

Implications of Core and Hip Injuries on Major League Baseball Pitchers on the Disabled List

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Purpose: To investigate the frequency of core and hip injuries in Major League Baseball (MLB) pitchers and their impact on performance, workload, and pitch type. **Methods:** Demographic, performance data, and injury data were acquired for 330 MLB pitchers with 454 injuries placed on the disabled list (DL) from 2014 to 2015 seasons. Core and hip/groin injuries were analyzed in which injury year data were compared with career data and against other injury groups. **Results:** Core injuries represented 14% of all injuries and hip/groin injuries represented 7%. Average days on the DL for core injuries were 47.0 (standard deviation 5.6) days and 37.7 (standard deviation 8.1) days for hip/groin injuries. Return from the DL the same season for core injuries was 78% and 73% for hip/groin injuries. Core injuries returned to the DL 46% of the time (73% for noncore injuries) and hip/groin returned 56% of the time (60% for nonhip/groin injuries). No changes in workload were noted except starters with core injuries pitched less innings/game (5.3 vs 4.9 innings/game, $P = .031$) and more pitches/game (85.5 vs 78.4 pitches, $P = .026$). Fastball velocity decreased in the core injury group the year of injury (91.6 vs 92.2 mph, $P = .001$). Core injuries had slightly fewer home runs/9 innings and fewer strikeouts/9 innings; hip/groin injuries had slightly more strikeouts/9 innings, with all other performance statistics no different between the groups including earned run average and wins above replacement. **Conclusions:** Core and hip injuries in MLB pitchers result in similar time on the DL compared with other injuries. Pitching workload during the year of injury does not seem to have a significant impact on sustaining a core or hip injury. Although there is a high rate of return to play from the DL, there is a high rate of reinjury in these pitchers more often for other injuries. **Level of Evidence:** Level III, retrospective comparative study.

Injuries can have a devastating impact on the career of a baseball pitcher as well as overall team success.¹ Major League Baseball (MLB) pitchers are particularly predisposed to injury due to the higher rate of throwing shoulder and elbow injuries. Professional pitchers have been exposed to increasing pitch counts, pitch types, and velocities at a younger age and throughout their career, which further increases their overall injury rate, caused by overuse.²⁻⁴ Moreover, pitchers also have a significantly increased rate of core body injuries when

compared with other position players.⁵⁻⁷ Pitchers with core and hip/groin injuries have been shown to have over 5 times the rate of days missed compared with other position players.⁵

Traditional overuse injuries of the shoulder and elbow in the pitching athlete have been well characterized; however, core and hip injuries in these athletes are largely understudied. Core and hip injuries can have a significant impact on both the frequency and duration of injury, especially as it pertains to time on the disabled list (DL).⁸ These injuries may also have an effect on other injuries due to their contribution in the overall pitching motion. The importance of core strength as it relates to overall pitching mechanics has previously been shown; as core and leg musculature fatigue, significant kinematic changes in the upper extremity are observed.⁹ Previous studies have also shown changes in hip biomechanics that can contribute to injury. These studies showed decreases in hip internal rotation and total hip motion resulted in an increased risk of hip and groin injuries.⁴ As these injuries become more prevalent, it has also been shown that there is a relatively high rate of reinjury and

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pitchers with these injuries require an extra 10 days on the DL compared with position players.¹⁰

The purpose of our study was to investigate the frequency of core and hip injuries in MLB pitchers and their impact on performance, workload, and pitch type. Our hypothesis was that core and hip injuries in MLB pitchers could lead to extended time on the DL and would be associated with increased pitching workload and might be the result of increased pitch velocity.

