THE KINEMATIC CHANGES OF PITCHING DURING A SIMULATED BASEBALL GAME

1 Daisaku HIRAYAMA, 2 Norihisa FUJII
1Graduate School of Comprehensive Human Science, University of Tsukuba, Japan
2Institute of Health and Sport Sciences, University of Tsukuba, Japan
e-mail: daisaku-h@lasbim.taiiku.tsukuba.ac.jp

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 1st inning and one in the 7th 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 1st inning and 7th inning (Table1).

1) The ball velocity of 7th inning was significantly smaller than that of 1st 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 7th inning at SFC was significantly larger than that of 1st inning. It shows that the shoulder is open up at SFC. Stodden et al.3) 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 7th inning at REL was smaller than that of 1st inning. Matsuo et al1) 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 7th inning at REL was larger than that of 1st inning. Murray et al.2) 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 7th inning.

REFERENCES

Table 1: Kinematic differences between 1st inning and 7th inning

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

Figure 1: Shoulder rotation

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