Lumbopelvic Control and Pitching Performance of Professional Baseball Pitchers

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Abstract

Chaudhari, AMW, McKenzie, CS, Borchers, JR, and Best, TM. Lumbopelvic control and pitching performance of professional baseball pitchers. *J Strength Cond Res* 25(X): 000–000, 2011—This study assessed the correlation between lumbopelvic control during a single-leg balancing task and in-game pitching performance in Minor-League baseball pitchers. Seventy-five healthy professional baseball pitchers performed a standing lumbopelvic control test during the last week of spring training for the 2008 and 2009 seasons while wearing a custom-designed testing apparatus, the "Level Belt." With the Level Belt secured to the waist, subjects attempted to transition from a 2-leg to a single-leg pitching stance and balance while maintaining a stable pelvic position. Subjects were graded on the maximum sagittal pelvic tilt from a neutral position during the motion. Pitching performance, number of innings pitched (IP), and injuries were compared for all subjects who pitched at least 50 innings during a season. The median Level Belt score for the study group was 7°. Two-sample *t*-tests with equal variances were used to determine if pitchers with a Level Belt score $<7°$ or $\geq 7°$ were more likely to perform differently during the baseball season, and chi-square analysis was used to compare injuries between groups. Subjects scoring $<7°$ on the Level Belt test had significantly fewer walks plus hits per inning than subjects scoring $\geq 7°$ (walks plus hits per inning pitched, 1.352 ± 0.251 vs. 1.584 ± 0.360, $p = 0.013$) and significantly more IP during the season (IP, 78.89 ± 38.67 vs. 53.38 ± 42.47, $p = 0.043$). There was no significant difference in the number of pitchers injured between groups. These data suggest that lumbopelvic control influences overall performance for baseball pitchers and that a simple test of lumbopelvic control can potentially identify individuals who have a better chance of pitching success.

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Introduction

Baseball pitching is a physically demanding and technically challenging activity, requiring decades of practice to reach the most elite levels of the sport. Even at the highest levels, coaches and administrative staff continuously monitor pitching technique and recent performance when making decisions to retain or release personnel. Although many aspects of pitching mechanics have been explored (1,2,8–15,17–20,25,27,28,33,34,38,39), most of these studies have focused on the shoulder and elbow. Excessive joint moments at the extremes of the range of motion for both shoulder and elbow have been identified as risk factors for pain and ligamentous injury at all levels of competition (8–11,13–15,17–19,27,28,33,38). Studies that included kinematics of the pelvis and torso have primarily focused on the gross twisting and bending motions of the upper torso relative to the pelvis (1,8,16,27,33,39,40). However, an examination of the stages of the pitching motion clearly suggests that the musculature of the hips and torso must play a role in creating an efficient baseball pitch. The initiation of a pitch begins with leg motion, to both counterbalance the extending arm and propel it forward.

Previous studies have shown that pitchers who are able to throw the fastest develop the largest ground reaction forces, suggesting that a successful pitch depends on energy generation from the legs (25). This energy must be transferred from the lower extremity through the body to the throwing hand (35), theoretically requiring optimal lumbopelvic control. Moreover, with proper lumbopelvic control a pitcher may be able to contract the hip, pelvis, and torso muscles to generate additional energy and efficiently transfer it to the throwing hand. Based on this theory, a pitcher with poorer lumbopelvic control may not be able to achieve as high a pitch velocity (power) as a pitcher with better lumbopelvic control, or he or she may have less control over pitch placement because of fatiguing more quickly (endurance). A few studies on pitching

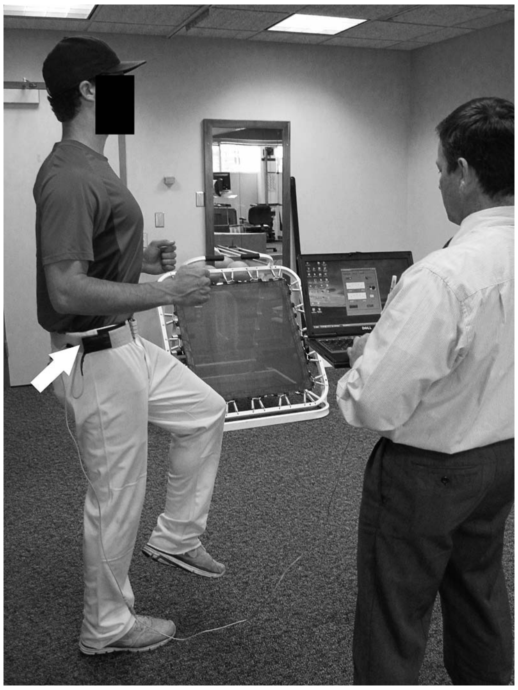

Figure 1. Subject wearing the Level Belt around the waist at the level of the anterior and posterior superior iliac spines. The sensor (arrow) is placed on the stance side.

