

## THE KINEMATIC CHANGES OF PITCHING DURING A SIMULATED BASEBALL GAME

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### INTRODUCTION

Maintaining consistent maximum ball velocity is an important factor for baseball pitchers. At the latter half of the game, ball velocity and control decrease due to fatigue by excess of pitching. Therefore, it is difficult for a baseball pitcher to pitch the whole game in many cases. The purpose of this study was to investigate the effect of fatigue on changes of pitching kinematics during a simulated baseball game.

### METHODS

Six male college baseball pitchers threw 15 pitches in an inning for 9 innings (135 pitched) in an indoor pitcher's mound. Rest time between innings was 6 minutes.

Three-dimensional positions of 47 reflective markers attached to subjects were tracked by an optical motion capture system (Vicon Motion System 612, Oxford Metrics) with eight cameras (250Hz). For each subject two fastball pitches (one in the 1<sup>st</sup> inning and one in the 7<sup>th</sup> inning) were chosen for analysis.

The pitching motion was divided into three phases by four instants of motion events: the first phase was defined as a phase from the instant for maximal knee height of the stride leg (MAXknee) to the instant for minimal ball height (MINball), the second phase from MINball to stride foot contact (SFC), and the third phase was from SFC to ball release (REL).

Differences among kinematic parameters were analyzed by paired t-test with significant level of 5%.

Kinematic parameters were analyzed as follows: ball velocity, knee angle of lead leg, shoulder rotation angle (Figure1), pelvis rotation angle, abduction angle and horizontal abduction angle of throwing arm, forward tilt angle (Figure2) and lateral tilt angle of trunk, backward tilt angle (Figure2) and lateral tilt angle of shank.

### RESULTS AND DISCUSSION

Four of ten kinematic parameters changed significantly between 1<sup>st</sup> inning and 7<sup>th</sup> inning (Table1).

1) The ball velocity of 7<sup>th</sup> inning was significantly smaller than that of 1<sup>st</sup> inning. It is generally accepted that the ball velocity often decreases when a pitcher throws about 100 pitches. Therefore, this research had the same tendency as the generally considered one.

2) The shoulder rotation of 7<sup>th</sup> inning at SFC was significantly larger than that of 1<sup>st</sup> inning. It shows that the shoulder is open up at SFC. Stodden et al.<sup>3)</sup> indicated that pitchers could generate larger momentum and transfer it from the trunk to the throwing arm when they were in a proper position to optimally rotate the pelvis and upper torso (shoulder). Therefore, it is important to twist the trunk appropriately.

3) The forward trunk tilt of 7<sup>th</sup> inning at REL was smaller than that of 1<sup>st</sup> inning. Matsuo et al<sup>1)</sup> found that ball velocity increased as forward trunk tilt increased. It is inferred that forward trunk tilting at REL might be appearance that the pitcher tried to enlarge the ball velocity.

4) The backward shank tilt of 7<sup>th</sup> inning at REL was larger than that of 1<sup>st</sup> inning. Murray et al.<sup>2)</sup> showed that the knee flexion angle at REL might indicate muscle fatigue. In turn, less energy was transferred from the support leg to the trunk, subsequently decreasing the amount of energy in the throwing arm at 7<sup>th</sup> inning.

### REFERENCES

1. Matsuo T, Escamilla R F, Fleising G S, et al (2001): Comparison of Kinematic and Temporal Parameters Between Different Pitch Velocity Groups. *Journal of Applied Biomechanics* 17: 1-13
2. Murray T A, Cook T D, Werner S L, Schlegel T F et al (2001): The Effects of Extended Play on Professional Baseball Pitchers. *The American Journal of Sports Medicine* 39(2): 137-142.
3. Stodden D F, Fleisig G S, McLean S P, et al (2001): Relationship of Pelvis and Upper Torso Kinematics to Pitched Baseball Velocity. *Journal of Applied Biomechanics*, 17: 164-172

Table 1: Kinematic differences between 1<sup>st</sup> inning and 7<sup>th</sup> inning

Parameters	1 <sup>st</sup> inning	7 <sup>th</sup> inning	P value
<b>Ball velocity (m/s)</b>	34.5	33.1	0.020
<b>Stride foot contact</b>			
<b>Shoulder rotation (deg)</b>	67.7	69.7	0.014
<b>Ball release</b>			
<b>Forward trunk tilt (deg)</b>	57.1	54.6	0.025
<b>Backward shank tilt (deg)</b>	99.1	102.7	0.032

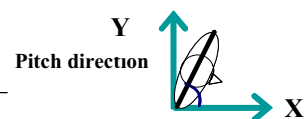


Figure 1: Shoulder rotation

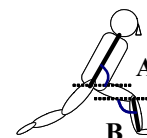


Figure 2:  
 A) Forward trunk tilt  
 B) Backward shank tilt