THE CORRELATION BETWEEN LUMBOPELVIC CONTROL AND PITCHING VELOCITY IN BASEBALL PITCHERS

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The purpose of this study was to investigate the relationship between lumbopelvic control and pitching performance among baseball pitchers. Four baseball pitchers participated in this pilot study. Each participant underwent measurements for lumbopelvic control ability in static posture and dynamic movement, as well as pitching performance assessments. The results indicated a significant correlation between lumbopelvic control in the static posture of the stride leg and pitching velocity ($R_s = -1.0$, $p < 0.01$), as well as a significant correlation between lumbopelvic control in dynamic movement and pitching velocity ($R_s = -0.90$, $p = 0.04$). Therefore, lumbopelvic control during pitching could play a pivotal role in enhancing pitching velocity. Coaches and practitioners should prioritize strategies aimed at improving these aspects to potentially enhance pitching velocity.

KEYWORDS: baseball pitchers, lumbopelvic control, pitching velocity

INTRODUCTION: Baseball pitching needs a complex and coordinated motion that uses both the upper and lower bodies to generate the required ball velocity. Although pitching is often associated with the upper extremity, the lower extremity and trunk also play a crucial role in optimizing performance and minimizing the risk of injury.(Chu, Jayabalan et al., 2016; K. Laudner, Wong et al., 2015) During the baseball pitching motion, force is initially created in the legs and then transferred to the trunk and upper extremities. Ensuring uninterrupted force transmission is crucial for effective pitching and injury prevention. Any disruption in force transmission can lead to excessive stress and altered kinematics in the subsequent joints. A crucial aspect of this kinetic chain entails substantial lumbopelvic control to effectively transfer forces generated in the lower extremities through the trunk to the upper extremities.(K. G. Laudner, Wong et al., 2019) Therefore, it is vital to maintain proper force generation and motion throughout the entire body to ensure optimal pitching performance and reduce the risk of injuries. Pitching velocity is one of the most important metrics for evaluating pitching performance in baseball, and researchers have extensively studied the biomechanical factors that impact it. It has been demonstrated that poor lumbopelvic control is associated with decreased overall performance (ex: pitching innings decrease) compared to individuals with better control.(Chaudhari, McKenzie et al., 2011) However, there is no study focused on the lumbopelvic control on the pitching velocity. Therefore, the purpose of this study was to investigate the relationship between lumbopelvic control and pitching velocity among baseball pitchers.

METHODS: Four baseball pitchers (mean age: 16.3 ± 0.5 years, height: 180.0 ± 4.8 cm, weight: 73.3 ± 5.8 kg, duration of baseball training: 6.5 ± 1.9 years) were recruited in this pilot study. Out of the four pitchers, three were right-handed, and one was left-handed. The data was collected in a single session at the baseball field. Prior to pitching, each participant underwent measurements of demographic information and lumbopelvic control. Following the measurements, the participants were given enough time to warm up. Each pitcher was instructed to throw 10 fastballs with maximum effort. During the pitching phase, pitching velocity was measured using a radar gun (Ball Coach Radar, Pocket Radar Inc., USA). The measurement of lumbopelvic control was divided into static posture and dynamic movement assessments. In static posture, a wireless inertial measurement unit (IMU; Xsens MVN Awinda, Xsens Technologies BV, Enschede, Netherlands) was utilized to evaluate lumbopelvic control. The IMU was securely fastened to an elastic belt positioned around the participant's waist, covering the anterior and posterior superior iliac spines.(K. G. Laudner, Wong et al., 2018) The participants were measured using the single-leg balance movement test.(K. Laudner, Wong et al., 2021; K. G. Laudner, Wong et al., 2019) This measurement repeated three times for both legs. The maximum peak absolute pelvic tilt measured from the beginning position was recorded.(Chaudhari, McKenzie et al., 2011; Chaudhari, McKenzie et al., 2014; K. Laudner, Wong et al., 2021) As a result, two variables will be calculated for each leg: anterior-posterior (AP) angle tilt and lateral angle tilt. In dynamic movement, we utilized three high-speed cameras (DFK 33GX287, The Imaging Source, LLC, Charlotte, United States) to capture joint positions during pitching. The cameras operated at a frequency of 300 Hz. Subsequently, we employed this data to measure lumbopelvic stability during the pitching motion. The recorded videos were subject to analysis employing Alphapose, a robust system adept at precise whole-body pose estimation and joint tracking. Subsequent processing through Opensim software facilitated the calculation of joint angles. The markerless motion capture system has already been validated, and the margin of error was within 3 cm compared with the Vicon system. The derived data allowed for the calculation of the mean pelvic angles in all directions: anterior-posterior (AP), lateral, and internal-external (IE), serving as indicators of lumbopelvic control.(Fallahtafti, Salamifar et al., 2022) In each pitch, the pitching motion was divided into three phases: from knee up to foot contact, from foot contact to maximal shoulder external rotation (Max ER), and from Max ER to maximal shoulder internal rotation (Max IR). Spearman correlation was utilized to assess the linear relationship between the variables and ball velocity. A p-value < 0.05 was considered statistically significant. PASW Statistics 25 for Windows (SPSS, USA) was employed for the analysis.

