Disabled List Analysis in Professional Baseball Athletes: Are All Injuries Created Equal?

Timothy Charlton, MD, Christopher Ball BS, Kevin M. Charlton, MS, MBA, Timothy Rearick, MD, Thomas House, PhD, Stephen Fealy, MD, George F. Rick Hatch, III, MD

Cedars-Sinai Medical Center, Los Angeles CA; University of Southern California, Los Angeles CA; Hospital for Special Surgery New York, NY

Background: Baseball performance has been extensively studied to the fraction of a percentage point, yet health analysis and the subsequent macro effects of staffing and contract structuring have been overlooked. While shoulder and elbow injuries are ubiquitous in Major League Baseball, no comprehensive study has linked all parts of the kinematic sequence. And no study has ever been conducted to address whether an athlete is predictably going to be injured years after the primary injury or address the question "does a knee injury in a pitcher have the same long term impact as TJS?"

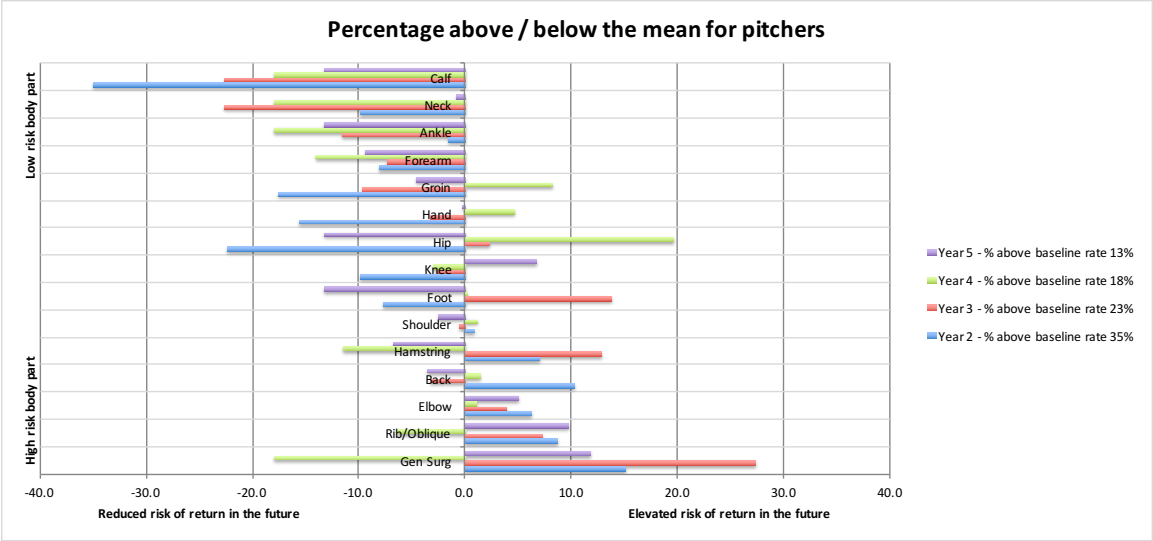
Purpose: The purpose of this study was to determine if an injury to a particular anatomic region was prone to having a higher reinjury rate in any area in the kinematic sequence and to see if a particular body part injury was the primer for a mechanical fault, muscle imbalance, or other compensation leading to a subsequent injury in a different area in future years. Staffing, contracts, and most importantly

health maintenance could be adjusted to account for this statistical risk for these high-risk body parts.

