RELATIONSHIP BETWEEN HIP RANGE OF MOTION AND PITCHING KINEMATICS IN HIGH SCHOOL BASEBALL PITCHERS

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The purpose of this study was to examine the association of hip rotational range of motion (ROM) with lower extremity and trunk kinematics in high school baseball pitchers. Twenty-five healthy high school baseball pitchers volunteered (15.9 ± 1.1 years). Passive hip internal rotation (IR) and external rotation (ER) ROM was measured with the pitchers seated using a digital inclinometer. Total hip ROM (IR + ER) was calculated for the stride leg and drive leg. Biomechanical data were collected with a 3-D electromagnetic tracking system while pitchers threw three fastballs. Simple linear regression analysis determined drive and stride leg hip IR, ER, and total ROM did not predict pitching kinematics. Future research should continue identifying parameters associated with altered biomechanics that may place baseball pitchers at increased risk of injury.

KEYWORDS: baseball, kinematics, pitching, range of motion.

INTRODUCTION: The repetitive nature of the pitching motion leads to adaptations in the hip joint tissues, often leading to changes in hip range of motion (ROM) and strength (Harding, Picha, & Huxel Bliven, 2018; Laudner, Moore, Sipes, & Meister, 2010; Oliver, Weimar, & Henning, 2016; Robb et al., 2010). Professional pitchers display less hip external rotation (ER), internal rotation (IR), and total ROM in the stride leg compared to the drive leg (Robb et al., 2010). Additionally, decreased stride leg total ROM has been associated with lower trunk separation velocity, while increased total drive leg ROM has been associated with a more open pelvis at foot contact (Robb et al., 2010). Robb et al.(2010) established that hip ROM is different between the stride and drive legs. Additionally, they found associations between stride leg total ROM and ball velocity as well as drive leg total ROM and pelvis rotation in professional pitchers during the arm cocking phase (foot contact to maximal shoulder external rotation) of the pitch. However, professional pitchers and high school pitchers may have different hip ROM profiles due to having more experience and exposure to pitching. Therefore, a comprehensive understanding of the relationships between hip ROM and pitching mechanics is needed in high school pitchers. The purpose of this study was to examine the association of hip rotational ROM with pelvis and trunk rotation and stride length kinematics at foot contact in high school baseball pitchers. It was hypothesized pitchers with lower IR, ER, and total hip rotational ROM would have altered pelvis rotation, trunk rotation, and stride length at foot contact.

METHODS: Twenty-five high school baseball pitchers volunteered (15.9 ± 1.1 years; 180.4 ± 5.5 cm; 75.4 ± 9.3 kg). Inclusion criteria consisted of no injury in the past six months and no history of surgery to the lower or upper extremities. The University's Institutional Review Board approved all testing protocols.

Hip rotational ROM was measured passively with a digital inclinometer. The examiner supported the femur to eliminate accessory motion and passively rotated the hip until capsular end-feel was achieved for both IR and ER. Total ROM was the sum of IR and ER. Minimal detectable change (MDC) values were calculated for hip IR and ER ROM, MDC_{95} was 5.6° and 4.7°, respectively.

Kinematic data were collected with an electromagnetic tracking system device (trakSTAR, Ascension Technologies Inc.; Burlington, VT, USA) synchronized with The MotionMonitor software (Innovative Sports Training; Chicago, IL, USA). Fourteen sensors were placed on the skin to build a full body model and data were collected at 240 Hz. Sensors were placed at the following sites: (1) posterior aspect of the first thoracic vertebrae, (2) posterior aspect of the pelvis at the first sacral vertebrae, (3-4) flat, broad portion of the acromion on the bilateral scapula, (5-6) lateral aspect of bilateral upper arm at the deltoid tuberosity, (7-8) posterior aspect of the bilateral distal forearm, (9-10) lateral aspect of bilateral upper leg centered between the greater trochanter and the lateral condyle of the knee, (11-12) lateral aspect of the bilateral lower leg centered between the head of the fibula and lateral malleolus, (13) dorsal aspect of the second metatarsal of the stride foot, and (14) dorsal aspect of the third metacarpal of the pitching hand. A fifteenth moveable sensor was attached to a plastic stylus and used for digitization of bony landmarks (Wu et al., 2002; Wu et al., 2005).

A link segment model was developed using the stylus. Joint centers for the wrist and elbow were determined by digitizing the medial and lateral aspect of a joint then calculating the midpoint between those two points (Wu et al., 2005). The shoulder joint center was calculated from the rotation of the humerus relative to the scapula (Veeger, 2000). The spinal column was defined as the digitized space between C7-T1 and T12-L1.

After warming up, pitchers threw three maximal-effort four-seam fastballs from a mound, for a strike, and to a catcher at regulation distance. The average of the three trials was calculated for each variable. The drive leg was defined as the ipsilateral hip to the throwing arm and the stride leg was contralateral to the throwing arm as shown in Figure 1. Ball velocity was recorded by a calibrated radar gun (Stalker Pro II; Stalker Radar; Plano TX, USA).

