KINEMATIC COMPARISONS OF DIFFERENT PITCH VELOCITY GROUPS IN BASEBALL USING MOTION MODEL METHOD

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The purpose of this study was to compare kinematic parameters of the pitching motion between different pitch velocity groups. Twenty - two varsity baseball players (19 pitchers and 3 fielders) volunteered to participate in this study as subjects. Throwing motions were videotaped with two high-speed (250 fps) VTR cameras. A 15 body segment model of the pitcher was constructed from 26 body segment endpoints reconstructed with the DLT technique. The motion model was constructed for each group to compare the kinematic parameters. High-pitch velocity group had a sequence of appropriate sequence of the joint and segment movement, i.e., hip rotation, shoulder rotation, shoulder horizontal adduction, and elbow extension, while low-pitch velocity group had done the shoulder rotation and elbow extension simultaneously.

KEY WORDS: motion model, kinematics, pitching, baseball.

INTRODUCTION: One of the most important abilities for a baseball pitcher is the ball velocity at release. Although many studies have been reported about the kinematic characteristics of baseball pitching, there are only a few reports comparing the characteristics of the movement between high - and low-pitch velocity baseball pitchers (Matsuo et al., 2001; Takahashi et al., 1999, 2000). The purpose of this study was to compare kinematic parameters of the pitching motion between high- and low-pitch velocity groups using motion model method.

METHODS: Twenty-two varsity baseball players (19 pitchers and 3 fielders) volunteered to participate in this study as subjects. After warming up, subjects threw some fastballs from regular pitcher's mound toward the catcher. The trial of the fastest pitch for each subject was selected for the analysis. Throwing motions were videotaped with two high-speed (250 fps) VTR cameras. A 15 body segment model of the pitcher was constructed from 26 body segment endpoints reconstructed with the DLT technique. The pitching motion was divided into three phases by four events: the first phase was defined as a phase from the instant for maximal knee height of the stride leg (MAX_{knee}) to the instant for minimal ball height (MIN_{ball}), the second phase from MIN_{ball} to stride foot contact (SFC), and the third phase was from SFC to ball release (REL). The procedure to construct the linked segment model of the pitcher was divided into three steps; Step 1: Subjects were divided into two groups according to the velocities of ball at REL, i.e. high velocity group (HG: height 1.80±0.05m, weight 76.9±5.5kg, and ball velocity 35.7±1.0m/s) and low velocity group (LG: height 1.77±0.06m, weight 72.5±6.8kg, and ball velocity 33.2±1.1m/s). Step 2: Coordinate data were normalized according to the body height. Step 3: Coordinate data and kinematic parameters were normalized according to the time for each phase and averaged for each group. Student's t-test was used to assess significant differences between HG and LG for all kinematic parameters at all normalized times. The significance level was set at $p<0.05$.

RESULTS AND DISCUSSION: Mean ball velocity of HG at REL was significantly larger than that of LG ($p<0.001$), while the height and weight have no difference. Figure 1 shows the patterns of the resultant velocities of the ball and segment endpoints of the throwing arm toward the home plate during the third phase. The peak values of the velocities of the elbow, wrist, hand and ball show significant difference between HG and LG. After 97% of the third phase, only ball velocity shows significant differences between them. Takahashi et al. (1999, 2000) showed that the motion of the finger of the hand just before REL was very important to increase the ball velocity. Therefore, HG could increase the ball velocity by the motion of the finger of the hand.