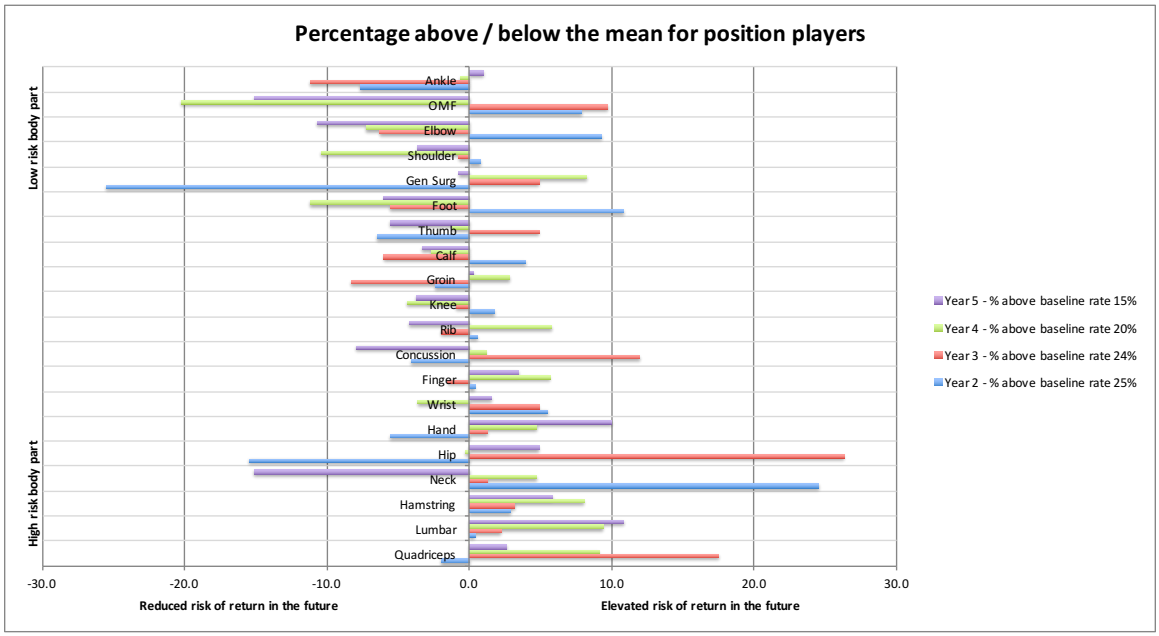
Study Design: Prospective Comparative Cohort Study, Level of Evidence III

Methods: A publicly available Major League Baseball disabled list database was evaluated over a 10 season period between 2002 and 2011, and then prospectively compared to a cohort in the following three years 2012-2015 for validation of the predictive ability of the model. Disabled list stays were evaluated for anatomic location, length, and recurrence. A novel and previously undescribed application of "mean rate of return to the disabled list above replacement" was analyzed for each of 4 years after the initial injury to determine which areas would lead to predictable higher/lower rate of return when compared to the global baseline disabled list rate

Results: A total of DL 2397 (166157 DL days) stays were recorded for pitchers and 2204 (103524 DL days) were recorded for hitters. For pitchers, rib/oblique, elbow, and back injuries posed the over greatest risk for return to the above the baseline risk.



For position players, injuries of the quadriceps, lumbar spine, hamstring, cervical spine, and hip posed the over greatest risk for RDL above the baseline risk.



Conclusion: Anatomic location and timing of an injury will have dramatic, measurable, predictable and profound impact on the long-term health status of a

player. Athletes and medical staff should be counseled as to expectations, and general managers / agents should recognize that players with these injuries will have a statistical elevation in DL days in the future contract and roster management should be adjusted accordingly for the long term staffing viability in the future.

Key Terms: Baseball, injury, epidemiology, shoulder, elbow, injury prevention, statistics

Introduction:

Major League Baseball (MLB) is a highly analyzed sport with advanced metrics to assess performance. However, there is limited information about injury rates in players even though there is an official disabled list as part of MLB management. Only 2 studies previously describe the epidemiology for MLB injuries and there is still a lack of information looking at length of stay specific to all anatomic regions or long-term prognosis.