Eighteen simple linear regressions were performed to examine the association between hip IR, ER, and total ROM with pitching kinematics at foot contact including stride length, pelvis rotation, and trunk rotation. A Bonferroni correction was applied to prevent Type 1 error, and statistical significance was set a prior to $p < 0.003$. Paired sample t-tests were also used as secondary analyses to assess differences in IR, ER, and total hip ROM between drive and stride legs.

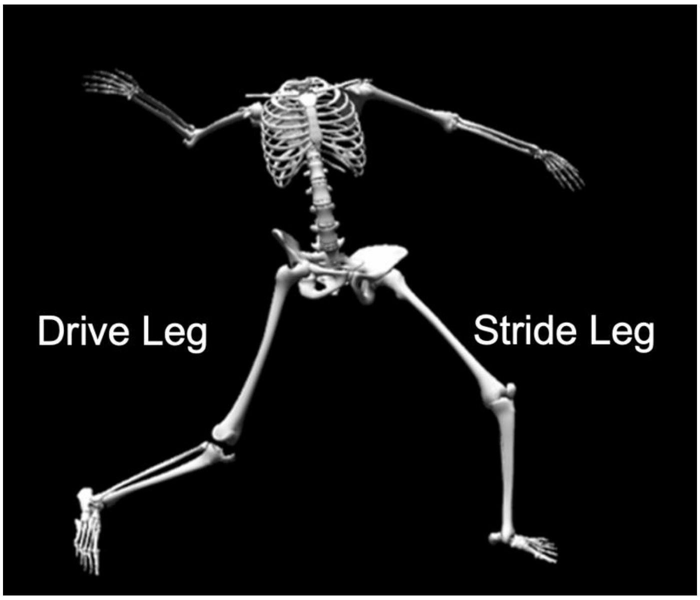

Figure 1. Foot contact of the baseball pitch.

RESULTS: Means and standard deviations can be found for kinematic data at foot contact and hip range of motion values in Tables 1 and 2, respectively. Mean and standard deviation for ball velocity was 70.1 and 4.6 mph, respectively. Simple linear regression analysis indicated drive and stride leg hip IR, ER, and total ROM did not predict pitching kinematics (all p-values > 0.036).

Table 1: Mean (standard deviations) for kinematic data at foot contact.

Pelvis Rotation (°)	Trunk Rotation (°)	Stride Length (m)
-61.1 (11.9)	-98.4 (17.7)	1.2 (0.09)

Table 2: Mean (standard deviations) for stride leg and drive leg hip ROM.

Stride Leg			Drive Leg		
Total ROM (°)	IR ROM (°)	ER ROM (°)	Total ROM (°)	IR ROM (°)	ER ROM (°)
57.0 (11.0)	24.2 (6.8)	32.9 (6.9)	58.2 (13.4)	25.1 (8.2)	33.1 (6.6)

DISCUSSION: Drive and stride leg hip IR, ER, and total ROM did not predict pitching kinematics. These results differ from similar research in professional pitchers (Robb et al., 2010). Robb et al. (2010) found decreased hip total ROM in the stride leg was associated with lower trunk separation velocity. Prior research has speculated that decreased stride leg hip IR ROM contributes to insufficient trunk rotation during pitching and may lead to increased forces about the shoulder and elbow, contributing to tissue breakdown and pain (Saito et al., 2014; Sekiguchi et al., 2020). The current study did not find associations between hip ROM and trunk rotation during baseball pitching; however, the findings were similar to Bullock et al. (2020) that also determined ROM was not associated with trunk rotation in a population of high school baseball pitchers. The lack of association in both studies is likely attributed to samples of pitchers being fairly homogeneous in their stride and drive leg ROM. It is possible that significant associations would be observed in a larger sample of high school pitchers from a variety of regions in the United States. Additionally, other hip ROM variables or hip strength may have a greater effect on pelvis and trunk rotation in high school pitchers.

Robb et al. (2010) additionally determined hip ROM was different between the stride and drive legs in professional pitchers; however, the current study found no differences between drive and stride legs in high school pitchers. High school pitchers appear to have more symmetrical motion at the hips compared to professionals. Total ROM in the current study (drive leg= 58.2°; stride leg= 57.0°) was less than data presented in professional pitchers (drive leg= 94.8°; stride leg= 67.0°). High school pitchers had approximately 37° less drive leg total ROM than professional pitchers, whereas there was not a large discrepancy in stride leg motion. These findings may indicate adaptations only appear in older pitchers who have accumulated more total pitching volume and had more time to elicit musculoskeletal adaptations. This may also explain the discrepancy with the Robb et al. study that found significant associations between hip ROM and trunk and pelvis orientation at foot contact as well as with stride length. These results should be interpreted with caution since ROM in professionals was measured in the prone position whereas the current study assessed ROM in a seated position. Prone positioning may be a less functional way to assess ROM because it reduces compressive forces at the hip.

CONCLUSION: The current study determined drive and stride leg hip IR, ER, and total ROM did not predict pitching kinematics in this population of high school baseball pitchers. High school pitchers also appear to have more symmetrical hip ROM compared to professional pitchers. Future research should continue identifying parameters associated with altered biomechanics that may place baseball pitchers at increased risk of injury.

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