

Research Article

Epidemiology and Outcomes of Concussions in Major League Baseball

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Abstract

Background: Little data exists on concussions in baseball, particularly at the professional level. The purpose of this study is to document the epidemiology of concussions in Major League Baseball (MLB) and their impact upon player performance.

Methods: Data on MLB concussions occurring between 2001 and 2010 was gathered from disabled list records. For each player identified, additional data was gathered from online game summaries and player profiles. Recorded variables included player position, date of injury, age at time of injury, injury mechanism, and date of return to play. Performance statistics were also compiled for each player for the 15- and 30-day periods immediately after they returned to play. This included: batting average, on-base percentage, slugging percentage, earned run average, and walks plus hits per innings pitched. To serve as internal controls, identical statistics were collected from each player for the 30 days immediately prior to injury. Statistical analysis was performed using two-sided z-test for proportions with a significance level of 0.05.

Results: 33 concussions were identified in 31 players between 2001-2010. Nine players were hit by batted balls (27.3%), 8 by pitches (24.2%) and 7 from collisions (21.2%). Nearly a third (30.3%) of injuries were to catchers. On average, players were sidelined for 32.12 days. Four players (12%) never returned at all. Slugging percentage was significantly decreased from pre-injury, but only through the first 15 days. All other statistics were showed no change from pre-concussion average through both the first 15 and 30 days after returning from injury.

Conclusion: The recognition and reporting of concussions in MLB appears to be increasing, as we observed a near 3-fold increase in our data over the past 5 years. Catchers were at particularly high risk, representing a third of injured players. Most players returned to MLB at an average of around 30 days, but there was a 12% rate of no return. Reasons for retirement or extended disability are not known. A decrease in slugging percentage was the only statistically significant finding, with all other performance measures remaining unchanged from pre-injury values. What additional long-term impact concussions will have, especially in the setting of multiply concussed players, is unknown at this time. Based on literature from other sports, possible late-onset cognitive impairment could be expected in a small percentage of players. Long-term studies in MLB players are needed before definitive conclusions can be made. For the time being, however, knowing the incidence of concussion, risk factors specific to MLB players, and expected effects on performance can help coaches and players improve risk management and prevention.

INTRODUCTION

Concussions are a very common sports-related injury. They are considered a major public health concern, with some studies reporting a per-year incidence of 3.8 million sports-related concussions in the United States [1-6]. The number of

concussions in sports has risen over the past several decades, as well. The number of concussions reported to the NCAA showed an average annual increase of 7.0% from the 1988-89 through 2003-2004 seasons [2,7]. Additionally, the concussion rate doubled from 0.17 per 1000 A-E (athlete-exposures, defined as one athlete participating in one practice or competition) in 1988-

89 to 0.34 per 1000 A-E in 2003-2004 [7]. There has been marked improvement in concussion recognition and management during this time, with coaches and players more cognizant of the potential for injury. However, this increase may also be due in part to an increase in the true rate of concussion [2,3,7]. Also, symptoms are often of rapid onset and resolve spontaneously, so many concussions may not be recognized by players, coaches, or athletic trainers. As a result, a large number of concussions are simply unreported, and the true incidence of concussion in sport is likely much higher than current estimates [2,3].

There has been extensive discussion of concussion-related issues in recent sports medicine literature, but the majority of research to date has addressed youth injury and/or post-injury monitoring to determine return to play. There has been research on professional sports as well, especially with boxers and players in the National Football League and National Hockey League, but little attention has been paid to the incidence of and outcomes after concussion in Major League Baseball (MLB).[1,2,9]It has been reported that baseball and softball cause more injuries requiring emergency room attention in the U.S. than any other sport, and may comprise up to 18.5% of all competitive sports-related head injuries [1,10]. Little is known about concussion rates in MLB, as a formal injury surveillance system does not yet exist [11]. Only a handful of studies have been published in which the injury rate in MLB has been attempted to be defined [11,12], and these have addressed total injury rates, not concussions specifically. At the collegiate and high-school level, however, there is reliable data on baseball injuries, including many studies published by the National Collegiate Athletic Association (NCAA) [11,12].