While shoulder and elbow injuries are ubiquitous in Major League Baseball, placement on the disabled list (DL) for injury is not limited to the shoulder and elbow. Limited studies have been done specific to one location of the body, but no study to date has assessed length of stay on the DL specific to all anatomic regions or compared multiple injuries and tracked players over subsequent years for other body location areas for relative risk. Such information can be vital for training staff, physicians, team management, and players in expectation management of injuries. Additionally, this information would be essential in identifying "parts at risks" that may warrant additional health care management, long after the initial injury has healed.

The purpose of this study was to quantify the average length of stay on the DL specific to anatomic region, assess re-injury probability, and identify high-risk areas for subsequent re-injury.

Materials and Methods:

A database of publically available injuries on Major League Baseballs disabled list was evaluated over a 10 season period between 2002 and 2011 retrospectively and prospectively studied between 2012 and 2015 . Only data from injuries that resulted in a player being placed on a disabled list was used. According to MLB rule 2(g), the disabled list is for players who are certified unable to play, with a specific diagnosis made by the team physician. When a player is placed on the disabled list, the player cannot return to the active roster for a minimum of 15 days with no upper limit. The player was taken off the disabled list when he was deemed ready to return to play. The same player could be placed on the disabled list more than once during a season. Data analysis and regression analysis of this database was performed using JMP Pro 10 (SAS inc, Cary NC) software. The following data criteria were investigated- age, position, anatomic region, length of stay on the DL and subsequent return to the DL up to 4 years after index injury.

The length of stay on the DL was recorded as well as location of injuries and year of injury. Injuries were categorized by strains, sprains, fractures, stress fractures, infection, contusions, dislocations, and surgery. DL listing for multiple anatomic regions, such as a player being listed for a shoulder strain and neck pain, for the same DL stay were separated to a primary injury, secondary, and tertiary if applicable. Analysis was performed to see if the addition of the additional anatomic region injury had any impact to the length of stay when compared to the

individually listed anatomic region. Exclusion criteria for the analysis were non orthopaedic injuries such as diabetes, kidney stones, gastrointestinal disorders, and non musculoskeletal disorders with the exception of concussions, although these are considered less related to the day to day activity of professional baseball players.

Each anatomic region was then quantified and the following categories were evaluated: number of injuries per anatomic region and average number of day on the disabled list. An analysis of average DL days was analyzed specific to anatomic region.

Each player injury was evaluated for return to the disabled for the subsequent 5 years. The original injury was designated as the index year and a return to the disabled list (RDL) was identified. An analysis was done to evaluate the long-term return to the disabled list for any reason and categorized based on anatomic region. The mean rate of return was analyzed for each of 4 years after the initial injury. RDL rates of years 2,3,4, and 5 were then subtracted by the corresponding overall average return rate (ie return rate independent to anatomic region) to determine rates over/under the mean, in an effort to see if particularly anatomic region has a potential long-term negative prognosis. This is best seen by the example below using the following formula. This example looks at the rates for a position player 2 years (year #3) after the initial quadriceps injury in index year #1. The overall baseline rate for position players is 24%. Yet a player with a quadriceps injury will

be return to the disabled list 40.5% of the time, providing a 16.5% higher than average rate.

RDL above / below mean = Rate of return for body part (example quadriceps) – overall rate of return for the year specific and cohort specific group (example year 3 and position players)

Example: RDLquad3 (Quadriceps, position players, year 3) = 40.5

RDLoverall3 (Overall, position players, year 3) = 24%

RDLabm= 40.5% - 24% = 16.5% above mean

Analysis – For the position player, a quadriceps injury in will pose a 16.5% higher risk to reinjury compared to all other body parts later in year 3.

This identical analysis was done for all years and all body parts. The rates were then graphed and evaluated for total rate above the mean. Anatomic regions with a high "above mean" cumulative return to the disabled list were considered at risk for an area of concern. This analysis was independent of whether the return was for the same body part injured in year 1 or an entirely different region.