Methods

This study is a retrospective review of all MLB pitchers who were placed on the DL for the 2014 and 2015 season (April-October per respective season). A total of 454 observations from 330 pitchers were identified who required time on the DL due to injury. All of these pitchers played in MLB and no minor league data were used. All pitchers identified had available MLB data and DL data and therefore none were excluded. The pitchers on the DL were identified using methods similar to previous studies.¹¹⁻¹⁵ Our main source was www.baseballheatmap.com that listed each player on the DL. This was then cross-referenced with team websites, press releases indicating players placed on the DL, personal websites, and baseball statistical websites, including baseballreference.com and fangraphs.com. To verify each pitcher's date of injury, we cross-referenced each player's reported disabled date with a gap in pitching statistics. Injuries were then categorized into upper body injuries, lower body injuries, hip/groin injuries, core injuries, and other. Specific injury diagnosis and pitchers requiring surgery were noted. The start date as well as end date of DL was collected and then total days on the DL were determined. Only total days on the DL were calculated, and games missed or starts missed during the time on the DL or any games missed before being placed on the DL were not collected.

Demographic data for each pitcher were collected including age at time of injury, throwing arm, position (starter or reliever), and career length at the time of injury. Injury was determined as ipsilateral to the throwing arm or contralateral to the throwing arm, for example, a right hip injury would be ipsilateral if the throwing arm was the right arm. Workload data, including games played, innings pitched (IP), and pitches, were collected for the year of injury as well as overall career, excluding year of injury, to give a reference of the pitcher's established workload. Performance and statistical data were also collected including walks/9 innings, earned run average, home runs/9 innings, strike-outs/9 innings (K/9), wins above replacement, fastball velocity, fastball percentage, and curveball percentage. Data were then compared for each injury group (core and hip/groin) against all other injuries the year of injury. Data were also compared within each injury group (core and hip/

groin), comparing workload, pitch type, and fastball velocity the year of injury in each group with the same group's career statistics to evaluate for any changes in that specific group the year of injury compared with career established statistics.

Our evaluation of pitches was limited to fastball and curveballs due to the fact that they represent the greatest number of pitch type thrown and we felt that curveballs were a good surrogate for off speed pitches. Pitch velocity was an average velocity of pitches thrown during that period and was not calculated on a pitch-by-pitch basis. Data for pitching style (windup, from the stretch, sidearm, etc.) were not available in our database.

Statistics

All continuous data were described using means and standard deviations (SDs), whereas all categorical data were described using counts and percentages. For players who were injured repeatedly and appeared multiple times, repeated-measures mixed models were used to account for the lack of independence. In these cases, adjusted means and standard errors (SEs) were used to describe continuous data, and odds ratios with 95% confidence intervals were used to describe categorical data. All *P* values were adjusted using the Benjamini-Hochberg method to control the type I error rate caused by multiple pairwise comparisons. *P* values were considered statistically significant if they were less than .05. All analyses are performed using SAS 9.4 (SAS Institute, Cary, NC).

Results

A total of 330 MLB pitchers with 454 injuries were identified who had an injury during the 2014 or 2015 seasons (April-October per respective season) who required time on the DL. The average age of injury for all pitchers was 28.9 (SD 4.1) years. Average number of years in MLB before injury was 5.4 (SD 0.2) years. All pitchers spent an average of 53.7 (SD 44.3) days on the DL, and 72% (329/454) of all of pitchers were able to return in the same season after being on the DL.

Core and hip/groin injuries represented 21% of all injuries (core: 63/454, 14%; hip/groin: 30/454, 7%) (Table 1). Most core injuries occurred at beginning of season in April and end of season in August (March/April 19/63, May 10/63, June 6/63, July 9/63, August 16/63, September 3/63). Most hip/groin injuries occurred at beginning of season in April (March/April 9/30, May 4/30, June 6/30, July 3/30, August 5/30, September 3/30). Core injuries were diagnosed as back spasms, stiffness, or strain in 32 of 63 of the injuries and oblique, abdominal, or intercostal strain in 30 of 63. Hip/groin injuries were diagnosed as groin strains in 24 of 30 and hip inflammation or impingement in 6 of 30. Three pitchers in the core group required surgery