mechanics have measured pelvic or torso motion with respect to pitch velocity (38,39), but to date, none have attempted to relate pitching mechanics to either lumbopelvic control or in-game performance. Direct examination of the role of lumbopelvic control to pitching performance could be an important step in refining and improving strength and conditioning training programs for pitchers to achieve peak performance (1,23) and may have implications for training regimens for athletes in other sports.

Using the "Level Belt," a clinical tool that we designed to measure lumbopelvic control in a functional upright posture, it was possible to examine the relationship between lumbopelvic control and performance in professional baseball pitchers. We hypothesized that pitchers with below-average performance on the Level Belt test would demonstrate poorer pitching performance compared with pitchers with above-average performance on the test. Pitching performance was assessed using the abovementioned standard metrics: number of innings pitched (IP), batting average against (BAA), strikeouts per inning (BBin), walks per inning, and walks plus hits per inning pitched (WHIP).

Methods

Experimental Approach to the Problem

We have developed a device called the "Level Belt" (patent pending) (4) to estimate the subject's ability to maintain a level pelvis in a standing position while shifting weight from double-leg to single-leg stance (30). The subject wears the device around the waist at the level of the anterior and posterior superior iliac spines (Figure 1), and the device uses an accelerometer-based sensor to measure the total range of anterior and posterior pelvic tilt relative to the horizon in degrees as the subject shifts to a controlled single-leg stance position and back to a double-leg stance position.

Standing lumbopelvic control was assessed using the Level Belt test during the last week of spring training. Through the course of the season, pitching statistics including IP, BAA, BBin, WHIP, and strikeouts per inning (Kin) were collected by individuals who were blinded to the Level Belt results and published on the official web site for Minor-League Baseball (31,32).

Subjects

Seventy-five healthy male professional minor-league baseball pitchers enrolled in this study during the last week of spring

Table 1. Performance, age, and injury results for group with better lumbopelvic control (LB < 7) and group with poorer lumbopelvic control (LB ≥ 7).*

	LB ≥ 7 ($n = 16$)†	LB < 7 ($n = 32$)†	Effect size	p Value
IP	53.4 ± 42.5	78.9 ± 38.7	0.64	0.043
WHIP	1.584 ± 0.360	1.353 ± 0.251	0.79	0.013
BAA	0.280 ± 0.059	0.260 ± 0.033	0.46	0.133
Kin	0.689 ± 0.160	0.767 ± 0.180	0.45	0.147
(BBin)	0.437 ± 0.279	0.334 ± 0.182	0.47	0.131
Age (y)	22.4 ± 2.3	22.6 ± 2.0	0.11	0.727
Number injured during season	8 of 16	12 of 33		0.362

*IP = innings pitched; WHIP = walks + hits per inning; BAA = batting average against; Kin = strikeouts per inning; BBin = walks per inning; LB = Level Belt score.

†Values are given as mean ± *SD*.