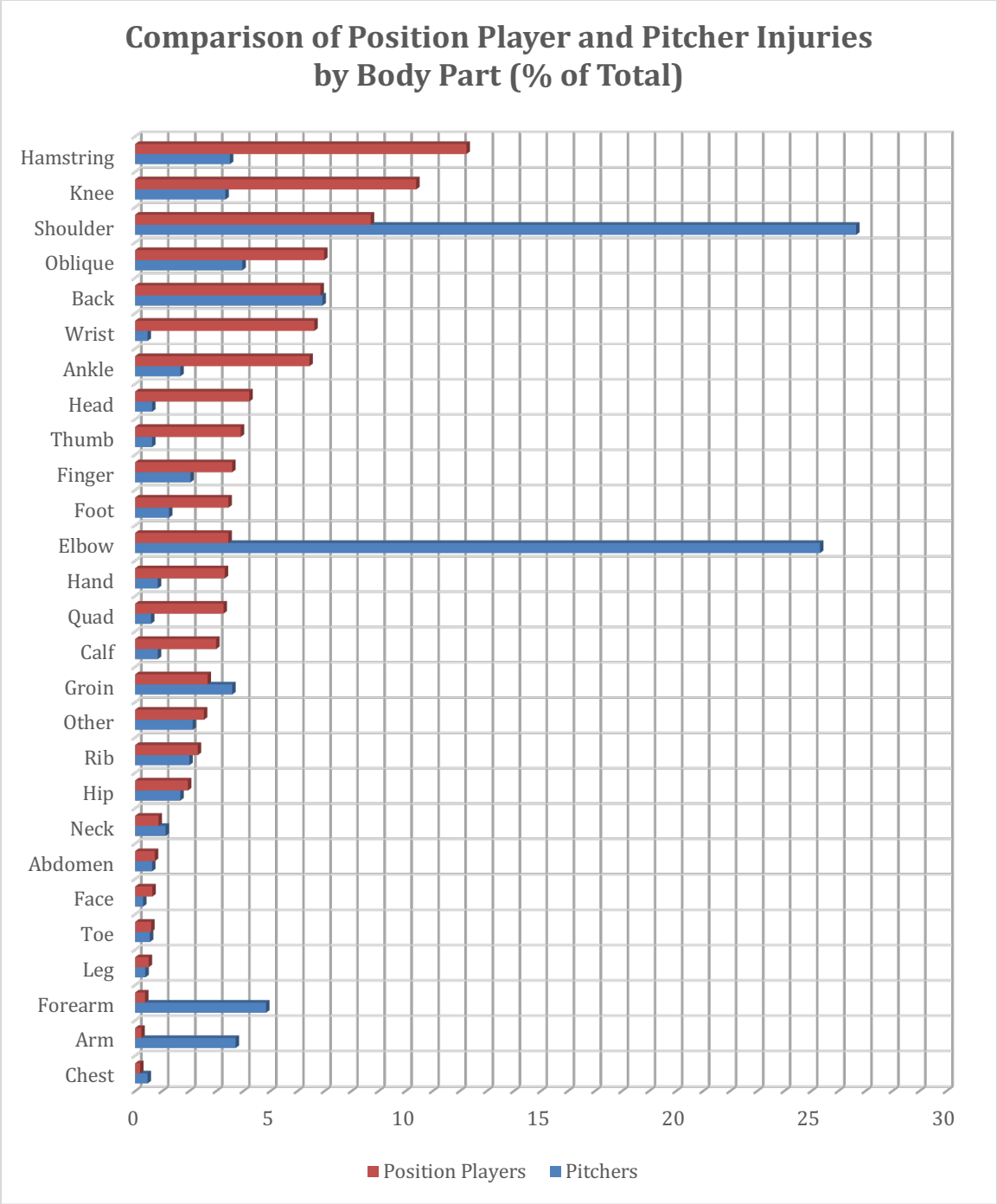
Results:

During the time period between 2002 and 2015, 2397 (166157 DL days) stays were recorded for pitchers and 2204 (103524 DL days) were recorded for hitters.