Table 1. Descriptive Statistics for Pitchers on the Disabled List

	Overall (n = 454), Avg, (SD)	Core (n = 63), Avg, (SD)	Hip/Groin (n = 30), Avg, (SD)	P Value
Starters	221	37	16	
Relievers	233	26	14	
Age at injury (yr)				
All	28.9 (4.1)	28.5 (0.2)	30.0 (0.7)	.903
Starting	28.3 (3.7)	27.7 (0.6)	30.8 (0.9)	.903
Relief	29.4 (4.3)	29.6 (0.8)	29.0 (1.1)	.903
Years in MLB before injury (yr)	5.4 (0.2)	4.8 (0.5)	5.1 (0.7)	.987
Return to play during the same season	72% (329)	77.8% (49)	73.3% (21)	.921
Time on DL (d)				
All	53.7 (44.3)	47.0 (5.6)	37.7 (8.1)	.215
Starting	53.6 (46.5)	48.1 (6.9)	35.4 (10.4)	.387
Relief	53.8 (41.8)	45.5 (9.1)	40.3 (12.5)	.378
Injury ipsilateral to throwing arm	77% (327)	33% (21)	57% (17)	<.001
Return to DL	78/283 (28%)	27/59 (46%)	15/27 (56%)	<.05

DL, disabled list; MLB, Major League Baseball; SD, standard deviation.

averaging 81 days on the DL. Two players in the hip/groin group required surgery averaging 164 days on the DL. Core injury pitchers were an average age of 28.5 (SE 0.51) years old with an average time in MLB of 4.8 (SE 0.51) years, which was no different from other injuries ($P = .90$ and $P = .26$, respectively). Pitchers with hip/groin injuries were an average age of 30.0 (SE 0.74) years ($P = .91$) and played an average of 5.1 (SE 0.74) years in MLB before injury ($P = .76$), also no different from other injuries. Fifty-seven percent (17/30) of hip/groin and 33% (21/63) of core injuries were on the ipsilateral side of the throwing arm.

Fifty-three percent (16/30) of hip/groin injuries and 57% (36/63) of core injuries occurred in starting pitchers. Of the pitchers with core injuries, 79% (50/63) were able to return from the DL in the same season. Pitchers with hip/groin injuries were able to return 73% (22/30) of the time. Core injury pitchers spent an average of 47.0 days (SE 5.6) on the DL and hip/groin injury pitchers spent 37.7 days (SE 8.1), both no different from other injuries ($P = .215$ and $P = .07$, respectively) (Table 1).

Pitchers with core injuries had a reinjury requiring time on the DL in 27 pitchers (27/59, 46%), with 4 (6%) returning for core injuries, 3 (5%) for hip/groin injuries, and 20 (32%) for any other injury (20/27, 74% of reinjured pitchers). Three pitchers also returned a third time to the DL for another injury. Evaluation of injuries in 2016 found that 6 of 34 returned to the DL for another core injury from the year prior and 7 of 34 for all other injuries. Pitchers with hip/groin injuries had a reinjury requiring time on the DL in 15 pitchers (15/27, 56%), with 3 (10%) returning for hip/groin injuries, 3 (10%) for core injury, and 9 (30%) for all other injuries (9/15, 60% of reinjured pitchers). One pitcher also returned a third time to the DL for another injury. Evaluation of injuries in 2016 found that 3 of 17 returned to the DL for another hip/groin injury from the year prior and 2 of 17 for all other injuries. In

comparison, all other pitcher injuries had overall 28% (78/283) return to the DL (Table 1).