RESULTS: The results showing the relationship between lumbopelvic control in static posture and pitching velocity were illustrated in **Fig. 1**. In the drive leg, no significant correlation existed between the AP angle tilt and pitching velocity (R_s = -0.8, p = 0.2). Additionally, no significant correlation existed between the lateral angle tilt and pitching velocity (R_s = 0.4, p = 0.6). In the stride leg, no significant correlation existed between the AP angle tilt and pitching velocity (R_s = -0.6, p = 0.4). However, a significant correlation was observed between the lateral angle tilt and pitching velocity (R_s = -1.0, p < 0.01).

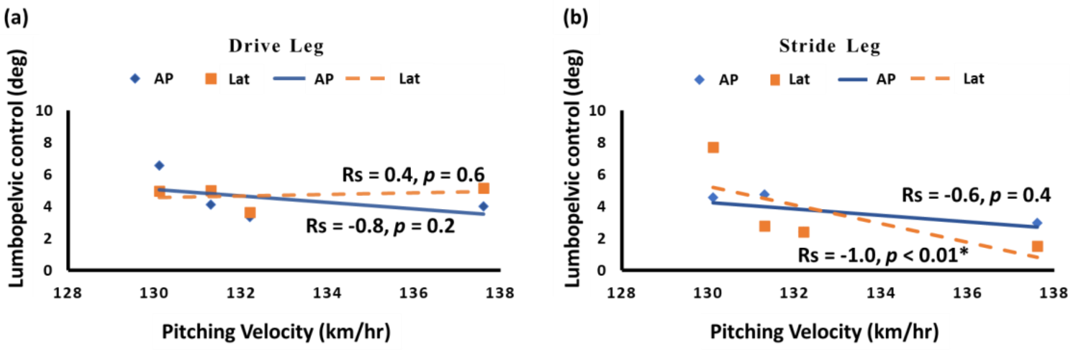

Figure 1: The relationship between lumbopelvic control and pitching velocity. (a) the results in drive leg; (b) the results in stride leg
AP: anterior-posterior tilt; Lat: lateral tilt;* significant correlation (p <0.05)

The results showing the relationship between lumbopelvic control in dynamic movement and pitching velocity were illustrated in **Table 1**. A significant correlation was found between the mean of the pelvic angles in the lateral direction from maximal shoulder external rotation to maximal shoulder internal rotation and pitching velocity (R_s = -0.90, p = 0.04).

Table 1: Correlation of lumbopelvic control in dynamic movement and pitching velocity

Pitching phase	Pelvic angle	Rs	*p*
Knee up to foot contact	AP	-0.50	0.39
	lateral	0.20	0.75
	IE	0.00	1.00
Foot contact to Max ER	AP	0.30	0.62
	lateral	-0.30	0.62
	IE	-0.60	0.29
Max ER to Max IR	AP	-1.00	0.87
	lateral	-0.90	0.04*
	IE	0.10	0.87

DISCUSSION: The purpose of this study was to investigate the relationship between lumbopelvic control and pitching velocity among baseball pitchers. Our preliminary results indicate a significant correlation between lumbopelvic control of the stride leg in the lateral angle tilt in static posture and pitching velocity. Additionally, our initial findings revealed a correlation between lumbopelvic control in dynamic movement, which was pitching motion, and pitching velocity. However, we did not find a correlation between lumbopelvic control of the drive leg and pitching velocity. Previous studies investigating lower extremity mechanics have indicated that the generation of force by the lower limbs plays a crucial role in enhancing pitching velocity.(Elliott, Grove et al., 1988; Guido & Werner, 2012; MacWilliams, Choi et al., 1998) The results of one of these studies demonstrated correlations between stride leg ground reaction forces and upper extremity mechanics, which may be related to injuries in collegiate baseball pitchers.(Guido & Werner, 2012) Other studies have illustrated a strong relationship between stride leg ground reaction forces and ball velocity.(MacWilliams, Choi et al., 1998; McNally, Borstad et al., 2015) Therefore, when compared with the drive leg, the stride leg appears to play a more significant role in generating pitching velocity. Previous study has mentioned that the more stable the trunk is, the less energy is prone to dissipate during the transmission of the kinetic chain.(Machado, Haik et al., 2023) In the baseball pitching motion, force originates in the legs and subsequently travels through the trunk and upper extremities. Ensuring smooth force transmission is paramount for successful pitching and injury prevention. Any interruption in this process can result in excessive strain and changes in the movement patterns of subsequent joints. The effective flow of energy through the kinetic chain depends on maintaining stable lumbopelvic control.(Chaudhari, McKenzie et al., 2011; K. G. Laudner, Wong et al., 2018) Our preliminary results indicated that lumbopelvic control in the lateral direction from maximal shoulder external rotation to maximal shoulder internal rotation during pitching was correlated with pitching velocity. Therefore, lumbopelvic control during pitching might play a pivotal role in generating pitching velocity.

CONCLUSION: Lumbopelvic control emerges as a key factor in enhancing pitching velocity among baseball pitchers. These findings underscore the importance of prioritizing lumbopelvic control in training programs for pitchers. Coaches and practitioners should focus on strategies aimed at improving these aspects to potentially enhance pitching velocity. However, further research with a larger sample size is essential to validate these initial results and provide more comprehensive guidance for clinical practice in this study.

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ACKNOWLEDGEMENTS: This work was supported by National Science and Technology Council (NSTC 112-2425-H-028-002).