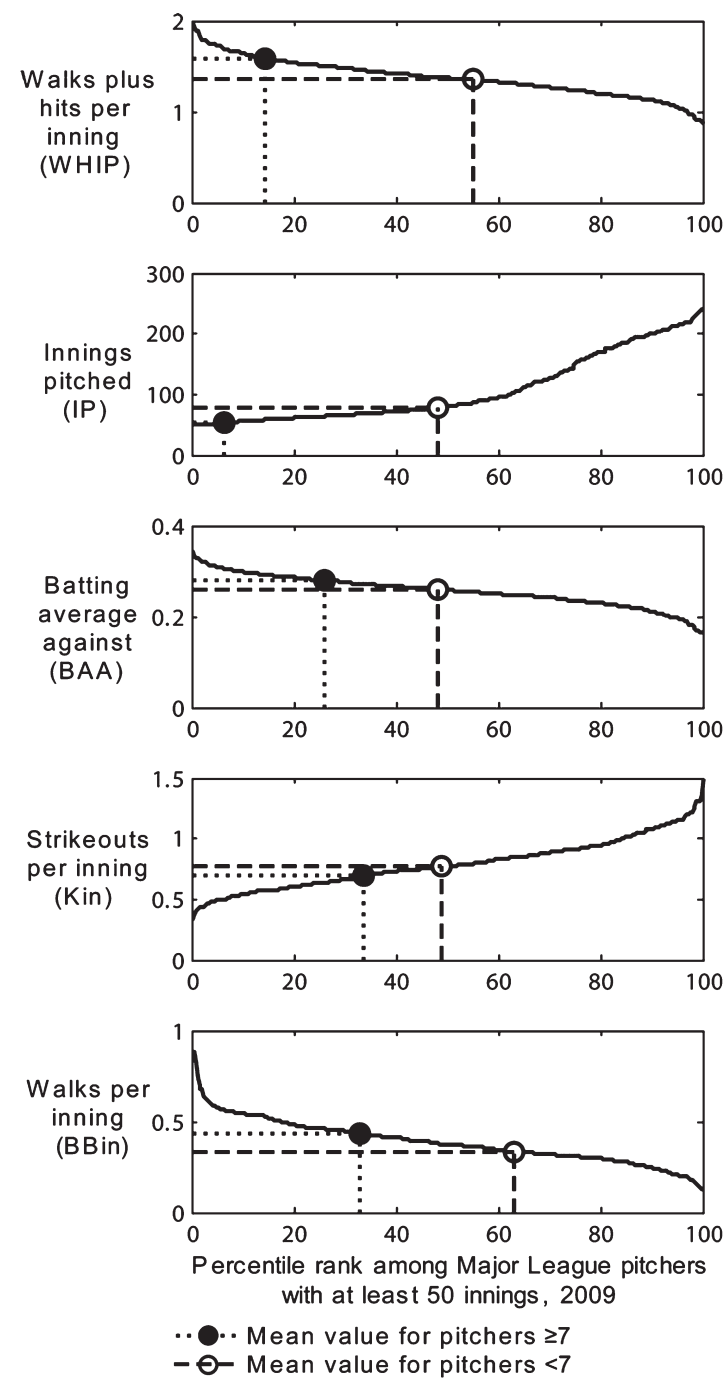

Figure 2. Distribution of walks plus hits per inning pitched (WHIP), innings pitched (IP), batting average against (BAA), strikeouts per inning (Kin), and walks per innings (BBin) among all Major League pitchers with at least 50 innings in 2010 ($n = 338$). Mean values for the 2 groups in the study (●: poorer lumbopelvic control and ○: better lumbopelvic control) are overlaid.

training before the 2008 and 2009 baseball seasons after providing informed consent as approved by the Institutional Review Board (2007H0030) of The Ohio State University. Each player was only tracked for a single season. The previous experience of these pitchers was unknown, but it can be assumed that their backgrounds and prior playing experience varied. All pitchers were tested at the spring training facilities of 1 baseball organization. To eliminate the possibility of skewed results because of a lack of IP, only the 48 pitchers who pitched 50 innings or more in Minor-League competition (A, AA, or AAA levels) were included in the analysis. The average age of these 48 pitchers was 22.5 ± 2.1 years.

Procedures

The Level Belt test was performed in the morning before engaging in any strengthening, throwing, or other workouts. Each subject was asked to find his own self-selected neutral position of the pelvis. From this neutral position with weight equally distributed across both feet, the subject was asked to lift the foot of his kicking leg approximately 10 cm, hold that position under control for 2 seconds, and then return under control to double-leg stance. This test was not intended to be for extended ability to maintain single-leg balance; a 2-second hold was chosen to allow the subject to demonstrate the ability to reach the position under control, without challenging the subject to hold a single-leg stance long enough to fatigue. The peak deviations from neutral in both the anterior and posterior directions during the entire motion were recorded. The larger absolute value of the anterior and posterior peak measurements was used for analysis. Subjects were only permitted 1 trial unless they stumbled on the first trial to limit potential training effects, and no specific instruction on how to perform the test beyond "Keep your waist still and level" was given. For subsequent analysis, the 49 pitchers who pitched 50 or more innings or were injured during the season were separated into 2 groups based on lumbopelvic control: those whose Level Belt score was less than the median value of 7° and those whose score was greater than or equal to 7°.

