KINEMATIC CHANGES AT BALL RELEASE IN BASEBALL PITCHING OVER A SIMULATED GAME OF BASEBALL

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INTRODUCTION

The defensive nature of baseball causes it to be dominated by the skill of the pitcher, who through speed of pitch or a combination of speed and guile in controlling the ball often determines the result of the game (Polk, 1982). Correct pitching mechanics enables a pitcher to throw the ball repeatedly at high velocities without undue risk of injury. Proper mechanics will only happen through the coordination of complex body movements. Coordination in pitching concerns the timing of various body motions such as trunk rotation, lower limb drive, and nonthrowing-limb and throwing limb movements. Inconsistent or erratic pitching performances will almost always result from an incorrect sequencing of body segment motions (Elliott, Grove, & Gibson, 1988).

There have been several studies describing the kinematics of pitching mechanics over a game situation. A starting pitcher may throw 200 pitches a game including warmup and may start 20-40 games a season. Since baseball is a game dominated by the skill and performance of the pitcher, fatigue could lead to a decrease in effectiveness of the pitcher and possibly the loss of the game. Poor mechanics due to fatigue could also lead to the injury of the pitcher. If a coach is knowledgeable about the effects of fatigue on pitching he can develop proper training exercises, identify when a pitcher is becoming fatigued, and possibly save a pitcher from injury.

The purpose of this experimental repeated measures design study was to kinematically describe the changes in pitching mechanics over a single simulated game of baseball pitching using collegiate pitchers. More specifically, it was to determine if there were changes in stride length, foot contact/baseball release time, release height, ball velocity, and knee angle, hip angle and trunk angle of the striding leg at ball release.

METHODS

Seven experienced collegiate baseball pitchers volunteered to participate in this study. Prior to collecting data, subjects were informed of the protocol of the study and signed a consent form. The Peak5 2D Video Motion Analysis System (Englewood, CO) with a super VHS camcorder (Pulnix

TM 620) set at 120 Hz was used in the collection of kinematic data. A Jugs radar gun was used to collect the velocity of the pitched baseballs.

The protocol for the simulated game was based on the research of Potteiger, Blessing, and Wilson (1992). The subjects were given five warm-up pitches at the beginning of each inning. Warmup pitches were thrown at a rate of one pitch every 12 seconds. Subjects then threw 14 pitches per inning at a rate of one pitch every 20 seconds. The subjects were instructed to throw at 100 percent effort on every other pitch which included the pitches being filmed and throw 85-90 percent on the other pitches. After 14 pitches (one inning), the subjects were given a 6-minute test period before beginning the next inning. Testing was completed when the subjects finished seven innings of pitching. The total number of pitches thrown, excluding warmup, was 98.

The subjects were videotaped during the lst, 7th, and 13th pitch of every inning using the Peak5 video camera. Velocity of the pitch was determined by a Jugs radar gun at the time of each pitch.
The data were analyzed from start to finish of pitches 1, 7,. 13 and of innings 1, 4, and 7. The values obtained from the video analysis were averaged according to the variable, pitch, and the inning using a 3x3 ANOVA. Alpha level was set at $p \leq .05$.

RESULTS

The results of the kinematic analysis are shown in Table 1. They include the 7 parameters under investigation for pitches 1, 7, 13 during innings 1, 4, and 7.

Table 1.
Kinematic data for pitches 1, 7, 13 during innings 1, 4, and 7.