Core injury starters pitched fewer innings/game (4.9 vs 5.3, $P = .031$), and threw more pitches/game (85.5 vs 78.4, $P = .026$) the year of injury compared with throughout their career. However, no other changes in workload were noted. Pitchers with core injuries had a significant decrease in fastball velocity the year of injury compared with overall career (91.6 vs 92.2 mph, $P = .001$), with starters showing a decrease (91.3 vs 91.9 mph, $P = .001$) and no change in relief pitchers. There

Table 2. Core Injury Workload, Pitch Type in Starters and Relievers

	Year of Injury Mean (SD)	Career Mean (SD)	P Value
Games played			
Starters	18.3 (9.9)	123.3 (103.3)	
Relievers	24.7 (16.8)	158.7 (124.7)	
Innings pitched/game			
Starters	4.9 (1.2)	5.3 (0.8)	.031
Relievers	1.2 (0.9)	1.4 (0.8)	.132
Pitches/game			
Starters	85.5 (13.9)	78.4 (18.7)	.026
Relievers	19.0 (14.7)	22.7 (13.4)	.135
Pitches/innings pitched			
Starters	16.2 (2.3)	16.1 (1.0)	.304
Relievers	16.3 (3.0)	16.3 (0.9)	.486
All	16.3 (2.6)	16.2 (1.0)	.371
Fastball velocity (mph)			
Starters	91.3 (2.23)	91.9 (1.99)	.001
Relievers	92.0 (2.4)	92.5 (2.0)	.059
All	91.6 (2.3)	92.2 (2.0)	.001
Fastball percent			
Starters	60.4% (11.0%)	60.7% (8.0%)	.347
Relievers	58.3% (12.8%)	60.0% (12.7%)	.127
All	59.5% (11.7%)	60.4% (10.2%)	.097
Curveball percent			
Starters	10.4% (5.1%)	9.8% (5.3%)	.186
Relievers	16.4% (11.5%)	12.1% (10.6%)	.339
All	11.6% (7.61%)	10.6% (7.30%)	.444

NOTE. Boldface indicates statistical significance ($P < .05$). SD, standard deviation.

Table 3. Hip/Groin Injury Workload and Pitch Type in Starters and Relievers

	Year of Injury Mean (SD)	Career Mean (SD)	<i>P</i> Value
Games played			
Starters	19.1 (8.8)	167.4 (101.8)	
Relievers	37.0 (25.7)	164.3 (139.5)	
Innings pitched/game			
Starters	6.0 (0.5)	5.4 (0.9)	.078
Relievers	0.9 (0.1)	1.6 (1.1)	.052
Pitches/game			
Starters	94.4 (4.0)	87.5 (13.2)	.097
Relievers	16.4 (2.2)	26.2 (18.8)	.052
Pitches/innings pitched			
Starters	15.9 (1.4)	16.3 (0.7)	.325
Relievers	17.5 (1.7)	16.8 (1.4)	.103
All	16.6 (1.8)	16.5 (1.1)	.210
Fastball velocity (mph)			
Starters	90.5 (1.9)	91.3 (1.5)	.005
Relievers	92.3 (3.1)	91.8 (3.5)	.490
All	91.3 (2.8)	91.6 (2.7)	.487
Fastball percent			
Starters	56.1% (13.1%)	60.4% (5.5%)	.053
Relievers	52.5% (19.9%)	53.8% (14.9%)	.249
All	54.4% (16.4%)	57.3% (13.7%)	.039
Curveball percent			
Starters	15.0% (10.3%)	12.6% (6.5%)	.047
Relievers	22.7% (15.3%)	10.8% (10.4%)	.049
All	17.2% (12.1%)	12.0% (7.8%)	.009

NOTE: Boldface indicates statistical significance ($P < .05$).
SD, standard deviation.

was no change in percentage of pitch type thrown (Table 2).

Hip/groin injury pitchers showed no change in workload the year of injury compared with career data with regard to innings/game, pitches/game, or pitches/inning. Starters with a hip/groin injury experienced a significant decrease in fastball velocity the year of their injury compared with their career (90.5 vs 91.3 mph, $P = .005$); however, there was no change in the velocity of relief pitchers (92.3 vs 91.8 mph, $P = .490$). There was an overall decrease in fastball percentage (54.4% vs 57.3%, $P = .039$) and increase in curveball percentage (17.2% vs 12.0%, $P = .009$) the year of injury compared with career (Table 3).

