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The epidemiology of single season musculoskeletal injuries in professional baseball

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Abstract

The aim of this descriptive epidemiology study was to evaluate the injury incidence, pattern and type as a function of position in one professional baseball organization for one complete season. The study was carried out in a major academic center. Participants were all major/minor league baseball players playing for one professional organization. The disabled/injury list of one single professional baseball organization (major and minor league players) was reviewed for all of the injuries and the number of total days missed secondary to each injury. All injuries were categorized into major anatomic zones that included: shoulder, elbow, wrist/hand, back, abdomen/groin, hip, knee, and ankle/foot. The data was further stratified based on the injury type and the number of days missed due to that particular injury and a statistical analysis was performed. In pitchers, elbow injuries (n=12) resulted in 466 days missed. In catchers, wrist injuries (n=4) resulted in 89 days missed. In position players, abdominal/groin injuries (n=16) resulted in 318 days missed and shoulder injuries (n=9) resulted in 527 days missed. Overall, 134 players were injured and a total of 3209 days were missed. Pitchers had 27 times and 34 times the rate of days missed due to elbow injuries compared to position players and all players, respectively. Abdominal and groin injuries caused the pitchers to have 5.6 times and 6.4 times the rate of days missed than the position and all players, respectively. Both elbow and abdominal/groin injuries are the most disabling injury pattern seen in pitchers. Among the position players, shoulder injuries resulted in the most days missed and knee injuries resulted in the highest rate of days missed in both pitchers and catchers.

Introduction

The first game of organized baseball was played on 19th June 1846, at the Hoboken ground, New Jersey. Since that day, it has become a popular sport for people of all ages in the United States and has been appropriately dubbed as the national pastime. The United States Consumer Product Safety Commission (CPSC) estimates that 6 million children play in organized baseball leagues and up to 13 million more play non-organized baseball each year.¹ McFarland *et al.*² estimates that there are 21,747 baseball players at college level made up of 276 Division I, 194 Division II, and 283 Division III programs. By 2003-2004, the number of NCAA university baseball teams has increased to 867 involving 27,262 participants in all three divisions.³ At the professional level, Conte *et al.*⁴ reports approximately 750 major league players and 2100 minor leaguers. Baseball-related injuries are commonly seen across the country, from emergency rooms to the training room tables of the professional clubhouse. Although a considerable amount of research has been devoted to the study of the biomechanics and the treatment of baseball-related injuries,⁵⁻⁸ there are surprisingly little data to describe the epidemiology of Major League Baseball (MLB) injuries. Posner *et al.*⁹ analyzed the publically available internet MLB disabled list data from 2002 through 2008. Only major league players that were placed on the disabled list (over 15 days missed) were included in their study, and injuries were categorized by anatomic zones and divided on a monthly basis. The author found that upper body injuries were predominantly associated with pitchers while lower body injuries were more common in position players, and injuries were more likely to occur at the beginning of the season. Conte *et al.*¹ studied a MLB disability list of 11 years from 1989-1999 and raised appropriate concerns that injury rates on the field have not decreased despite vast improvements in training and conditioning, diagnostic methods, and surgical treatment over the study period.

Although there are two studies describing baseball injury patterns for major league players who were placed on the disabled list, we have not been able to find any report describing the injury patterns of both major and minor league players of one professional organization and the associated days missed due to the particular injury from both the injury (<15 days missed) and disabled list (>15 days missed) for one single complete season. Given the paucity of epidemiology data on MLB injuries in the literature, the purpose of this study was to prospectively evaluate the injury incidence, pattern and type as a function of position with associated days missed in one professional baseball organization (major and

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minor league players) for one complete season. Furthermore, a rate ratio (RR) analysis was performed on the data comparing the rate of days missed due to a particular injury per season according to baseball position for each injury anatomic zone. Our hypothesis is that certain injury patterns/zones, *i.e.* elbow injuries in pitchers or hip/groin injuries in the position players, will result in a significantly higher rate of days missed.