Injury Occurrence Specific to Body Part

Injuries occurrence was calculated specific to each anatomic region and separated into position players and pitchers and summarized in figure 1. The most common

areas of injury for the hitter were the hamstring, shoulder, and knee, with an overall percentage of injury occurrences being 31% of injuries in the study of the hitting cohort. The most common areas of injury for the pitchers were the shoulder and elbow, with an overall percentage of injury occurrences being 52% of injuries in the study of the pitching cohort.



<u>Return to the Disabled List Specific to Body Part</u>

Figure 2a demonstrates the rate of return to the disable list (RDL) for position players. 25% of position players returned to the disabled list the following year

after the index injury. In years 3,4, and 5, those same players returned to the disabled list 24%, 20%, and 15% respectively. Figure 2a demonstrates parts considered at risk. It was calculated by subtracting the overall yearly baseline rate from the part specific rate. For position players, quadriceps, lumbar spine, hamstring, cervical spine, and hip injuries posed the over greatest risk for RDL above the baseline risk. Elbow, oral maxiofacial injuries and ankle injuries posed the lowest risk for RDL.

Figure 2a - Long-term Return To Disabled List (RDL) Above Baseline For Position Players. Regions on the bottom are considered "high risk" with above average RDL and pose a higher rate of injury in the future.

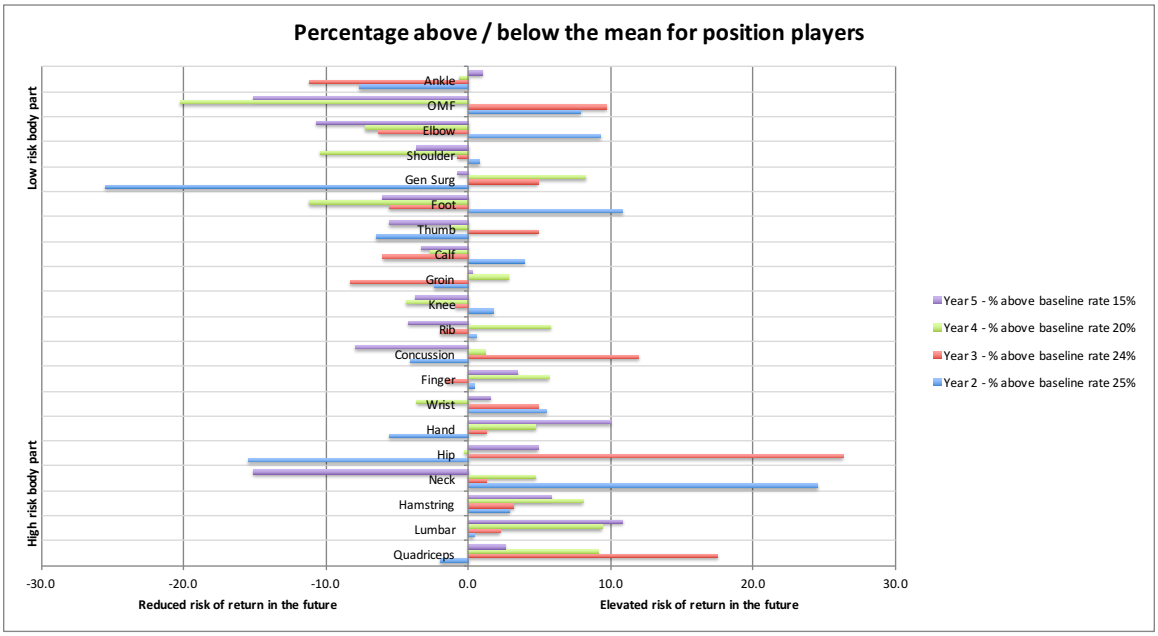
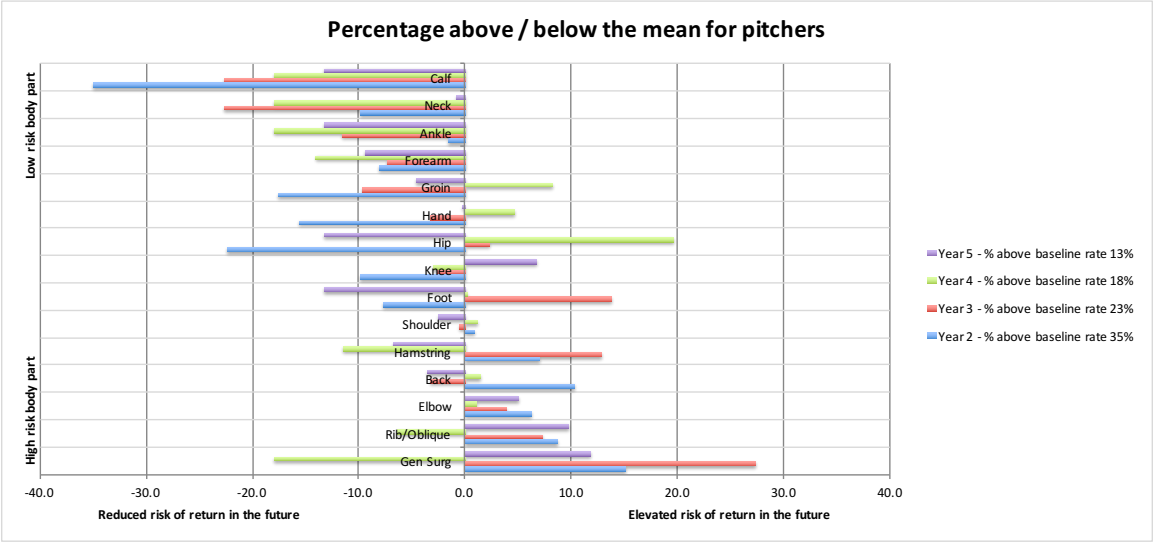


