), age, player position at the time of injury (pitcher, catcher, infield, outfield, base runner, or batter), field location where the injury occurred (home plate, pitcher’s mound, infield, outfield, foul territory or bullpen, or other), mechanism of injury, days missed, and treatment rendered (conservative vs surgical). The classification used to describe the mechanism of injury consisted of contact with ball, contact with ground, contact with another player, contact with another object, or noncontact.

Statistical Analysis: Epidemiologic data are presented with descriptive statistics such as mean, median, frequency, and percentage where appropriate. When comparing player age, days missed, and surgical vs nonsurgical treatment between MLB and MiLB players, t-tests and tests for difference in proportions were applied as appropriate. Statistical significance was established for P values < .05.

The distribution of days missed for the variables considered was often skewed to the right (ie, days missed mostly concentrated on the low to moderate number of days, with fewer values in the much higher days missed range), even after excluding the season-ending injuries; hence the mean (or average) days missed was often larger than the median days missed. Reporting the median would allow for a robust estimate of the expected number of days missed, but would down weight those instances when knee injuries result in much longer missed days, as reflected by the mean. Because of the importance of the days missed measure for professional baseball, both the mean and
median are presented.

In order to estimate exposure, the average number of players per team per game was calculated based on analysis of regular season game participation via box scores. This average number over a season, multiplied by the number of team games at each professional level of baseball, was used as an estimate of athlete exposures in order to provide rates comparable to those of other injury surveillance systems. Injury rates were reported as injuries per 1000 athlete-exposures (AE) for those knee injuries that occurred during the regular season. It should be noted that the number of regular season knee injuries and the subsequent AE rates are based on injuries that were deemed work-related during the regular season. This does not necessarily only include injuries occurring during the course of a game, but injuries in game preparation as well. Due to the variations in spring training games and fluctuating rosters, an exposure rate could not be calculated for spring training knee injuries.

**RESULTS**

**Overall Summary**

Of the 30 general body regions/systems included in the HITS database, injuries to the knee were the fifth most common reason for days missed in all of professional baseball from 2011-2014 (Table 1). Injuries to the knee represented 6.5% of the nearly 34,000 injuries sustained during the study period. Knee injuries were the fifth most common reason for time out of play for players in both the MiLB and MLB.

A total of 2171 isolated knee injuries resulted in time out of sport for professional baseball players (Table 2). Of these, 410 (19%) occurred in MLB players and 1761 (81%) occurred in MiLB players. MLB players were older than MiLB players at the time of injury (29.5 vs 22.8 years, respectively). Overall mean number of days missed was 16.2 days per knee injury, with MLB players missing an approximately 7 days more per injury than MiLB athletes (21.8 vs. 14.9 days respectively; \( P = .001 \)). Over the course of the 4 seasons, a total of 30,449 days were missed due to knee injuries in professional baseball, giving an average rate of 7612 days lost per season. Surgery was performed for 263 (12.1%) of the 2171 knee injuries, with a greater proportion of MLB players requiring surgery than MiLB players (17.3% vs 10.9%) \( P < .001 \). With respect to number of days missed per injury, 26% of knee injuries in the minor leagues resulted in greater than 30 days missed, while this number rose to 32% for knee injuries in MLB players (Table 3).
For regular season games, it was estimated that there were 1,197,738 MiLB and 276,608 MLB AE, respectively, over the course of the 4 seasons (2011-2014). The overall knee injury rate across both the MiLB and MLB was 1.2 per 1000 AE, based on the subset of 308 and 1473 regular season knee injuries in MiLB and MLB, respectively. The rate of knee injury was similar and not significantly different between the MiLB and MLB (1.2 per 1000 AE in the MiLB and 1.1 per 1000 AE in the MLB).

