Evaluation of hip internal and external rotation range of motion as an injury risk factor for hip, abdominal and groin injuries in professional baseball players

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Abstract

Normal hip range of motion (ROM) is essential in running and transfer of energy from lower to upper extremities during overhead throwing. Dysfunctional hip ROM may alter lower extremity kinematics and predispose athletes to hip and groin injuries. The purpose of this study is characterize hip internal/external ROM (Arc) and its effect on the risk of hip, hamstring, and groin injuries in professional baseball players. Bilateral hip internal and external ROM was measured on all baseball players (N=201) in one professional organization (major and minor league) during spring training. Players were organized according to their respective positions. All injuries were documented prospectively for an entire MLB season (2010 to 2011). Data was analyzed according to position and injuries during the season. Total number of players (N=201) with an average age of 24±3.6 (range=17-37). Both pitchers (N=93) and catchers (N=22) had significantly decreased mean hip internal rotation and overall hip arc of motion compared to the positional players (N=86). Players with hip, groin, and hamstring injury also had decreased hip rotation arc when compared to the normal group. Overall, there is a correlation between decreased hip internal rotation and total arc of motion with hip, hamstring, and groin injuries.

Introduction

Abnormal restricted hip motion, such as that in femoroacetabular impingement syndrome, has been associated with increased hip or groin-related pain in the athletic population.[1-4] Several studies have shown a high prevalence of abnormal hip pathomorphology in the athletic population including football, soccer, and hockey.[1-4] There is a paucity of data, however, regarding hip pathomorphology and elite overhead athletes.[5] While overhead sports, such as baseball, are typically linked to upper extremity injuries, there is now also increasing recognition regarding hip injuries in this population of overhead athletes.

Normal hip motion is essential for proper kinematics during the throwing motion. During an overhead throw, the energy generated by the lower extremity is transferred proximally via the hip through the core, shoulder, elbow, and ball release from the hand.[5-7] As a result, there is a correlation between forces generated during leg push-off or drive during the cocking phase with increase arm and ball velocity.[5-8] Furthermore, studies have suggested there may be distinctive hip kinematics associated with different player positions in baseball,[8-10] which may predispose particular player positions to certain types or pattern of injuries.

Repetitive loading and stress to the lower extremity may lead to the development of hip injuries and osteoarthritis.[11,12] Several factors contribute to the stabilization of the hip joint to prevent injury including range of motion, physical loading, and the amount of stress placed on the hip joint (body mass index).[13-15] Restriction in the hip rotational range of motion have been linked to increased risk for adductor strain in professional soccer players and also have been associated with increased lower back pain in professional tennis players.[16,17] Numerous studies have demonstrated adaptation of the glenohumeral joint range of motion or translation secondary to asymmetric loading patterns and repetitive stress of the involved extremity.[13,18-21] This same adaptation in rotational range of motion may also occur in the hip due to the demand placed on the extremity. Reduced joint range of motion secondary to musculoskeletal adaptations affects the efficiency of force production in the lower extremity, which leads to disruption of the kinetic chain and increases the likelihood of injury.[22-24] While studies have demonstrated the association of hip range of motion to the overall pitching mechanics and velocity, there are no studies evaluating the abnormal hip motion as a relative risk factor for lower extremity injuries in the hip, abdominal, and groin regions among overhead athletes, particularly baseball players.

The overall objective of this study is to evaluate the hip motion arc (internal and external rotation) as an injury risk factor for hip, hamstring, and groin injuries during a complete season among players of a Major League Baseball (MLB) organization. Specifically, this study aims to i) evaluate the overall hip arc of motion between the pitchers, catchers, and positional players (*i.e.* outfielders and infielders), and ii) determine the relationship between internal and external rotation range of motion as an injury risk factor for hip, hamstring, and groin injuries. Our hypothesis is that i) hip range of motion will be different among the three different role players secondary to the differences in the mechanics required for each position, and ii) players with decreased hip range of motion or stiffness will be prone to hip, hamstring, and groin injuries.