Statistical Analyses

Statistical comparison of the 2 groups was performed for each variable of interest using a Student's t-test with equal variances. No corrections for multiple comparisons were performed. One player suffered an injury before pitching in any games, so only 48 players were included in the tests of performance variables. Mean ± SD was calculated for each group + variable combination. To assure that one group did not display poorer performance because of injury alone, injuries were tabulated by the medical staffs of the teams at the different levels of minor-league competition (A, AA, AAA), where an injury was defined as missing at least 1 day of work because of a throwing-related problem. Any player who suffered multiple injuries through the course of the season was only counted once, because of any subsequent injuries could be because of returning from the index injury too quickly or due to compensations for the index injury. A Chi-square test was performed on all 49 pitchers to determine whether the number of injuries experienced was significantly different between the 2 groups. A priori thresholds for statistical significance for all tests were set at $p \leq 0.05$. All statistical calculations were performed in STATA version 10 (StataCorp, College Station, TX, USA).

Results

The results of the statistical analyses including effect sizes (ESs) (7) are included in Table 1. Two of the performance variables showed significant differences between groups: WHIP (accuracy) and total IP (endurance). Walks plus hits per IP were significantly lower for the group with better lumbopelvic control than for the group with poorer lumbopelvic control (WHIP, 1.352 ± 0.251 vs. 1.584 ± 0.360, ES = 0.79, $p = 0.013$). The group with better lumbopelvic control also pitched significantly more innings on average (IP, 78.89 ± 38.67 vs. 53.38 ± 42.47, ES = 0.64, $p = 0.043$). Trends toward significantly better performance in the group with better lumbopelvic control were seen in opponents' batting average (BAA, 0.260 ± 0.033 vs. 0.280 ± 0.059, ES = 0.46, $p = 0.133$), strikeouts per inning (Kin, 0.767 ± 0.180 vs. 0.689 ± 0.160, ES = 0.45, $p = 0.147$), and walks per inning (BBin, 0.334 ± 0.182 vs. 0.437 ± 0.279, ES = 0.47, $p = 0.131$). No differences in injury incidence were seen between the 2 groups. Chi-square analysis did not show any significant difference in the incidence of injuries suffered by the group with poorer lumbopelvic control (Level Belt scores ≥7°) over the course of the season vs. the group with better lumbopelvic control (Level Belt scores <7°) ($p = 0.362$).

Discussion

A limitation that has perhaps prevented widespread research into the role of lumbopelvic control in baseball pitching has been the lack of a clinical tool for its measurement in a functional position (23). In fact, most research examining lumbopelvic control or "core stability" has actually used strength, endurance, or both as surrogate measures rather than directly measuring control. For example, the Biering–Sorensen test measures endurance of the lumbar extensors in a prone position (3). The side bridge test quantifies endurance of the lateral core muscles such as the quadratus lumborum (29). Isometric tests have also been used to measure hip abductor and external rotator strength as surrogates for "core stability"(24), but none of these tests measure how the individual controls his or her hips, pelvis, and torso during a functional activity.

One functional test that is commonly used as an estimate of lumbopelvic control in the rehabilitation setting is the Abdominal Muscle Test described by Gilleard and Brown (21). In this test, the subject lies in a supine position and attempts to maintain the lumbar spine a fixed distance from the table while performing progressively more difficult lower extremity activities. An inflated air bladder similar to a blood-pressure cuff placed between the lumbar spine and the table provides a visual display of whether the subject is maintaining that fixed distance. Although this test meets the desired requirement to measure the subject's ability to control the hips, pelvis, and torso while performing an activity with the legs, it is not ideal because the subject is supine rather than maintaining an upright posture. We developed the "Level Belt" to estimate the subject's ability to maintain a level pelvis in a standing position while shifting weight from double-leg to single-leg stance and overcome the limitations of previous studies (30).

To our knowledge, our study is the first to show quantitatively that lumbopelvic control is related to pitching performance in elite baseball pitchers. Our results support the hypothesis that lumbopelvic control is an important component to successful pitching and provide motivation for future research investigating the influence of lumbopelvic control on pitching mechanics. The mechanism by which lumbopelvic control might influence performance remains unknown. Poor lumbopelvic control may be associated with poor ball control or velocity if pitchers are unable to transfer energy efficiently from the lower body to the throwing arm. In this case, pitchers may overexert the muscles of the shoulder and arm to create velocity, perhaps forfeiting control in the process. Future studies may be able to characterize these associations and lead to improved training techniques to improve lumbopelvic control for improved performance and, possibly, reduced injury.