**Characteristics of Injuries**

When considering the position of the player during injury, defensive players were most frequently injured (n = 742, 56.5%), with pitchers (n = 227, 17.3%), infielders (n = 193, 14.7%), outfielders (n = 193, 14.7%), and catchers (n = 129, 9.8%) sustaining injuries in decreasing frequency. Injuries while on offense (n = 571, 43.5%) were most frequent in base runners (n = 320, 24.4%) followed by batters (n = 251, 19.1%) (Table 4). Injuries while on defense occurring in infielders and catchers resulted in the longest period of time away from play (average of 22.4 and 20.8 days missed, respectively), while those occurring in batters resulted in the least average days missed (8.9 days).

The most common field location for knee injuries to occur was the infield, which was responsible for n = 647 (29.8%) of the total knee injuries (Table 4). This was followed by home plate (n = 493, 22.7%), other locations
outside those specified (n = 394, 18.1%), outfield (n = 320, 14.7%), pitcher’s mound (n = 210, 9.7%), and foul
territory or the bullpen (n = 107, 4.9%). Of the knee injuries with a specified location, those occurring in foul
territory or the bullpen resulted in the highest mean days missed (18.4), while those occurring at home plate
resulted in the least mean days missed (13.4 days).

When analyzed by mechanism of injury, noncontact injuries (n = 953, 43.9%) were more common than being hit
with the ball (n = 374, 17.2%), striking the ground (n = 409, 18.8%), other mechanisms not listed (n = 196, 9%),
contact with another player (n = 176, 8.1%), or contact with other objects (n = 63, 2.9%) (Table 4). Noncontact
injuries and player to player collisions resulted in the greatest number of missed days (21.6 and 17.1 days,
respectively) while being struck by the ball resulted in the least mean days missed (5.1).

Of the n = 493 knee injuries occurring at home plate, n = 212 (43%) occurred to the batter, n = 100 (20%) to the
catcher, n = 34 (6.9%) to base runners, and n = 7 (1.4%) to pitchers (Table 5). The majority of knee injuries in the
infield occurred to base runners (n = 283, 43.7%). Player-to-player collisions at home plate were responsible for
51 (2.3%) knee injuries, while 163 (24%) were noncontact injuries and 376 (56%) were the result of a player being
hit by the ball (Table 5).

Injury Diagnosis

By diagnosis, the most common knee injuries observed were contusions or hematomas (n = 662, 30.5%), other
injuries (n = 415, 19.1%), sprains or ligament injuries (n = 380, 17.5%), tendinopathies or bursitis (n = 367,
16.9%), and meniscal or cartilage injury (n = 200, 9.2%) (Table 6). Injuries resulting in the greatest mean number
of days missed included meniscal or cartilage injuries (44 days), sprains or ligament injuries (30 days), or
dislocations (22 days).
Based on specific SMDCS descriptors, the most frequent knee injuries reported were contusion (n = 662, 30.5%), patella tendinopathy (n = 222, 10.2%), and meniscal tears (n = 200, 9.2%) (Table 6). Complete anterior cruciate ligament tears, although infrequent, were responsible for the greatest mean days missed (156.2 days). This was followed by lateral meniscus tears (47.5 days) and medial meniscus tears (41.2 days). Knee contusions, although very common, resulted in the least number of days missed (6.0 days).

**Discussion**

Although much is known about knee injuries in other professional athletic leagues, little is known about knee injuries in professional baseball players.\(^2\)\(^4\) The majority of epidemiologic studies regarding baseball players at any level emphasizes the study of shoulder and elbow injuries.\(^3\)\(^4\)\(^19\) Since the implementation of the electronic medical record and the HITS database in professional baseball, there has been increased effort to document injuries that have received less attention in the existing literature. Understanding the epidemiology of these injuries is important for the development of targeted prevention efforts.