Materials and Methods

We analyzed the disabled and injury list of one single professional baseball organization for the entire season of 2010 to 2011. This included players of both the major and all associated minor league organizations. The minor league organizations were composed of players from the rookie ball, A, AA, and AAA leagues (total of 7 different teams). We reviewed all of the injuries and the number of total days missed secondary to each injury. The data consisted of the player's name, team, position, type of injury, numbers of games played, and total number of

days missed due to the particular injury. All musculoskeletal injuries were included within this report; however, we did not include any injury days missed due to lacerations or medically-related issues. Some players may have had the same injury that occurred on multiple occasions during the season that resulted in days missed. Although the injuries are the same, we recorded each incidence separately; we also calculated the number of days missed separately. All of the players who had recurring injuries to the same anatomic zone of the body were reported according to positions.

All of the injuries were categorized into major anatomic zones that included: shoulder, elbow, wrist (hand), back, abdomen/groin, hip, knee, and ankle (foot). The data were further stratified based on the injury type and the number of days missed due to that particular injury. All musculoskeletal injuries reported on the official team injury documents and the disabled list were included in this study whether the player missed days or not. The difference between the injury list and the disabled list is that players who missed more than 15 days and cannot return to the active roster were put on the disabled list, whereas players that missed less than 15 days were placed on the injury list. We reviewed all of the injuries and days missed of all players in one professional organization. Players were then organized according to position: pitchers, catchers, and position players which included all infield and outfield players.

Statistical analysis

Descriptive analysis of the player population was calculated in terms of means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Group differences among continuous variables were evaluated using independent sample t-tests or one-way analysis of variance (ANOVA) for multiple groups.

Additional analysis performed for this study was a RR analysis with 95% confidence intervals (CI) comparing the rate of days missed due to injury per season by baseball position for each injury location. Rate was defined as the number of games missed divided by the total person-time at risk (athlete exposure). Athlete exposure in this study was defined as a game competition. Since we captured data for a single professional baseball season (162 games), we defined our ratio as the ratio of injuries per games in one season.

Initial comparisons of rate of days missed were made for pitchers and catchers against a reference category of position players (Figure 1). To ascertain the rate for all positions, rate ratio calculations were made for each position compared to a reference group of all other positions (Figure 2). Analyses were completed for both overall injuries as well as stratified by injury site. Statistical

significance was set to alpha equal to 0.05 with SPSS version 19.0 (SAS) used as the statistical software package for this study.

Results

During the 2010-2011 season, we followed a total of 291 professional baseball players in one

organization. This included 127 pitchers, 31 catchers, and 133 position players (infield and outfield players). A total number of 134 players were injured during this time period due to a number of injury zones including: shoulder, elbow, wrist/hand, abdomen/groin, hip, knee, and ankle/foot (Table 1). These 134 players missed a total of 3209 days during the season.

Pitchers most commonly sustained shoulder and elbow injuries. A total of 885 days of the sea-