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Materials and Methods

All professional major and minor league baseball players (N=201) within a single Major League Baseball organization were included in the study during the 2010-2011 season. The Institutional Review Board of our hospital approved this study and all participants signed the informed consent. During the mandatory pre-season spring training physical, bilateral hip internal and external rotation were measured and recorded. Two evaluators participated in the measurements of each hip. One evaluator positioned the extremity and passively internally and externally rotated the hip. The second evaluator measured and recorded the degree of rotation. Players were positioned supine with both the hip and knee flexed to 90 degrees. Using a universal two-arm goniometer, maximal passive internal and external rotation (ER) were manually measured and recorded for each hip. The distal limb of the goniometer was aligned parallel to the mid-axillary axis. The proximal limb of the goniometer was aligned with the long axis of the tibia. Each player was interviewed and prior history of hip, hamstring, or groin injury was recorded. All subsequent injuries relating to the hip, hamstring, and groin region were then prospectively documented for the entire organization (A, AA, AAA, and Major League) during the 2010 to 2011 season that included both the spring training and also regular season. At the conclusion of the season, the data was analyzed based on player age, field position, history of prior hip, hamstring, or groin injuries, and development of a related injury during the season. Statistical analysis was performed using ANOVA analysis with significance set at P<0.05.

Results

A total of 201 professional baseball players (Pitchers 93, Catchers 22, and Position Players 86) were included in this study. The average age of the players was 24±3.6 years old (range: 17-37 years old). In terms of total hip rotation arc (internal + external hip rotation), positional players had the greatest amount of hip rotation (right hip: 79±16°, left hip: 80±14°) when compared to pitchers (right hip: 72±13°, left hip: 72±12°) and catchers (right hip: 68±9°, left hip: 69±12°) (P<0.001). Catchers (left hip IR: 31.6°, right hip IR: 30.95°) and pitchers (left hip IR: 31.24°, right hip IR: 31.89°) had significantly less left and right hip internal rotation when compared to positional players (left hip: 40.12°, right hip: 38.92°) (P<0.001). There were no differences amongst the three player groups in terms of hip external rotation (Table 1). A total of 29 players suffered in-season hip, hamstring, or groin injuries, which ranged from hip/groin/hamstring sprains to hip labral tears (Table 2). Comparing the group of players that had in-season injury relating to the hip region to players that did not have any injury, the overall arc of motion on both right and left side was decreased (right hip arc 73 *vs* 77 degrees and left hip arc 75 *vs* 78 degrees, respectively). Additionally, in the subset of players that had hip injuries comparing to the no injury group, both internal rotation (right hip IR 29 *vs* 35 degrees and left hip IR 34 *vs* 36 degrees) and overall arc of motion (right hip arc 70 *vs* 77 degrees and left hip arc 73 *vs* 78 degrees) was decreased (Table 2). A total of 583 days and 134 games were missed due to these injuries, averaging 20 days missed or 4.6 games missed per injury, respectively. Within our population, baseball players with in-season hip/hamstring/groin injuries had a decrease in total hip arc of motion on both the right and left side as compared to baseball players with no in-season hip/hamstring/groin injuries (right hip arc 73 vs. 77 degrees and left hip arc 75 vs. 78 degrees; Table 3). With regards to risk factors for the in-season injuries, logistic regression model for likelihood of injury showed that both younger-aged (Odds Ratio: 0.798, Confidence Interval of 0.671 to 0.95) and positional players were at highest risk (Odds Ratio: 4.633, Confidence Interval of 1.553 to 13.817) of developing hip/hamstring/groin injuries. The average age for players who sustained hip/hamstring/groin injuries was lower than those who had no injuries (22.5±1.92 *vs.* 24.5±3.66, P<0.05). Furthermore, position players accounted for 62.1% of the hip, hamstring and groin injuries while pitchers were 24.1% and catchers accounted for 13.8% (Figure 1 and Table 4). Furthermore, loss of hip internal rotation predisposed players to in-season hip injuries (Table 2, P<0.05). Players with a previous history of hip/hamstring/groin injury were significantly more likely to suffer in-season hip/hamstring/groin injuries (Table 5, P<0.001).

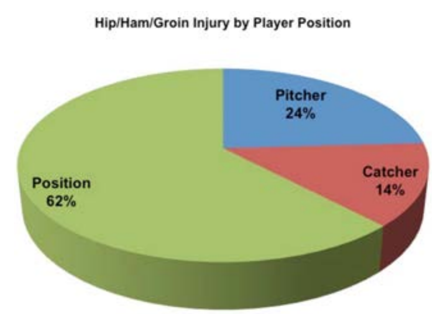

Figure 1. Distribution of the players that had hip/hamstring/groin injury according to the positions played.

Table 1. Hip measurements in internal and external rotation (Arc) in pitchers *vs.* catchers *vs.* position players.