With the longest season of professional sports (162 games over 6 months), MLB players have extended exposure to conditions in which concussions are possible. Sustaining such an injury can have severe short and long-term implications, including both health and career-related sequelae. The purpose of this study is to document the epidemiology of concussions in Major League Baseball and to quantify the impact of these injuries upon player performance. Knowing the incidence of concussion, risk factors specific to MLB players, and expected effects on performance can help coaches and players improve risk management and prevention.

METHODS

In this retrospective study, data on MLB concussions occurring between 2001 and 2010 was gathered from disabled list (DL) records. The DL was readily accessible online, and is the official disabled list of MLB; thus injuries are validated by the league. The inclusion criteria for this study were: 1) MLB players on an active roster and; 2) placement on the DL with a diagnosis of concussion. All MLB teams were included. For each player identified, additional data was gathered from online game summaries and player profiles. This was gathered from official MLB player demographics and statistics available on MLB.com as well as each team's website. Recorded data included: demographics (age, position), injury characteristics (date, mechanism), and time sidelined (in games and in days). In addition, different performance statistics were recorded based on player position (hitter versus pitcher). These included batting

average, slugging percentage, and on-base percentage (OBP). For pitchers, separate values for earned run average (ERA) and walks plus hits per inning pitched (WHIP) were recorded. These outcome measures were chosen because frequently reported outcome measures (visual analogue scale, return-to-work rates, etcetera) are insufficient for elite athletes; performance measures are often more valuable. This data was recorded for a 30-day period prior to injury, to establish each player's baseline level of performance, as well as at 15 and 30-day time periods after return to major league play. This enabled us to determine the effect, if any, that injury had on a player's individual performance. Statistical analysis was performed using two-sided z-test for proportions with a significance level of 0.05. There was no external source of funding for this study.

RESULTS

There were a total of 31 MLB players meeting the inclusion criteria, from a pool of 1200 potential players (30 MLB teams, each with 40-man roster). These were all male players with an average age of 31.2 years (range 23-36) at the time of injury. They had an average career length of 4.5 years prior to injury (range: 1 day - 13 years). Eight total concussions were reported between 2001-2005 and 25 between 2006-2010. Two of these were repeat concussions in previously injured players. With 162 games per year per team, and 30 teams in the league, this produces an approximate per-game incidence of concussion of 0.0003 and 0.001 per team, respectively, for each 5-year interval evaluated in our study (Figure 1). In the high school and collegiate baseball literature, one study reports concussion risk of 0.08 and 0.23 per 1000 athlete-exposures (A-E) during games, respectively [8]. A second study reports an overall injury incidence of 1.26 injuries per 1000 A-E, of which 3.5% were concussions [13]. This study also found no difference in rate of concussion between player positions. not hit by pitch).Of the The exact incidence in Major League Baseball is unknown, and to the best of our knowledge, our study is one of the first to report this.

The highest percentage of injuries in our study was seen in catchers (10 players, 30.3%), with infielders and outfielders a close second (9 and 8 players, respectively). Mechanism of injury varied (Figure 2), but the most common was being hit by a batted ball (9 of 33 injuries, 27.3%), including fielding (tipped off glove,

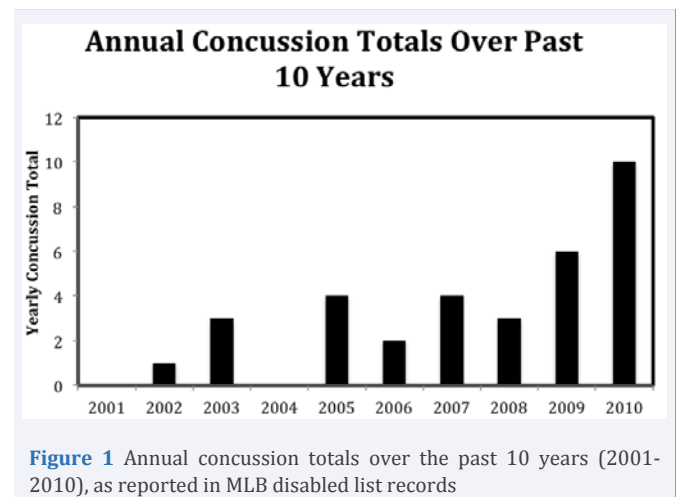


Figure 1 Annual concussion totals over the past 10 years (2001-2010), as reported in MLB disabled list records

bad hop), foul balls and line drives. Being hit by a pitch (24.2%) and fielding collisions (21.2%) were the second and third most common means of injury. In high school and collegiate baseball players, approximately 51% of reported concussions occur in hit-by-pitch incidents [8]. MLB catchers are perhaps at higher risk of concussion due to the nature of their position, but their true exposure to these incidents is unknown. When looking specifically at catchers in our study, they were found to be the cohort with the highest rate of injury, with 9 of 10 players injured during defensive play (i.e. not hit by pitch). Of the 31 patients we studied, there were two players who sustained two concussions.