The observed mean differences between the 2 groups (defined by Level Belt score) in the performance variables all were clinically significant at elite levels of competition, in addition to showing moderate to large ESs and either statistical significance or a trend toward it. For example, the difference in mean WHIP of the 2 groups was 0.23, which would equal approximately 2 hits or walks in a 9-inning game. This difference is clearly enough to alter the outcome of a game. Figure 2 shows the distributions of WHIP, IP, BAA, Kin, and

BBin from the 338 pitchers in Major League baseball who pitched 50 or more innings in 2009 (26), with the mean values for the 2 groups in this study overlaid. For each of these variables, the pitchers in the group with better lumbopelvic control rank very close to the median for Major League pitchers, whereas the pitchers in the group with poorer lumbopelvic control rank in the bottom third. For BAA, Kin, and BBin the results of the statistical tests had p values of 0.13–0.15 (Table 1). Although these p values do not reach the standard desired value of 0.05, by the definition of type 1 error (5) they indicate that we are 85–87% certain that the mean values of the 2 groups are different from one another in these variables. This level of certainty may be high enough to influence personnel decisions at elite levels of competition. In contrast, the p value of the Chi-square test comparing injury incidence was 0.362. We interpret this lack of difference between groups in injury rates to suggest that we should not expect any bias in the performance data because of injuries in the group with poorer lumbopelvic control. Future study with a larger population is necessary to determine if lumbopelvic control is related to injuries when exposure and performance variables are considered as covariates.

The results of this study must be considered in light of its limitations. The subject population was small and represented a small subset of the overall pitching population. It did not examine major league pitchers, youth baseball pitchers, or adolescent pitchers. Youth baseball pitchers are typically much smaller and weaker, whereas major league pitchers may be larger and stronger, leading to different requirements for lumbopelvic control in these other groups. However, previous kinematic and kinetic comparisons of baseball pitching found that almost all position and temporal parameters of the baseball pitch were conserved across age and skill levels (19). The WHIP is fundamentally a measure of the pitcher's ability to control the trajectory of the ball, and IP is in large part because of a pitcher's physical fitness and endurance. Therefore, this previously observed invariance in kinematics and kinetics between skill levels suggests that players at all levels may experience similar relative limitations in the control and fitness of the lumbopelvic region. Although future research is important to identify the variation in lumbopelvic control across skill levels, these observations may be an indication for increasing lumbopelvic control and fitness at all skill levels.

One limitation of using the Level Belt to assess lumbopelvic control is that no a priori guideline exists for delineating "good" vs. "bad" lumbopelvic control. Because of this lack of prior data, we chose the median value of 7° as the threshold for separating groups. It is possible that a different threshold value might reveal a larger difference between groups, but with such a small number of subjects, it was not possible to perform a sensitivity analysis of the choice of threshold. Moreover, it is likely that different thresholds may be appropriate for athletes at different levels of competition, in different sports and activities, of different gender, or at different maturation stages. Future work should attempt to determine the best threshold to differentiate between lumbopelvic control in this and other athletic populations.

Another potential limitation of using the Level Belt to assess lumbopelvic control is that the device measures pelvic tilt in the sagittal plane relative to horizontal, which is only a portion of the complete control of the hips, pelvis, and torso. In the future, measuring motion of the pelvis relative to horizontal in the coronal plane may provide additional insight. Moreover, while standing, the position of the pelvis is also affected by the motion of the lower extremity and the torso. Therefore, the measurement made by the Level Belt is a function of several different parameters, some of which are external to the pelvis itself, rather than a single measure of the pelvis independent of the rest of the body. Other research testing paradigms have been developed that attempt to isolate the torso and specifically the lumbar spine more effectively, such as unstable sitting (6,37) or applying a sudden perturbation to the torso (22,36,41). However, these paradigms involve complicated and difficult-to-operate devices that may not be suitable for a clinical or on-the-field setting.

Practical Applications

This study used an objective, quantitative measurement device to observe that professional baseball pitchers with poorer lumbopelvic control did not perform as well as those with better lumbopelvic control. This study represents only a beginning, demonstrating a relationship between lumbopelvic control and performance that should be considered by strength and conditioning professionals when developing programs aimed at improving pitching performance of baseball players at all levels of skill. A similar approach in the future may also yield valuable insights into the role of lumbopelvic control in other athletic activities as well.

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