	Pitcher			Catcher			Position			P
	N.	Mean	SD	N.	Mean	SD	N.	Mean	SD	
Right IR	93	31.89	9.65	22	30.95	8.46	86	38.92	11.08	<0.001
Right ER	93	39.65	9.93	22	37.4	7.44	86	40.51	8.04	0.368
Right Arc	93	71.55	12.67	22	68.35	8.65	86	79.43	15.52	<0.001
Left IR	93	31.24	9.44	22	31.6	8.65	86	40.12	9.89	<0.001
Left ER	93	40.93	9.19	22	37.8	6.99	86	40.3	8.06	0.331
Left Arc	93	72.17	12.22	22	69.4	11.6	86	80.42	13.54	<0.001

SD, standard deviation; IR, internal rotation; ER, external rotation.

Table 2. Hip measurements in internal and external rotation range of motion (arc) categorized according to injury group.

	No injury			Hip injury			Any in-season injury			Hip/ham/groin injury			P
	N.	Mean	SD	N.	Mean	SD	N.	Mean	SD	N.	Mean	SD	
Right IR	109	35.61	11.37	26	28.92	12.52	94	35.32	10.15	29	35	10.3	0.042
Right ER	109	41.23	10.98	26	40.69	7.19	94	38.67	7.95	29	38.1	5.46	0.150
Right Arc	109	76.84	16.72	26	69.62	14.11	94	73.99	14.04	29	73.1	11.57	0.128
Left IR	109	36.14	11.95	26	33.77	9.15	94	34.33	9.05	29	35.21	7.75	0.558
Left ER	109	41.81	10.39	26	39.23	7.23	94	39.39	7.76	29	39.79	4.23	0.193
Left Arc	109	77.94	16.26	26	73	10.65	94	73.72	13.32	29	75	8.49	0.131

SD, standard deviation; IR, internal rotation; ER, external rotation.

Discussion and Conclusions

Our study demonstrated a correlation between total hip rotation arc (internal + external hip rotation) and lower extremity injuries around the hip region (hip, groin, and hamstring). We found decreased hip internal rotation and total arc of motion are associated with in-season hip, hamstring, and groin injuries among our MLB players. Players with decreased internal rotation of the hip may be plagued with lower throwing velocity as the transfer of energy between the lower and upper extremity in the kinetic chain is altered. We believe these faulty throwing biomechanics not only lead to increased stress on the upper extremities, but also result in players over-compensating by attempting to increase the forces generated by the lower extremities. Furthermore, decreased hip range of motion has been described as an adaptation similar to glenohumeral internal rotation deficits (GIRD) in shoulders.[9] Such adaptations can produce microtrauma,[9] and leads to joint contractures,[25,26] structural changes,[11,27] and altered kinematics at the hip and pelvis.[28,29] Previous reports have noted improper loading technique and inadequate muscular adaptations among throwers as a consequence of decreased hip range of motion.[30-32] Gomes *et al.*[33] also documented a strong correlation between decrease in hip rotational range of motion, especially internal rotation, with anterior cruciate ligament (ACL) ruptures in soccer players. In a cohort of 50 soccer players with ACL ruptures compared to control group, the internal rotation measurements were 26.4±7.7 degrees *vs.* 39.0±7.1 degrees (P<0.001), respectively. These above studies are consistent with our finding of a correlation between increased lower extremity injuries (hip, hamstring, and groin) with decrease in the internal rotation and overall hip range of motion (arc). Furthermore, during the throwing motion, proper alignment of the pelvis is important for foot contact and kinetic force from the leg drive.[5-10] This is achieved with a combination of sufficient hip internal rotation of the trail leg and hip external rotation of the lead leg.[7] Several publications have studied hip motion in baseball players. Ellenbecker *et al.*[13] first reported active hip range of motion among professional baseball pitchers and found no statistical differences. The authors did report 17% and 42% of the pitchers with ≥10° of observable differences in active internal rotation and external rotation, respectively. Laudner *et al.*[6] previously reported that baseball pitchers have significantly smaller amounts of hip internal rotation range of motion and abduction strength of the trail leg compared to position players, but they concluded that the differences were not clinically relevant. Stodden *et al.*[5,34] reported increased pitch velocity associated with increased hip rotation at the point of maximum shoulder external rotation. This was reported as an *opening* of the pelvis, where the anterior pelvis is more visible to the hitters.[34] Inadequate hip internal rotation of the trail leg may lead to the player throwing across the body, limiting the transfer of energy created in the kinetic chain, placing unnecessary stress on the shoulder.[8] Thus, the altered transfer of energy in the kinetic chain may predispose a baseball player with decrease hip ROM to upper extremity injuries.