The total rate of return to play after injury was approximately 88% (29 of 33 injuries; representing 31 players), however, approximately 12% of players never returned to MLB (for reasons that may or may not be related to concussion). Four players were injured near the end of the regular season and were therefore out of commission until the start of the following season. Because their length of disability was extended due to scheduling and not necessarily from medical issues, their data was excluded from analysis so it would not artificially inflate our results. After these four players were removed, the average number of days sidelined was 32.12 days (range 1-124). The average number of games sidelined was 28.6 (range 1-111). By MLB rules during the collection period of this study, once an athlete has been placed on the disabled list he must remain there for at least 15 days not necessarily related to actual injury recovery.

Batting average through the first 15 days (0.237, $p=0.423$) and the first 30 days (0.252, $p=0.970$) after returning from injury were unchanged from the pre-concussion average (0.253). Similarly, on-base percentage through 15 days (0.302, $p=0.237$) and 30 days (0.326, $p=0.996$) was unchanged from pre-injury (0.326). Slugging percentage through the first 15 days back (0.358, $p=0.013$) was significantly decreased from pre-injury (0.412), but not through the first 30 days (0.393, $p=0.290$). (Figure 3)

Earned run average in pitchers through the first 15 days (5.02, $p=0.819$) and the first 30 days (5.78, $p=0.706$) after returning from injury was not significantly different from the pre-concussion average (5.32). Similarly, walks plus hits per innings pitched (WHIP) through the first 15 days (1.40, $p=0.237$) and 30 days (1.57, $p=0.996$) was not significantly different from pre-injury values (1.46) (Figure 4).

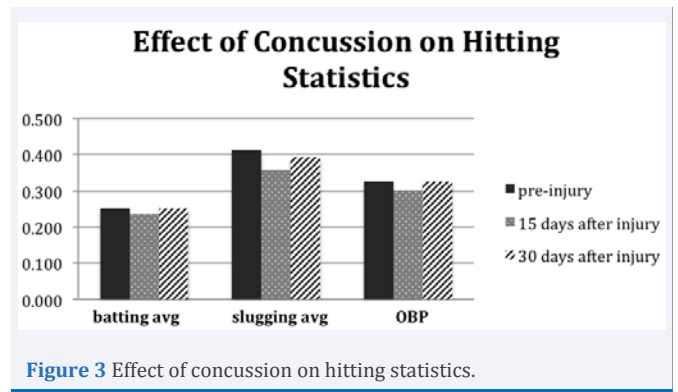


Figure 3 Effect of concussion on hitting statistics.

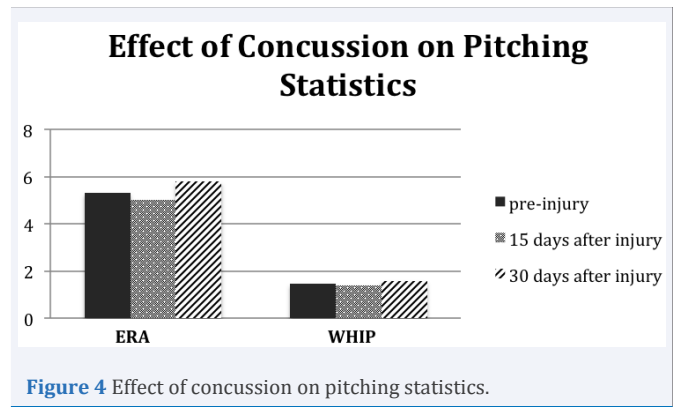


Figure 4 Effect of concussion on pitching statistics.