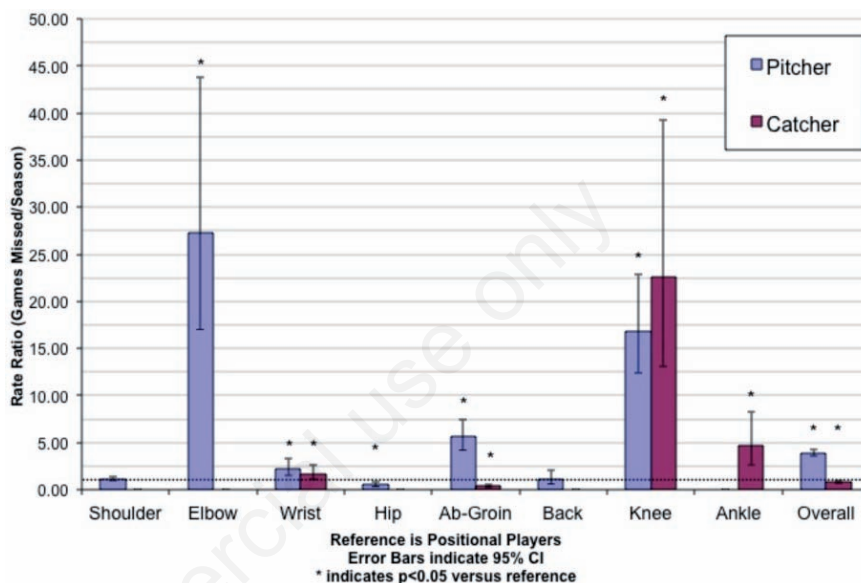


Figure 1. Comparison of the rate ratio analysis of the rate of days missed due to injury for pitchers and catchers against a reference category of position players. Error bars indicate 95% confidence interval. *P<0.05.

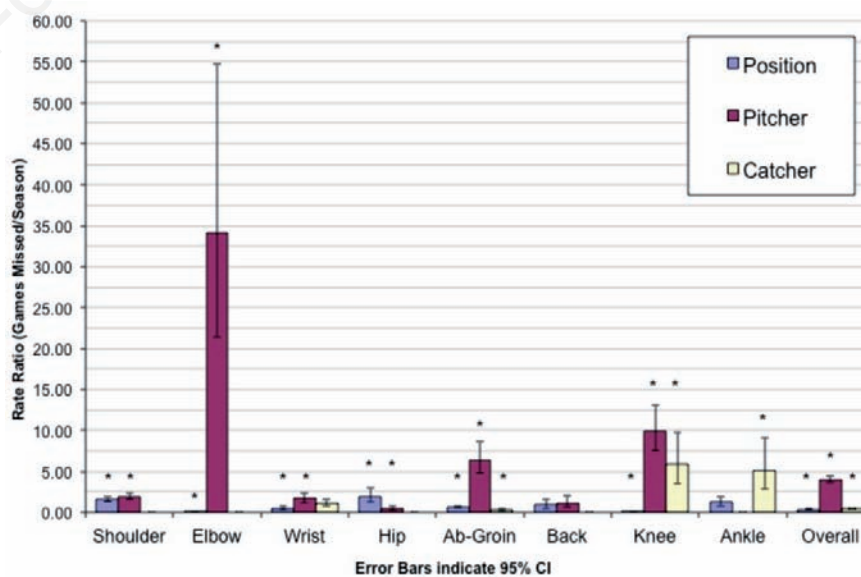


Figure 2. Comparison of the rate ratio analysis of the rate of days missed due to injury for all positions with a rate ratio analysis made for each position compared to a reference group of all other positions. Error bars indicate 95% confidence interval. *P<0.05.

son were missed due to 12 players with shoulder injuries and 12 players with elbow injuries, respectively. Pitchers were least affected by ankle injuries. Only 2 players had ankle injuries and no days were missed. Furthermore, the data indicate that pitchers tend to have concomitant shoulder injuries, as we would expect given the biomechanics of the overhead-throwing athletes. Hip and knee injuries were also quite common among pitchers, with 5 and 8 injured players, respectively. On average, elbow and knee injuries kept the pitchers out of competition the longest, as elbow injuries cost an average of 38.8 days missed *versus* 37.1 missed days for knee injuries, respectively. Looking at specific shoulder injuries, our data show that one pitcher sustained subscapularis strain/SLAP repair and missed 157 days, the longest of all shoulder injuries. Two had diagnosis of biceps tendinitis and missed a total of 86 days. For elbow injuries, UCL rupture/tear, and flexor muscle strain kept the injured pitchers sidelined the longest: 275 and 128 days, respectively. One player sustained hook of hamate fracture and missed 55 days. One pitcher missed 169 days for ACL/medial meniscal repair and another missed 83 days for medial meniscal repair.