When evaluating hip ROM according to the players position, we found that catchers and pitchers have significantly decreased hip motion arc when compared to positional players. Laudner *et al.*[6] reported similar findings with positional players having significantly more internal rotation in the trail leg compared to pitchers. Ellenbecker *et al.*[13] compared uninjured hip ROM between professional baseball players and tennis players. They found

Table 3. Hip measurements injured hip/ham/groin *versus* non-injured players.

	No injury			Hip/ham/groin injury			P
	N.	Mean	SD	N.	Mean	SD	
Right IR	172	35.61	11.37	29	35	10.3	0.792
Right ER	172	41.23	10.98	29	38.1	5.46	0.141
Right Arc	172	76.84	16.72	29	73.1	11.57	0.259
Left IR	172	36.14	11.95	29	35.21	7.75	0.692
Left ER	172	41.81	10.39	29	39.79	4.23	0.31
Left Arc	172	77.94	16.26	29	75	8.49	0.349

SD, standard deviation; IR, internal rotation; ER, external rotation.

Table 4. Player position in no injury *versus* hip/ham/groin injury players.

	No injury			Hip/ham/groin injury			P
	N.	Mean	SD	N	Mean	SD	
Pitcher	109	56	51.4	29	7	24.1	0.030
Catcher	109	8	7.3	29	4	13.8	
Position	109	45	41.3	29	18	62.1	

SD, standard deviation; IR, internal rotation; ER, external rotation.

Table 5. Previous injury in no injury *versus* hip/ham/groin injured players.

	No Injury			Hip/Ham/Groin Injury			P
	N.	Mean	SD	N.	Mean	SD	
No	109	109	100.0	12	8	66.7	<0.001
Yes	109	0	0.0	12	4	33.3	

SD, standard deviation; IR, internal rotation; ER, external rotation.

no significant difference between the non-dominant and dominant hip in rotational range of motion. However, in professional pitchers, 42% of the players had a 10 degrees or more difference in external rotation between the two different limbs. Conversely, Tippett *et al.*[7] reported greater hip internal rotation ROM in the trail leg versus the lead leg in pitchers but no bilateral difference in external rotation. In our study, we found a difference in the overall hip range of motion (arc) between the different playing positions. Catchers and pitchers tend to throw more throughout a baseball season, thus these players may sustain more repetitive microtrauma to the hip compared to positional players. Additionally, the concept of adaptation of the hip range of motion in catchers as they tend to play in a squatted position with the lower extremity in external rotation may explain the differences in the IR *vs*. ER range of motion. With time, this position may result in contracture of the posterior capsule/hip external rotators and stretching of the anterior capsule that will result in decrease in internal rotation thus leading in a decrease in the overall arc of motion in the hip. In addition, the hip flexors may also tighten which will further decrease internal rotation. In contrast, younger players and positional players have a higher relative risk for developing lower extremity injuries including hip, hamstring, and groin. This can be attributed to the amount of sprinting positional players do in a season, which certainly places them at a higher risk for lower extremity injuries compared to catchers and pitchers. In contrast to our findings, Verrall *et al.*[35] reported that increasing age was a risk factor for hamstring injuries in Australian football. Furthermore, they also reported that previous posterior thigh injury and history of knee injury also increased the chances of hamstring muscle strain.

There are limitations to our study. One limitation is the lack of radiographic data on our players, which precludes us from making conclusions regarding our observed hip motion arcs and pathomorphology of the hip. While femoroacetabular impingement is reportedly prevalent among elite athletes and a common cause of restricted hip motion, we are unable to make this correlation given routine radiographic imaging was not typically a part of pre-season physicals. The other limitation to our study is the absence of data regarding the players' dominant arm in our study population. Thus it is impossible for us to analyze the effect of the lead leg *versus* the trail leg in hip IR, ER and total arc of motion. Our study found significantly more hip/hamstring/groin injuries among players with right hip internal rotation deficits. This may be particularly relevant if our population were predominantly right-handed throwers since the trail leg (right leg for right-handed throwers) undergoes more internal rotation stresses during leg drive of the throwing motion. Another limitation is the collection of data over a single season in the major league that may bias the data given the relative shorter time period. Future prospective studies that will include more seasons will help further determine the relationship between hip range of motion and lower extremity injuries. However, it may be difficult to collect prospective data on the same players from the beginning of the season as there are a significant amount of trades and transfer of players throughout the seasons.

In conclusion, our study found a correlation between decreased hip internal rotation and total arc of motion with in-season hip, hamstring, and groin injuries among one MLB organization. Catchers and pitchers have significantly decreased hip motion arc when compared to positional players. Among our player population, younger-aged players had a higher relative risk for developing hip/hamstring /groin injuries.

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