DISCUSSION

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces [3,14]. It may be caused by either a direct blow to the head, or elsewhere on the body with an impulsive force transmitted proximally [3,9,14,18]. It typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously, and represents a functional rather than a structural injury [6,9,14]. There are a graded set of clinical symptoms, including headaches, dizziness, fatigue, irritability and anxiety, as well as impaired neuropsychological functions such as reduced attention, concentration and memory [3,5,6,9,15,16]. Loss of consciousness may or may not be involved, and there are typically no abnormalities seen on standard structural neuroimaging studies [3,9,14]. Resolution of the clinical and cognitive symptoms typically follows a sequential course. The majority of concussions (80-90%) resolve in a short (7-10 day) period, although the recovery time frame may be longer in children and adolescents [4,5,6,14,16]. In addition, in a small percentage of cases post-concussive symptoms may be prolonged.

In most sports, there has been consensus that a player diagnosed with concussion should not be allowed to return to play on the day of injury [9,14]. The cornerstone of concussion management is physical and cognitive rest until symptoms resolve and then a graded program of exertion prior to medical clearance and return to play [14]. With this stepwise progression, the athlete should generally proceed through the full rehabilitation protocol in 7-10 days [14,16]. This approach

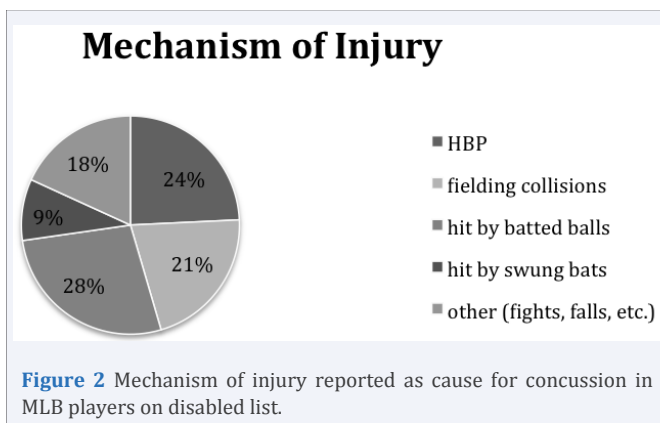


Figure 2 Mechanism of injury reported as cause for concussion in MLB players on disabled list.

is supported by published guidelines, such as the American Academy of Neurology, US Team Physician Consensus Statement, and US National Athletic Trainers Association Position Statement [14]. These short injury durations and patterns of recovery were not reflected in our study, however, as the average length of time sidelined was 32.12 days. Our average period of disability was also higher than that reported recently by Athiviraham et al in which concussions caused by MLB baseball-to-helmet impacts were analyzed [8]. Of 18 players hit in the helmet by a pitch during the 2009-2010 seasons, 9 were diagnosed with concussion. Four of those nine players missed less than 3 days, whereas the other concussed players missed at least 16 days (average = 14.2 days; range 1.6 – 48) [8]. It is worth noting that since both our study and that by Athiviraham et al were conducted, the MLB has created a 7-day disabled list specifically for concussions, to prevent players from returning prematurely [8,17]. Prior to this change, there were no uniform guidelines in MLB for assessment and management of concussed athletes. They were included with the general population of injured athletes, and were sidelined for a mandatory 15 days before return to play. Each individual medical practitioner would have diagnosed and managed their respective team's athletes based on generally accepted standard of care protocols. With the creation of the 7-day DL have also come standardized protocols that are now used throughout the league, which in combination may increase the rate of injury reporting after concussion [8,9].

Of athletes that do return to play, most have good recovery of neurologic function, as measured on standard neuropsychological testing. This cognitive recovery has been shown to occur within 2-10 days after injury [3]. Little has been reported, however, on sports-specific physical performance after return to play. The literature to date on concussion in MLB has reported best-known incidences and to a lesser extent mechanism of injury, but little to nothing has been reported on post-injury player performance [2,8,9]. Our paper is unique in that we attempted to define a relationship between changes in post-injury performance and the presence of concussion, if any existed. Although players may appear to be fully recovered with respect to attention, memory, and basic motor functions, as assessed by their team physician, the affect that concussion may have had on sports-specific skills like batting and pitching, is not well known. In this study we found no difference in batting average, on-base percentage, ERA, or WHIP when compared to pre-injury values. The only significant finding in post-concussive performance was in slugging percentage, which decreased through the first 15 days back from injury, but had returned to normal by 30 days. Admittedly, caution must be used when interpreting data trends that do not achieve statistical significance; nonetheless, the fact that each statistic evaluated decreased from baseline over the first 15 days of return then normalized by day 30 should raise some concerns and encourage further research on the subject. A larger sample size with a comparative cohort is needed to clarify this relationship. Fortunately, based on our data, continued disability or deficits in performance are not likely after a single concussive event and 88% of players can expect to make a full return to play.