Core injuries experienced a decrease in homeruns/9 innings (0.95 vs 1.07 homeruns, $P = .023$) and K/9 (6.94 vs 7.63 strike-outs, $P = .020$), whereas hip/groin injuries experienced an increase in K/9 (7.87 vs 7.51 strike-outs, $P = .016$). Neither core nor hip/groin injured pitchers had a significant differences with walks, earned run average, and wins above replacement, the year of injury compared with all other injuries (Tables 4 and 5).

Discussion

Pitching is a complex motion in which the lower extremity and trunk generate energy to the throwing shoulder through an intricate coordination of

Table 4. Core Injury Performance Statistics Year of Injury Compared With Other Injuries

	Core Injuries Mean (SD)	All Other Injuries Mean (SD)	<i>P</i> Value
Walks/9 innings	3.19 (1.31)	3.45 (2.33)	.227
ERA	4.74 (3.33)	4.83 (4.39)	.325
Home runs/9 innings	0.95 (0.56)	1.07 (0.94)	.023
Strikeouts/9 innings	6.94 (2.37)	7.63 (2.69)	.020
WAR	1.06 (3.69)	0.61 (1.16)	.198

NOTE: Boldface indicates statistical significance ($P < .05$).
ERA, earned run average; SD, standard deviation; WAR, wins above replacement.

movement. In our study, we found that core and hip/groin injuries represented 21% of all injuries requiring time on the DL. Core and hip injuries in MLB pitchers show similar time on the DL compared with other injuries. Pitchers maintained similar workload in the season before injury compared with overall career. Although there is a high rate of return to play from the DL, these pitchers also have a high rate of reinjury, most commonly, injury to other regions of the body.

Core and hip musculature is coordinated throughout the pitching motion with the rectus femoris, rectus abdominis, abdominal obliques, and lumbar paraspinal muscles having the most significant activity during the acceleration phase of throwing.^{16,17} As a result, the core musculature is subjected to a great deal of energy transfer throughout the pitching motion. Recent studies have shown an increase in core injuries in MLB players, with even more frequency in pitchers compared with position players.² Core injuries had an incidence of 14%. The incidence of core injuries has previously been noted at approximately 11% in all player positions, with abdominal strains representing 5% of injuries in pitchers.^{9,12} The pitchers in our study spent an average of 47 days on the DL with core injuries and 38 days with hip/groin injuries. This is similar to other studies, in which pitchers with abdominal strains missed and average 35.4 days.¹¹ Of the pitchers in our study who required time on the DL, most were able to return to play the same season with 78% of core and 73% of hip/groin injuries returning to play the same season. Previous studies have not commented on return to

Table 5. Hip/Groin Injury Performance Statistics Year of Injury Compared With Other Injuries

	Hip/Groin Injuries Mean (SD)	All Other Injuries Mean (SD)	<i>P</i> Value
Walks/9 innings	3.93 (1.34)	3.38 (1.97)	.402
ERA	5.51 (2.72)	4.77 (2.49)	.428
Home runs/9 innings	1.17 (1.05)	1.04 (0.89)	.072
Strikeouts/9 innings	7.87 (2.79)	7.51 (2.65)	.016
WAR	0.73 (0.96)	0.67 (1.79)	.172

NOTE: Boldface indicates statistical significance ($P < .05$).
ERA, earned run average; SD, standard deviation; WAR, wins above replacement.

