KINEMATIC AND KINETIC COMPARISON OF DIFFERENT VELOCITY BASEBALL PITCHERS

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INTRODUCTION

Pitching faster ball is one of the most important abilities for baseball pitchers. There are many investigations of baseball pitching motions focused on pitching kinematics in a range of different skill levels. Although there are a few investigations of pitching kinetics, there are no comparative investigations of the differences in pitching kinetics between different pitch velocity pitchers. By comparing kinetics of the pitcher with different ball speeds, the sizes and timings of kinetic parameters which the pitcher with a fast ball velocity demonstrates can be carried out for whether being dawn, and the useful knowledge for coating is acquired. The purpose of this study was to compare the pitching kinematics and kinetics between two levels of pitchers.

METHODS

Twenty-two healthy baseball players (19 pitchers and 3 fielders, 18 right-handed and 4 left-handed) volunteered to participate in this study as subjects. After warming up, the subjects threw fastballs from regular pitcher’s mound toward a catcher with maximal effort until they were fully satisfied (3~5 trials). Pitching motions were videotaped with two high-speed VCR cameras (250fps). The trial of the fastest ball velocity for each subject was selected for analysis and was digitized manually from windup to the follow-through. The coordinates of 26-body segment endpoints were reconstructed with a DLT method to construct 15-body segments model, and were smoothed using a Butterworth digital filter. The three-dimensional coordinates were shown with a right-handed orthogonal reference frame XYZ, in which Z was vertical and pointed upward, Y was horizontal and pointed in the direction from the center of the pitcher’s plate to the center of the home plate, and X was perpendicular to Y and Z. The performance area (1.5×2.2 m) was calibrated with a net root mean square error of 0.01m.

The subjects with pitch velocity greater than the mean velocity (34.4m/s, n=22) were classified into the high velocity group (HG, 35.7±1.0m/s, n=10), while the subjects with a pitch velocity lower than the mean velocity were classified into the low velocity group (LG, 33.2±1.1m/s, n=12).

In this study, we focused on the acceleration phase: from stride foot contact (SFC) to ball release (REL). The kinematic parameters compared are the elbow joint angle (varus/valgus, flexion/extension, and pronation/spination), and wrist (varus/valgus, flexion/extension, and pronation/spination). All torques applied to each segment was set equal to the vector product of the segment’s moment of inertia and angular acceleration. Segment mass, center of the mass location, and moment of inertia values were derived from the data of young living Japanese athletes (Ae et al., 1992).

Kinematic and kinetic parameters of upper extremity (shoulder, elbow, and wrist of throwing arm) were calculated, and then normalized according to the duration time of acceleration phase and averaged for each group. Student’s t-test was used to assess significant differences between HG and LG at all normalized times (p<0.05).

RESULTS

Table 1 shows the average heights, weights, and initial ball velocities for HG and LG. The velocity of the ball of HG was significantly larger than LG (p<0.001). Required time of this phase for each group was approximately same (0.09±0.01ms of HG and 0.10±0.02ms of LG).

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1.80 ± 0.05</td>
<td>76.9 ± 5.5</td>
</tr>
<tr>
<td>Low</td>
<td>1.77 ± 0.06</td>
<td>72.5 ± 6.8</td>
</tr>
</tbody>
</table>

Table 1: Mean and standard deviation of height, weight, and ball velocity of the HG

Figure 1 shows the shoulder external rotation angle (top), angular velocity (middle), and torque (bottom) for HG and LG during the acceleration phase. The shoulder internal/external rotation angle had no significant differences between HG and LG during acceleration phase. Though HG exerted the significant larger joint torque of shoulder internal rotation than LG from 80% to 89% of this phase, there were no significant differences in shoulder internal rotation angular velocity between two groups.

Figure 2 shows the shoulder horizontal adduction angle (top), angular velocity (middle), and torque (bottom) during the acceleration phase. From the beginning of this phase, horizontal adduction angle of HG was larger than LG, and was significantly larger from 48% to 75% of this phase. From 66% to 74% of this phase, HG showed significantly larger torque of shoulder horizontal adduction than LG, and HG showed significantly larger horizontal adduction angular velocity than LG from 70% to 99% of this phase.
Figure 3 shows the elbow extension angle (top), angular velocity (middle), and torque (bottom) for HG and LG during the acceleration phase. From 12% to 61% of this phase, HG kept their elbow about 80°, while the elbow angle of LG was smaller than HG. HG began to extend the elbow joint earlier than LG, and showed significant larger extension angular velocity from 61 to 77% of this phase than HG. In addition, HG demonstrated flexion torque from 67 to 74% of this phase, and had delayed the start of extension of the elbow joint.

DISCUSSION

Though HG showed significant larger shoulder internal rotation torque than LG, the shoulder internal rotation angular velocity had no significant difference between two groups (Figure 1). From the beginning of this phase, HG kept their elbow angle about 80°, while LG flexed their elbow to 60° (Figure 3). It was considered that the moment of inertia of the upper limb around the upper arm of HG was larger than LG, and that the large internal rotation torque of the shoulder was needed in spite of the same rotation angle. Therefore, it can be inferred that it was not able to enlarge internal rotation angular velocity of the shoulder although HG demonstrated significant larger internal rotation torque. However, it is important to keep an elbow joint angle at about 90 degrees like HG in order to accelerate a ball since the larger turning radius is effective to accelerate the endpoint of the segment. Many investigations suggested that peak internal rotation torque of shoulder was important to increase the ball velocity, but it may be more important to make an appropriate posture of shoulder or elbow that the torque or angular velocity works more effectively.
HG had horizontally abducted the shoulder larger than LG from the beginning of the acceleration phase, exerted larger horizontal adduction torque in the second half of this phase, and then performed horizontal adduction by large angular velocity (Figure 2). In addition, HG extended the elbow after the horizontal adduction angular velocity of the shoulder reached to the peak. On the other hand, LG had begun to extend the elbow while horizontal adduction angular velocity of the shoulder had hardly increased. From 67% to 74% of the acceleration phase, HG exerted flexion torque of the elbow (Figure 3). If the elbow extended earlier than the actual pitching, it would be extended fully before horizontal adduction angle of the shoulder became positive. This means that the acceleration of the ball by extension of the elbow would be performed in the direction different from the pitching direction. Therefore, HG extended the elbow after HG adducted the shoulder horizontally, and accelerated the ball efficiently to the pitching direction. The torque of elbow flexion would be exerted to prevent the elbow extension by the motion dependent force (Putnam, 1991) of the shoulder horizontal adduction and/or internal rotation. These things suggest that HG was performing joint movement from horizontal adduction and internal rotation of the shoulder to extension of the elbow in good order.

**REFERENCE**


**Figure 3**: Average extension angle (top), angular velocity (middle) and torque (bottom) of the elbow for HG and LG during the acceleration phase. The line and circle show the same as that in Figure 1 and 2.