Catchers were most commonly affected by shoulder, elbow and wrist injuries with 4 players affected in each injury category. The catcher position was least affected by ankle injuries as only one player was injured. Not only are wrist injuries common among catchers, it also appears to be costly. Four catchers missed a total of 89 days, averaging 22.3 days per injury, one of the highest days missed per injury in the catcher position. Interestingly, despite 4 catchers sustaining shoulder injuries, no days were missed. Furthermore, one catcher sustained a 1st degree elbow UCL strain and missed 19 days, and another missed 69 days

for hook of hamate removal. According to our data for lower body injuries for catchers, there was one recorded hamstring strain that sidelined the player for 20 days, one medial meniscal repair missed 60 days, and one ankle sprain missed 30 days. Overall, hamstring and internal oblique strain were the most costly hip injuries for catchers.

A total of 63 position players were injured during the season and missed a total of 1548 days, which is an average of 24.5 days per player. Abdominal/groin injuries were the most common injured anatomic zone for position players. A total of 16 players were injured and those players missed 318 days. Shoulder, elbow and ankle injuries were equally as common, but shoulder injuries were most costly since 9 players missed a total of 527 days, an average of 58.6 days per injured player, which is the highest among position player injuries. Position players were least likely to have elbow injuries since 2 players missed a total of one day. According to our study, position players also tend to have ankle/foot related injuries: 10 players missed a total of 296 days. Looking at the specific shoulder injuries, long head of biceps tendinitis resulted in 243 days missed, and shoulder SLAP/biceps tendon instability resulted in 88 days missed. Wrist injuries include wrist hyperextension that resulted in 26 days missed and scaphoid contusion that resulted in 24 days missed. For specific abdominal/groin injuries, 10 players had hamstring strain that resulted in 175 days missed. Two cases of hip labral tear resulted in 118 days missed. Lumbar muscle, oblique muscle and parathoracic muscle strain were also observed amongst the position players. One case of knee PCL/MCL/meniscus injury sidelined the player for 64 days. Two ankle fractures in position players were recorded that resulted in 287 days missed.

Overall, pitchers had 27 times and 34 times the rate of days missed due to elbow injuries compared to position players and all players, respectively (Figures 1 and 2). Abdominal and groin injuries caused the pitchers to have 5.6 times and 6.4 times the rate of days missed than the position and all players, respectively. Pitchers and catchers had 16.8 times and 22.6 times the rate of days missed due to knee injuries compared to the position players, respectively. Abdominal/groin injuries resulted in the most number of recurrences (n=5) in position players (Table 2).

Discussion

Despite the large number of participating athletes, not much attention has been given to the epidemiology of MLB injuries in the scientific literature. Previous work in this area used disabled lists to report the incidence of injuries and patterns over time. Both Conte *et al.*⁴ and Posner *et al.*⁹ found that MLB injuries increased over the study period. No clear reason for the rising trend in injuries has been identified, but it is an obvious cause for concern for everyone involved in the sport, as well as for the medical personnel taking care of these injured players. In this study, official team injury documents along with the disabled list were used to examine the incidence of injuries during a single MLB season in one professional organization. Our results corroborate with previous reports that the majority of injuries in MLB occur in the upper body. Conte *et al.*⁴ and Posner *et al.*⁹ found the upper body injury rate in professional baseball to be 49% and 51%, respectively. Similarly, 47% of all injuries in our study were in the upper body.

Table 1. Single season injuries of professional baseball players grouped according to positions, types of injury, total number days missed and the average days missed per injury.