Parameter	Inning 1	Inning 4	Inning 7
Velocity (mph)			
1st pitch	80.5	81.3	79.6
7th pitch	78.0	81.0	79.1
13 th pitch	81.6	81.0	79.5
Release height (m)			
1st pitch	2.22	2.24	2.27
7th pitch	2.21	2.23	2.22
13th pitch	2.23	2.20	2.21

Parameter	Inning 1	Inning 4	Inning 7
Stride length (m)			
1st pitch	1.37	1.40	1.37
7th pitch	1.37	1.38	1.37
13th pitch	1.38	1.36	1.38
Knee angle (deg)			
1st pitch	201	195	203
7th pitch	206	200	203
13th pitch	207	200	201
Foot contact/ball release (s)			
1st pitch	.161	.179	.168
7th pitch	.182	.168	.175
13th pitch	.168	.168	.168
Hip angle (deg)			
1st pitch	233	254	250
7th pitch	247	249	251
13th pitch	241	247	250
Trunk angle (deg)			
1st pitch	255	258	254
7th pitch	255	257	255
13th pitch	257	257	257

Following the statistical analysis involving the 3x3 ANOVA, it was determined that there were no significant changes in the kinematic parameters of ball velocity, stride length, foot contact to ball release time, release height, knee angle and trunk angle between innings. There was, however, a significant difference in the hip angle between innings and an interaction between inning and pitch. A paired t-test was used to determine that there was a significant difference between pitch 1 of inning 1 and pitches 1, 7 and 13 of innings 4 and 7. There were no significant changes in any of the kinematic parameters between pitches.

DISCUSSION

KNEE ANGLE

The knee flexes to increase distance over which work is done (Hay, 1993). One would expect that as a pitcher fatigues, the depth of the knee flexion would decrease. The pitchers in this study did not change knee angle over the course of a simulated game.

RELEASE HEIGHT

The height at which the ball is released varies from pitcher to pitcher and in some cases from pitch to pitch. Atwater (1979) found variations in release height from fast ball to curve ball in professional ball players. The subjects in the current study threw all fast balls on the pitches analyzed. The release height determines where the ball is released and subsequently where in the strike zone the ball will pass. Generally speaking, pitchers must throw fast balls at angles above the horizontal to get them into the strike zone. (Selin, 1959). As pitchers fatigue, the elbow tends to drop which lowers the release height. This creates high pitches and less velocity. (Kalmer, 1982). No significant changes were noted in the release height of the pitchers in this study over the course of the simulated game.

STRIDE LENGTH

Related to the release height is the stride length. As stride length increases, release height decreases. No significant changes were observed in the pitchers over the course of a simulated game. This is not surprising since there were no differences in the release height.

FOOT CONTACT TO BALL RELEASE TIME

This study showed foot contact to ball release time to be consistent over the course of a simulated game. There was no previous literature to suggest that this time factor changes over the course of a game.

HIP AND TRUNK ANGLES

The angle of the hip at ball release did show significant differences between innings. The pitchers showed more flexion at the hip after inning 1. This significant change in the hip angle may be due to a warming up of the lower back and leg muscles. It may also be important to note that since there was no significant change in release height between inning 1 and 4, but there was a change in the hip angle, the angle of the arm would have had to adjust to maintain the same release height. It is also interesting that even though the hip angle did change, the trunk angle did not change significantly.

BALL VELOCITY

Perhaps the most meaningful finding of this study involved the ball velocity. Over the course of a simulated game, there were no significant changes in the velocity of the pitch. One would expect that a decrease in velocity would indicate that the pitcher is tiring. Since the velocity of the pitch did not change over the course of the game, all kinematic parameters observed would not have been expected to change. Perhaps the controlled conditions of the study were not conducive to eliciting a fatigue pattern. In a real game situation, psychological as well as physical factors could contribute to the fatigue of a pitcher. There may be times in a live game when the pitcher has to sprint to a base or be involved in a run down, and then there are times when there is pressure on the pitcher to the produce when there are runners on the bases.

CONCLUSIONS

Based on the scope and limitations of this study, the following conclusions were drawn: (1) During a simulated game situation coaches may not see the same changes in stride length, ball velocity, release height, foot contact to ball release time, and knee and trunk angle at ball release. This may not hold true in an actual game situation; (2) During a simulated game situation the coach may observe changes in hip angle at ball release that may reflect changes during an actual game; and (3) Fatigue did not occur in the span of 98 pitches in a simulated game situation, as measured by the constant velocity of the pitched ball.

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