Prior studies of injuries in professional baseball relied on data captured by the publicly available DL. Posner and colleagues\(^2\) provide one of the most comprehensive reports on MLB injuries in a report utilizing DL assignment data over a period of 7 seasons. They demonstrated that knee injuries were responsible for 7.7% (12.5% for fielders and 3.7% for pitchers) of assignments to the DL. The current study utilized a comprehensive surveillance and builds on this existing knowledge. The present study found similar trends to Posner and colleagues\(^2\) in that knee injuries were responsible for 6.5% of injuries in professional baseball players that resulted in missed games. From the 2002 season to the 2008 season, knee injuries were the fifth most common reason MLB players were placed on the DL,\(^2\) and the current study indicates that they remain the fifth most common reason for missed time from play based on the HITS data. Since the prevalence of these injuries have remained constant since the 2002 season, efforts to better understand these injuries are warranted in order to identify strategies to prevent them. These analyses have generated important data towards achieving this understanding.

As with most injuries in professional sports, goals for treatment are aimed at maximizing patient function and performance while minimizing time out of play. For the 2011-2014 professional baseball seasons, a total of 2171 players sustained knee injuries and missed an average of 16.2 days per injury. Knee injuries were responsible for a total of 7612 days of missed work for MLB and MiLB players per season (30,449 days over the 4-season study period). This is equivalent to a total of 20.9 years of players’ time lost in professional baseball per season over the last 4 years. The implications of this amount of time away from sport are significant, and further study should be
targeted at prevention of these injuries and optimizing return to play times.

When attempting to reduce the burden of knee injuries in professional baseball, it may prove beneficial to first understand how the injuries occur, where on the field, and who is at greatest risk. From 2011 to 2014, nearly 44% of knee injuries occurred by noncontact mechanisms. Among all locations on the field where knee injuries occurred, those occurring in the infield were responsible for the greatest mean days missed. The players who seem to be at greatest risk for knee injuries appear to be base runners. These data suggest the need for prevention efforts targeting base runners and infield players, as well as players in MiLB, where the largest number of injuries occurred.

Recently, playing rules implemented by MLB after consultation with players have focused on reducing the number of player-to-player collisions at home plate in an attempt to decrease the injury burden to catchers and base runners. This present analysis suggests that this rule change may also reduce the occurrence of knee injuries, as player collisions at home plate were responsible for a total of 51 knee injuries during the study period. The impact of this rule change on injury rates should also be explored. Interestingly, of the 51 knees injuries occurring due to contact at home plate, 23 occurred in 2011, and only 2 occurred in 2014—the first year of the new rule. Additional areas that resulted in high numbers of knee injuries were player-to-player contact in the infield and player contact with the ground in the infield.

Attempting to reduce injury burden and time out of play related to knee injuries in professional baseball players will likely prove to be a difficult task. In order to generate meaningful improvement, a comprehensive approach that involves players, management, trainers, therapists, and physicians will likely be required. As the first report of the epidemiology of knee injuries in professional baseball players, this study is one important step in that process. The strengths of this study are its comprehensive nature that analyzes injuries from an entire population of players on more than 200 teams over a 3-year period. Also, this research is strengthened by its focus on one particular region of the body that has received limited attention in the empirical literature, but represents a significant source of lost time during the baseball season.

There are some limitations to this study. As with any injury surveillance system, there is the possibility that not all cases were captured. Additionally, since the surveillance system is based on data from multiple teams, data entry discrepancy is possible; however, the presence of dropdown boxes and systematic definitions for injuries reduces this risk. Finally, this study did not investigate the various treatments for knee injuries beyond whether or not the injury required surgery. Since this was the first comprehensive exploration of knee injuries in professional baseball, future studies are needed to explore additional facets including outcomes related to treatment, return to play, and performance.

**Conclusion**

Knee injuries represent 6.5% of all injuries in professional baseball, occurring at a rate of 1.3 per 1000 AE. The burden of these injuries is significant for professional baseball players. This study fills a critical gap in sports injury research by contributing to the knowledge about the effect of knee injuries in professional baseball. It also provides an important foundation for future epidemiologic inquiry to identify modifiable risk factors and interventions that may reduce the impact of these injuries in athletes.
Key Info

Figures/Tables

References


**Multimedia**

**Product Guide**

- **BioComposite SwiveLock Anchor**
- **BioComposite SwiveLock C, with White/Black TigerTape™ Loop**
Citation