Anatomic zone	Pitchers			Catchers			Position players			All players		
	Total injured pitchers	Total days missed	Days missed per injured player	Total injured catchers	Total days missed	Days missed per injured player	Total injured position players	Total days missed	Days missed per injured player	Total injured players	Total days missed	Days missed per injured player
Shoulder	12	419	35	4	0	0	9	527	59	25	946	38
Elbow	12	466	39	4	19	5	2	1	0.5	18	486	27
Wrist	6	107	18	4	89	22	7	75	11	17	271	16
Back	3	14	5	0	0	0	8	119	15	11	113	10
Abdominal /groin	5	122	24	3	31	10	16	318	20	24	471	20
Hip	5	27	5	0	0	0	2	132	66	7	159	23
Knee	8	297	37	2	60	30	9	80	9	19	437	23
Ankle/foot	2	0	0	1	30	30	10	296	30	13	326	25
Total	53	1452	27	18	229	13	63	1548	25	134	3209	24

Shoulder injuries accounted for significantly more time on the injury/disabled list for players in our study. Pitchers were more likely to miss playing days due to elbow and wrist injuries. Interestingly, data collected from another sport, cricket, which also involves overhead throwing athletes, found phalanges and lumbar injuries were the most common injuries amongst players.¹⁰ However, shoulder injuries are also believed to be more prevalent in cricket, with an estimated rate of approximately 23%.¹¹ In our study, a total of 946 days were missed in the 25 players with shoulder injuries, that is 18% of the total injured players who missed 29.4% of all the injured days. Furthermore, Kelly *et al.*¹² found the prevalence of shoulder injuries in NFL quarterbacks to be 15.2% with overuse injuries accounting for 14% of them, the most common being rotator cuff tendinitis (6.1%) followed by biceps tendinitis (3.5%). Biomechanics of overhead throwing motion, as well as the strenuous training and season schedule, certainly place baseball pitchers at a greater risk of upper body injuries that is unparalleled in other sports.⁵⁻⁸ As reported by Kelly *et al.*,¹² when compared to quarterbacks, pitchers produce greater forces and torques in the shoulder and elbow during arm deceleration, and higher angular velocities throughout the pitching motion. Shoulder internal rotation velocities are between 3 and 4.5 times faster during the baseball throwing motion, and elbow extension velocities are between 2 and 3 times faster during the throwing motion. Furthermore, baseball-throwing motion has a significantly higher activation of the accelerator muscles (subscapularis, latissimus dorsi, and pectoralis major) compared to football throwing motion. All of the above factors can contribute to the significant disability associated with shoulder injuries seen in professional baseball pitchers.

Posner *et al.*⁹ found lower body injuries accounted for approximately 30% of all injuries amongst baseball players. McFarland *et al.*² also reported lower body injury to account for 27% of

all reported injuries. Our data found the overall lower body injury rate to be 50%. Furthermore, position players are more likely to sustain abdominal/groin and knee injuries compared to pitchers. Feeley *et al.*¹³ studied hip injuries in NFL players and found muscle strain to be the most common injury pattern followed by hip contusion. While hip contusion does not frequently occur in baseball, muscle strain and hip labral tear certainly led to a considerable number of injury days for position players. Interestingly, Arnason *et al.*¹⁴ found that a history of groin strains or limitation of abduction led to a higher rate of hip muscle strains in professional soccer players. Feeley *et al.*¹³ suggested that programs that identify those players at risk for hip strains may be beneficial to identify NFL players and treat them with a dedicated hip strengthening and stretching program in the pre-season period. This program could certainly be applied to MLB players also for the prevention of abdominal/groin injuries. In our study, we found abdominal and groin injuries resulted in pitchers having 5.6 times and 6.4 times the rate of days missed when compared to position and all players, respectively. Furthermore, our data led to conclusions similar to those of Conte *et al.*⁴ who found the average number of days missed due to abdominal injuries by pitchers was higher than that for position players: 35.4 *versus* 26.7 days. It is interesting to note that Conte *et al.*⁴ found that injuries to abdominal muscle in the majority of pitchers were contralateral to their dominant pitching arm, and for position players, the majority of the abdominal injuries were contralateral to their dominant batting side (excluding switch hitters).

