Introduction: The act of throwing a baseball is a complex maneuver, involving not only the shoulder, elbow, and wrist, but also an entire "kinetic chain" of the back, hip, and leg. Injuries to any of the links in this chain may be expected to result in alterations in other components, and to possible secondary injuries, as the player attempts to compensate for limitations in local range of motion (ROM). Both hips extend, flex, and rotate throughout the phases of throwing to help generate or dissipate energy. It is plausible, for instance, that throwers with anterior shoulder pathology have associations between the hip and shoulder measures (stabilization, or back) leg. This would cause a pitching mechanism fault called "flying open" (early lower body advancement and/or decreased dominant-side hip extension, developing late arm action). Non-dominant lower extremity (lead leg) restrictions with hip internal rotation on follow-through may lead to posterior shoulder dysfunction.

If the non-dominant hip cannot maximally internally rotate during follow-through to absorb the energy from the acceleration phase, the posterior shoulder will have to become the primary brake to slow down the arm. We hypothesize that decrease of dominant-side hip extension and non-dominant hip internal rotation are associated with altered glenohumeral rotation (specifically, with a decrease in internal rotation), and that this relationship would be greater as skill levels increase (either by increase in level of play, or in pitchers as opposed to position players).

Methods: Population: Under local IRB approval, 124 male volunteer baseball players were included (60 pitchers, 64 position players; 35 high school, 32 NCAA Div. I college, 57 professionals; age 18-32 y). Measurements: Hip internal rotation (sitting), hip extension (supine), shoulder internal and external rotation (supine) were measured during pre-season physical examinations, on a standard plinth, in one trial, by a single PT, using a Biomechanics G300, Industry, CA, a method with a predictable error of ±3 degrees. "Ipsilateral"=dominant, throwing arm side. Each subject completed a questionnaire that included positions played, general medical history, and specific history of hip, elbow, or shoulder injury. Analysis: Correlations between continuous variables: Associations between the 2 hip measures of interest (ipsilateral extension, and contralateral internal rotation), and the 3 shoulder measures of interest (ipsilateral internal rotation, external rotation, and ROM) were evaluated through the use of Spearman rank-order (non-parametric) and Pearson (parametric) product-moment correlation analyses. Where the results were statistically significant by both methods, the particular relationship was then examined as a function of Level of Play (High School, College, or Professional) and Player Position (Pitcher, or position player) through use of a 2-way ANOVA, with post-hoc Fisher's LSD test.

Risk of shoulder injury: The associations between the hip or shoulder measures of interest, and the history of a shoulder injury were evaluated using a multiple logistic regression, performed in a stepwise manner. Presence or absence of a shoulder injury is considered as a binary outcome, and the measure of interest (continuous), level of play (categorical) and player position (binary) are considered in the initial model as input variables. Input variables whose contribution to the model is significant at the p=0.12 level are kept in the model, and the analysis is repeated, with the standard of inclusion reduced until inclusion threshold is p=0.05. Odds ratios were calculated, and the probability of a shoulder injury was calculated in terms of the logit function Probability(injury)=e^x/(1+e^x), where x is a linear function of the significant risk factors.

Results: Hip and Shoulder ROM: Dominant shoulder internal rotation correlated positively with contralateral hip internal rotation (p=0.0106). Amateur players differed significantly in this relationship from professionals, though the relationship among the college position players approached that of the professionals. Among the high school pitchers there was a negative correlation (p<0.001, r=-0.730) between ipsilateral hip extension and dominant shoulder external rotation, a relationship not present in the higher skill-level subjects. Among the professional non-pitchers, there was a significant negative correlation (p=0.023, r=-0.429) between dominant shoulder total ROM and ipsilateral hip extension.

Shoulder Injury and Shoulder/Hip ROM: A history of shoulder injury was associated with a lower total shoulder ROM (p=0.036, OR=0.978, CI 0.95-0.999), a relationship largely driven by shoulder internal rotation (p=0.0005, OR=0.955, 95%CI 0.925-0.986) and not by shoulder external rotation (p=0.937). Among professionals, a history of shoulder injury was associated with a lower contralateral hip internal rotation (Figure 1, red line). This effect was marginally non-significant when the data from all players were considered (Figure 1, black line); the relationship appeared to progress with increasing level of play.

Discussion: This is a cross-sectional study, and interpretations should necessarily be cautious. Changes in risk with increased level of play could be ascribed equally to increased exposure to the risk of overhand throwing (High school seasons are typically 20 games, college 60 games, and professional 162 games; and increased pitch count has been associated with risk of injury), to simple aging, or to subtle selection pressures as players advance to the professional levels. The loss in dominant shoulder internal rotation in throwers, and specifically in those with a history of shoulder injury is consistent with previous studies.

What is of interest here is the relationship between dominant glenohumeral rotation and contralateral hip internal ROM, and its association with a history of shoulder injury. Again, as in any cross-sectional study, we cannot necessarily infer the sequence of events. It is plausible that a loss of hip motion may allow less force dissipation through the trunk and increase forces on the shoulder; it is equally plausible that the shoulder may have been the site of the primary lesion, followed by compensatory mechanisms that resulted in a loss of hip ROM. However, these results suggest an intriguing set of relationships worthy of future study. It may well be that training to improve hip flexibility in baseball players may be an effective adjunct to upper-extremity training in decreasing the risk of shoulder injury, or in rehabilitation of the injured shoulder.

Acknowledgements: This research was supported by grant number T32-AT00060 from the National Institute on Drug Abuse. The authors thank all the participating baseball players.