Figure 2b demonstrates the rate of return to the disable list (RDL) for pitchers. It was calculated in an identical fashion to figure 2a. 35% of pitchers returned to the disabled list the following year after the index injury. In years 3,4, and 5, those same players returned to the disabled list 23%, 18%, and 13% respectively. For pitchers, rib/oblique, elbow, and back injuries posed the overall greatest risk for RDL above the baseline risk. Calf, neck, and ankle injuries posed the lowest risk for RDL. General surgery problems were of note to have a high RDL but had a very small sample size.

Figure 2b - Long-term Return To Disabled List (RDL) Above Baseline For Pitchers. Regions on the bottom are considered "high risk" with above average RDL and pose a higher rate of injury in the future.



Prospective and Retrospective cohorts:

Evaluation of the retrospective and prospective cohorts demonstrated no differences in RDL rates of both position players and pitchers using unpaired student t-testing. This demonstrated that the model was valid for prospectively using the data in a predictive method. The overall distribution of the cohort did slightly change slightly. Pitchers represented 52.4% of the retrospective cohort (2002-2011) whereas it was nearly evenly distributed at 50.1%. However this difference was determined not to be statistically significant ($p = 0.644$).

Discussion:

There is a general lack of information available regarding injury trends and DL stints in Major League Baseball players. No study to date has analyzed length of stay on the disabled list and the potential risk to return to the disabled list based on injury to all of the anatomic regions of the body. Posner et al. examined the epidemiology of DL stints over a 7-year period and found that upper extremity injuries were more common in pitchers while lower extremity injuries were more common in position players. Our study reaffirms this observation, with shoulder and elbow injuries comprising the vast majority of DL stints in pitchers whereas hamstring, knee, and ankle injuries made up a higher proportion of DL stints in position players.