Our study also shows that pitchers have a higher rate of days missed due to upper body injuries (especially elbow injuries) compared to position players while position players and catchers are found to have a higher rate of days missed due to lower body injuries (especially knee injuries) compared to pitchers. This is certainly not surprising. With the advancement in sports medicine and rehabilitation, and the focus on physical fitness, ath-

letes today are stronger and faster than ever before. Studies have shown that higher pitch count in a pitcher can lower future performance levels, with each pitch averaged in the preceding 5 and 10 games increasing the ERA by 0.014 and 0.022, respectively.¹⁵ However, no studies have found a correlation between pitch count and risk of future injuries. The disadvantages of different types of pitches, such as fastball *versus* curveball, have also been extensively studied but no general consensus regarding the possible association between pitch count and future injuries has been reached. Nissen *et al.*¹⁶ suggested that the rising incidence of shoulder and elbow injuries in pitchers may be related to the increased movement of the shoulder and elbow joint observed in the fastball pitch when compared to the curveball. The observed injury patterns in baseball are multifactorial and future research that compares the incidence of injuries and the player's physical activity workload, such as pitch count or number of games played, could help determine a *cause and effect* relationship between increased pitch count and upper body injuries in baseball pitchers.

A major strength of this study is that information was taken directly from the extensive official records of a single MLB organization that included both the injured list and the disabled list. This is the only study to date that has not relied exclusively on disabled list reports for epidemiological data. Other studies calculated the incidence of baseball injuries from publicly available internet data. However, many injuries that occur in professional baseball are recorded on the injury list and not just on the disabled list. Therefore, results that use only the disabled list can be biased toward the more severe injuries, neglecting those less severe that still, however, affect the player's ability to perform at a high level. Furthermore, decisions to place a player on the disabled list might be based on non-medical factors in order to maximize the chances of having the best available players on the active roster at any given time.¹ This can further bias the previous studies reporting on the injury pattern of professional baseball players. Our reported injury pattern was obtained from the entire MLB organizational injury report list that was made up of both the injury list and the disabled list. Another major strength is that the calculations for this study also accounted for all the minor league players and their injury patterns providing a true description of the overall incidence of injuries and patterns in one season for one professional baseball organization.

This study has several limitations. First, the timing of the injury during the season was not reported. It is unknown whether the injury occurred during the pre-season period, early in the season, or late in the season. Such data would be useful to determine whether overuse

Table 2. Professional baseball players with multiple recurring injuries in the same body category according to positions.

Anatomic zone	Pitchers	Catchers	Position players	Total
Shoulder	4	0	1	5
Elbow	1	0	0	1
Wrist	0	0	0	0
Back	1	0	2	3
Abdominal/groin	0	2	5	7
Hip	1	0	2	3
Knee	1	0	0	1
Ankle/foot	1	0	0	1

and deconditioning could be the cause of some injuries. Second, while these data certainly give a panoramic view of injuries sustained in a single MLB team, the number of players injured is limited. It is, therefore, difficult to draw conclusions as to patterns of injuries sustained during the season and to apply these data to other teams or to the entire major league baseball. Third, data from prior epidemiology studies covered more than one season while our study was limited to one baseball season that included spring training. Therefore, injury patterns revealed by our data are certainly not representative of the overall injury pattern in the entire league or any other season.

Conclusions

This is the first study to examine the incidence rates and injury patterns during one season of a single MLB organization. Both elbow and abdominal/groin injuries are the most disabling injury pattern seen in pitchers. In the position players, shoulder injuries resulted in the most days missed. Knee injuries resulted in the highest rate of days missed in both pitchers and catchers. Although abdominal and groin injuries are more common in position players, these injuries resulted in the highest rate of days missed in pitchers. Collecting and analyzing data on the epidemiology of injuries in professional baseball is the first step in their ultimate prevention. More work on training regimens could help identify strategies for increas-

ing player conditioning and reducing the overall incidence of injuries.

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