Introduction: The act of throwing a baseball is a complex maneuver, involving not only the shoulder, elbow, and wrist, but also an entire “kinetic chain” of the back, hip, and leg. Injuries to any of the links in this chain may be expected to result in alterations in other components, and to possible secondary injuries, as the player attempts to compensate for limitations in local range of motion (ROM). Both hips extend, flex, and rotate throughout the phases of throwing to help generate or dissipate energy. It is plausible, for instance, that throwers with anterior shoulder pathology have associations between the hip and shoulder measures (stabilization, or back) leg. This would cause a pitching mechanism fault called “flying open” (early lower body advancement and/or decreased dominant-side hip extension, developing late arm action). Non-dominant lower extremity (lead leg) restrictions with hip internal rotation on follow-through may lead to posterior shoulder dysfunction.

If the non-dominant hip cannot maximally internally rotate during follow-through to absorb the energy from the acceleration phase, the posterior shoulder will have to become the primary brake to slow down the arm. We hypothesize that decrease of dominant-side hip extension and non-dominant hip internal rotation are associated with altered glenohumeral rotation (specifically, with a decrease in internal rotation), and that this relationship would be greater as skill levels increase (either by increase in level of play, or in pitchers as opposed to position players).

Methods: Population: Under local IRB approval, 124 male volunteer baseball players were included (60 pitchers, 64 position players; 35 high school, 32 NCAA Div. I college, 57 professionals; age 18-32 y). Measurements: Hip internal rotation (sitting), hip extension (supine), shoulder internal and external rotation (supine) were measured during pre-season physical examinations, on a standard plinth, in one trial, by a single PT, using a Biomechanics G300, Industry, CA, a method with a predictable error of ±3 degrees.

“Ipsilateral”=dominant, throwing arm side. Each subject completed a questionnaire that included positions played, general medical history, and specific history of hip, elbow, or shoulder injury. Analysis: Correlations between continuous variables: Associations between the 2 hip measures of interest (ipsilateral extension, and contralateral internal rotation), and the 3 shoulder measures of interest (ipsilateral internal rotation, external rotation, and ROM) were evaluated through the use of Spearman rank-order (non-parametric) and Pearson (parametric) product-moment correlation analyses. Where the results were statistically significant by both methods, the particular relationship was then examined as a function of Level of Play (High School, College, or Professional) and Player Position (Pitcher, or position player) through use of a 2-way ANOVA, with post-hoc Fisher’s LSD test. Risk of shoulder injury: The associations between the hip or shoulder measures of interest, and the history of a shoulder injury were evaluated using a multiple logistic regression, performed in a stepwise manner. Presence or absence of a shoulder injury is considered as a binary outcome, and the measure of interest (continuous), level of play (categorical) and player position (binary) are considered in the initial model as input variables. Input variables whose contribution to the model is significant at the p=0.12 level are kept in the model, and the analysis is repeated, with the standard of inclusion reduced until inclusion threshold is p=0.05. Odds ratios were calculated, and the probability of a shoulder injury was calculated in terms of the logit function Probability(injury)=e^x/(1+e^x), where x is a linear function of the significant risk factors.

Results: Hip and Shoulder ROM: Dominant shoulder internal rotation correlated positively with contralateral hip internal rotation (p=0.0106). Amateur players differed significantly in this relationship from professionals, though the relationship among the college position players approached that of the professionals. Among the high school pitchers there was a negative correlation (p<0.001, r=-0.730) between ipsilateral hip extension and dominant shoulder external rotation, a relationship not present in the higher skill-level subjects. Among the professional non-pitchers, there was a significant negative correlation (p=0.023, r=-0.429) between dominant shoulder total ROM and ipsilateral hip extension.

Shoulder Injury and Shoulder/Hip ROM: A history of shoulder injury was associated with a lower total shoulder ROM (p=0.036, OR=0.978, CI 0.95-0.999), a relationship largely driven by shoulder internal rotation (p=0.0005, OR=0.955, 95%CI 0.925-0.986) and not by shoulder external rotation (p=0.937). Among professionals, a history of shoulder injury was associated with a lower contralateral hip internal rotation (Figure 1, red line). This effect was marginally non-significant when the data from all players were considered (Figure 1, black line); the relationship appeared to progress with increasing level of play.

Discussion: This is a cross-sectional study, and interpretations should necessarily be cautious. Changes in risk with increased level of play could be ascribed equally to increased exposure to the risk of overhand throwing (High school seasons are typically 20 games, college 60 games, and professional 162 games; and increased pitch count has been associated with risk of injury), to simple aging, or to subtle selection pressures as players advance to the professional levels. The loss in dominant shoulder internal rotation in throwers, and specifically in those with a history of shoulder injury is consistent with previous studies.

What is of interest here is the relationship between dominant glenohumeral rotation and contralateral hip internal ROM, and its association with a history of shoulder injury. Again, as in any cross-sectional study, we cannot necessarily infer the sequence of events. It is plausible that a loss of hip motion may allow less force dissipation through the trunk and increase forces on the shoulder; it is equally plausible that the shoulder may have been the site of the primary lesion, followed by compensatory mechanisms that resulted in a loss of hip ROM. However, these results suggest an intriguing set of relationships worthy of future study. It may well be that training to improve hip flexibility in baseball players may be an effective adjunct to upper-extremity training in decreasing the risk of shoulder injury, or in rehabilitation of the injured shoulder.

Acknowledgements: This research was supported by grant number T32-AT00060 from the National Institute on Drug Abuse. The authors thank all the participating baseball players.