In our study, shoulder and elbow injuries were common in the overhead athlete. However, the risk of future injury above baseline differed between the two

sites of injury. The risk of spending subsequent time on the DL in the four years following an elbow injury for a pitcher was 7% above baseline, suggesting that this injury does warrant additional attention to athletes with this injury. Rib / oblique injuries posed a similar concern in the pitcher. This study suggests that an initial injury of these areas may be the primer for a mechanical fault, muscle imbalance or other compensation that leads to a subsequent injury in the elbow or other link in the kinematic sequence.

Shoulder injuries in pitchers, however, did not pose an increased risk above baseline for a future DL stint at the baseline rate. Specific to pitching injuries of the shoulder and elbow, the recurrence rate of an elbow injury leading another elbow injury was 29.2%, with an average time of recurrence of 1.8 years. Similarly, shoulder recurrence was 29.9% with a slighter longer delay in recurrence of 2.1 years. This would suggest that a pitcher was more likely to have a separate body part be injured in the first year back from injury, but the shoulder an elbow had a high chance of recurrence in the subsequent later years after injury.

For positional players in this study, hamstring injuries were found to be the most frequent injury. A recent study by Ahmad et al. analyzed the epidemiology of hamstring injuries over a one-year period in professional baseball players. They found that 20% of Major League Baseball players sustaining a new hamstring strain during the study year had a history of a hamstring strain in the previous year. This finding correlates with the results in our current study demonstrating the increased future injury risk of above baseline, in both pitchers and position players. Our study is unique in that it identifies that a hamstring injury demonstrates a higher

rate of return across all bodies parts, not just hamstring injuries, which is essential in team management and athletic training. This could have many explanations such as conditioning, nutrition, or kinematic mechanical flaw. However, conjecture for a player being "injury prone" using a more molecular explanation such a collagen based argument could be made.

The incidence of abdominal core injuries has previously been shown by Conte et al. to be increasing with a high re-injury rate of 12.1%. Our study demonstrates similar findings in that rib and oblique injuries in the pitcher have a significant impact on future injury as a negative prognostic indicator. Biomechanical analyses have established core muscles such as the obliques, the abdominal cage, intercostals, and the rectus abdominus as vital components to core mechanical synergy. These muscles play a critically important role in the rotational kinematic sequence and targeting the health of these anatomic areas may be important in avoiding overuse injuries.

Figures 2a and 2b call attention to "areas at risk" for future re-injury. This study did not attempt to assign causality as to why these anatomic regions were prone to future problems. Given the regions of re-injury for pitchers (rib, elbow, and back) and the biomechanical nature and connection of these areas in the throwing mechanics, it is reasonable to counsel the athlete that injury and subsequent compensation in throwing mechanics may have a negative future impact. Similarly, the position player should be instructed that injury to the core rotation and running mechanics might affect the position player in the future.

This study has several limitations. The first is that the data has been collected by way of an independent database of publically available data as opposed to directly from Major League Baseball. In addition, the injuries included in this study are limited to those that required a DL stint during the season. Injuries that occurred during the postseason or offseason or those that were not severe enough to require the minimum fifteen-day stay on the DL in-season are not included in this database. Therefore, the true epidemiology of these injuries in major league baseball are likely underestimated in this study.

Conclusion:

The implications of this study are profound. This study does succeed in demonstrating that all injuries are not created equal. An elbow or rib/oblique injury in a pitcher does not act in the same way as a knee, and as a result, the expectations are different. This certainly would have significant impact on the team management of a pitching staff or the contractual negotiation of a player with these injuries. In the example of the elbow or rib/ oblique injury, reducing a team's overall risk by 7% would have significant effect on team performance as well as lost income due to injury, with potentially championship level implications. This study would be the first step in identifying the quantifiable risk of investment on a long term contract of an injured player. It would also be the first step in identifying a potential opportunity to sign an injured player at a reduced cost, secondary to the misconception that the player was injury prone. Billy Beane was quoted, "If you look at any sports team, one of the greatest predictors of a team's success is the

team's health record." The result of this study are the first to address that specific point.

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