play, but have shown a high incidence of reinjury in this population.^{8,11}

Conte et al.¹¹ evaluated all positions with abdominal injuries and found a reinjury rate for another abdominal injury at 12.1% throughout their career. Our study found a 6% reinjury rate of core injuries and 10% reinjury rate of hip/groin injuries. There was, however, a very high reinjury rate in these pitchers for other types of injuries. Overall, pitchers with core injuries sustained a recurrent injury of any type in 46% of pitchers and pitchers with hip/groin injuries had a recurrent injury of any type 50% of the time. Of those with reinjuries, the core group sustained injuries to other areas of the body 74% of the time. The hip/groin injury group had a 40% rate of reinjury of core and hip/groin injuries with the remaining 60% sustaining other injuries. This further shows the importance of core and hip musculature throughout the throwing motion. Because of the high rate of subsequent injuries after core and hip/groin injuries, prevention should focus on core strengthening and proper throwing technique. Specifically, a focus on full return of core strength and proper pitching mechanics may help to alleviate undue stress to other areas prone to injury.

Because of the significant contribution from the hip and core musculature during pitching, one may expect fatigue or increased pitching workload to have a significant contribution to injury incidence. This, however, did not hold true in our study. The only group that showed an increased workload was starters with core injuries, pitching an average of 6 more pitches per game but pitching about half an inning less. All other measures of workload evaluated showed no significant difference in core or hip/groin injuries before injury compared with career established workload. This would indicate that pitching workload differences do not appear to directly correlate with core or hip/groin injuries.

Small changes in fastball velocity were also found in the core injury pitchers, with only starters in hip/groin injuries showing changes in velocity. Starters with core injuries lost about 0.6 mph of velocity and starters with hip/groin injuries lost about 0.8 mph of velocity. This small decrease in velocity may not be clinically significant; however, previous studies have shown small changes in velocity to be significant with an increase of only 1.2 mph helped predict the need for ulnar collateral ligament reconstruction in MLB pitchers.¹⁰ We feel that this small decrease in velocity in our study is likely from a weakening or deconditioning of the core musculature that results in a slight decrease in velocity; however, we had no specific correlation of this change in games leading up to injury. We believe that this decrease in velocity could be attributed to a multitude of factors, such as unreported concomitant injury, pitcher fatigue, or several other possible confounding variables.

Previous studies have shown that core and hip injuries have a preponderance for injury contralateral to the throwing arm, because pitchers with abdominal strains were found to occur 78% of the time contralateral to the throwing arm.¹¹ Our study found just under half of hip injuries and two-thirds of core injuries occurred on the contralateral side of the throwing arm. This would indicate that pitchers in our study were vulnerable to injury on both the ipsilateral and contralateral side to the throwing arm, with core injuries occurring more often to the contralateral side.

Limitations

There are several limitations to this study. One limitation is that the injury and player statistical data collected were internet-based information, which has its inherent limitations. This method, however, has been used in several previous studies and all of the data were cross-referenced with multiple sources.¹²⁻¹⁶ The accuracy of injury reporting is also a limitation as this is dependent on the medical staff and organization to accurately identify and report injuries. Pitchers placed on the DL are also not exclusively a surrogate of injury because players may have missed games due to injury without requiring time on the DL. We also noted that few pitchers in each group underwent surgical intervention; however, the databases used to obtain our data often listed each pitcher's specific injury and mentioned surgery in only intermittently. We therefore feel that the data may not give the most accurate information for pitchers who required surgery and these numbers may be under-reported. The group of pitchers analyzed also did not have a comparison with a control group; instead comparison was performed between the year of injury and career established data for these pitchers and against pitchers with separate injuries. The fastball velocity is an average velocity of each fastball thrown during the time period in question and is not based on a pitch-by-pitch basis, which would have helped evaluate changes in pitch velocity closer as they happen game to game. There were also no data collected on pitchers 2 years after return from injury to evaluate for velocity or IP. We feel that comparisons of each specific pitcher's career established pitch velocity as well as workload serve as good comparisons.

Conclusions

Core and hip injuries in MLB pitchers result in similar time on the DL compared with other injuries. Pitching workload during the year of injury does not seem to have a significant impact on sustaining a core or hip injury. Although there is a high rate of return to play from the DL, there is a high rate of reinjury in these pitchers more often for other injuries.

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