Although the majority of players return to play at full function after a short period of rest, some studies have suggested that

post-concussive symptoms may persist as long as 1 year post-injury [9]. There have also been reported long-term physical, psychological and cognitive difficulties in a small percentage of patients [3,5,6,9,18]. Mental health issues such as depression have been reported as long-term consequences of mild traumatic brain injury (mTBI), including sports-related concussion [14]. Epidemiological studies have suggested an association between repeated sports concussions during a career and late life cognitive impairment [18]. Similarly, case reports have noted anecdotal cases where neuropathological evidence of chronic traumatic encephalopathy was observed in retired athletes [14,18]. This study is unable to report on long-term effects of concussion in our players, as this study only looked at a 1-month window before and after injury and cannot provide additional explanation regarding the 12% of athletes that failed to return to play. Long-term follow-up is needed to assess whether players have any chronic health-related issues as a result of sports-related head injury.

While this study presents new findings to the literature including the mechanism of concussive injury in MLB and the fact that catchers are at particular risk, we must acknowledge design limitations and the potential influence of other confounding factors. One potential critique of this study is the data source. The data we gathered was obtained from publicly available MLB disabled lists and not from direct review of medical records. The potential of selective reporting by teams must be considered, as they may not choose to report an injury, or may use placement on the disabled list for political and not medical reasons. We chose to review disabled list records because they represent injuries determined severe enough to remove a player from competition for at least 15 days. In addition, players are not removed from play until they have been evaluated by a trained physician. Based on this, we felt this method of review was reliable. In addition, this method of review was used in a recent study by Athiviraham et al. [1], who used publicly available information, videos from MLB, and pitch speed data from PITCHf/x (online database in which speeds of all pitches thrown in MLB can be accessed) to analyze results of baseball-to-helmet incidents and rates of concussion during the 2009-2010 MLB seasons [1]. In addition, this method of data collection has been used in several prior studies, in which publicly available MLB disabled list records were used to quantify a total injury rate across several seasons [11,12] as well that of specific injuries [19]. Our study, however, is the perhaps the first to attempt to quantify total rates of concussion in MLB.

The second potential critique of the data in this study is the influence that non-medical factors could have had on player return to play. Managerial decisions, competing player performance, rotation schedule, contract stipulations, and personal reasons for retirement could all influence a player's return to play. Based on this, we carefully restricted our conclusions to be based on the performance of athletes that returned to play rather than the 12% that did not return to play. The failure to return might be due to a more severe concussion, multiple concussions, or any one of these non-medical factors.

CONCLUSION

While respecting the limitations of small sample size, the potential of reporting error, as well as other confounding

variables, we believe our study raises several important points. There was a per-game incidence of concussion leading to placement on the disabled list of 0.001 per team over the past 5 years. This is lower than the reported rates of concussion in high school and collegiate baseball; however, the true incidence of concussion in Major League Baseball is unknown and may be minimized by data collected only from the disabled list. Catchers were at particularly high risk, representing a third of injured players, a finding reported in previous literature, but not quantified by statistical data until our study. The most common mechanisms were injury while fielding (by a ball or collision with another player) or being hit by a pitch while batting. Once placed on the disabled list for a concussion, most players returned to play at an average of 30 days. There was a relatively high rate (12%) of never returning from this injury though, for reasons that are not well known. Of additional concern is the possible transient impact on performance amongst those that return to play, although in our study only a decrease in slugging percentage at 15 days achieved statistical significance. Based on literature from other sports, possible late-onset cognitive impairment could be expected in a small percentage of players. Long-term studies in Major League Baseball players are needed before definitive conclusions can be made, and is an area of possible future research.

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