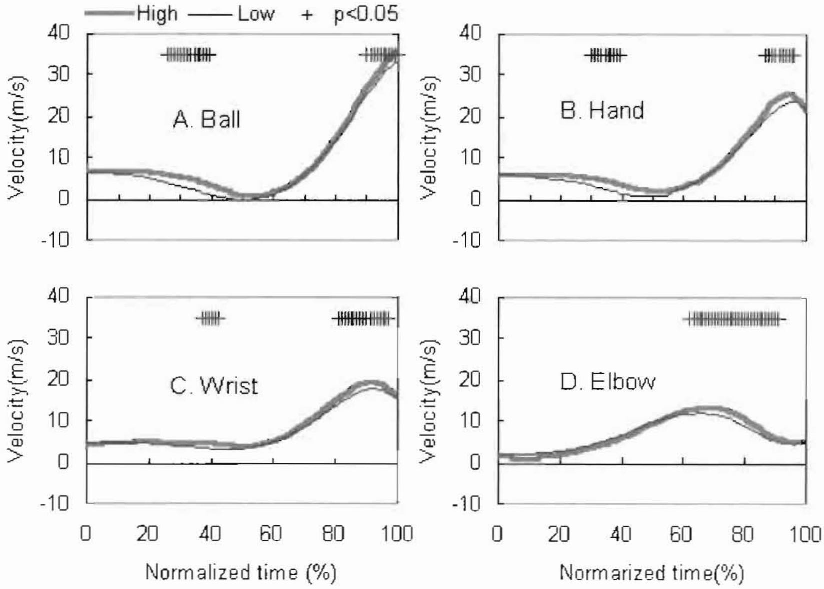

Figure 1. Velocities of the ball, hand, wrist, and elbow during third phase. + mark show the time when significant difference appeared between HG and LG.

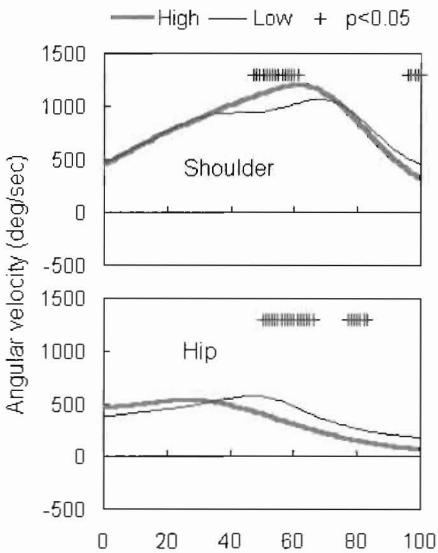

Figure 2. Angular velocity of the shoulder (top) and hip rotation (bottom) during third phase.

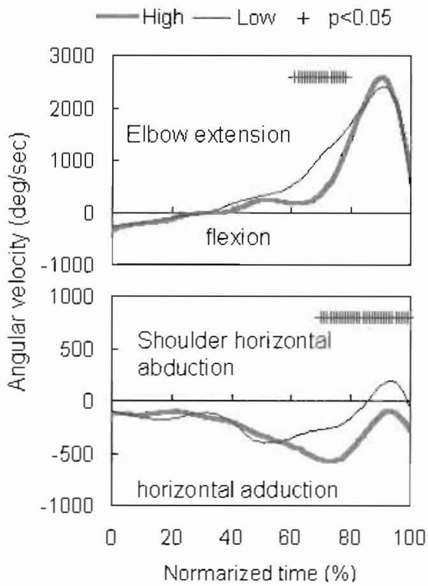

Figure 3. Angular velocity of the elbow flexion/extension (top) and Shoulder horizontal abduction/adduction (bottom) during third phase.

Figure 2 shows the angular velocities of the hip and shoulder rotation during the third phase. The angular velocities of the hip and shoulder rotation of HG and LG increased from 0% of the third phase. Hip rotation angular velocity of HG rose to peak at 27% of the third phase, while shoulder angular velocity kept increasing until 60%. On the other hand, LG could not increase shoulder angular velocity from approximately 30% to 50% of the third phase since LG increased hip rotation angular velocity until 48%. Stodden et al. (2001) indicated that when pitchers were in a position to optimally rotate the pelvis and upper torso, they could generate increased momentum and transfer it from the trunk to the throwing arm. Figure 3 shows the angular velocities of the elbow flexion/extension and shoulder horizontal abduction/adduction during the third phase. Although the elbow extension angular velocity of HG and LG increased after the peak of shoulder horizontal adduction angular velocity, the ratio of increase in the elbow extension angular velocity of HG was larger than LG. In addition, LG increased the shoulder rotation and elbow extension angular velocities simultaneously from 60% to 70%. These results suggest that HG had a more appropriate sequence of the joint and segment movements than LG, and HG could increase ball velocity more than LG. Figure 4 shows the hip abduction angular velocity of the pivot leg during the third phase. Peak values of the hip adduction angular velocity for HG (505±192deg/sec) and LG (489±194 deg/sec) have no difference, but the ratio of increase in the hip adduction angular velocity of HG was larger than LG. In addition, increase of hip adduction and hip rotation angular velocities have done simultaneously. Shimada et al. (2000) indicated that the hip adduction torque in the early period of the third phase enhanced the hip rotation. Therefore, HG has done the hip adduction earlier than LG in order to rotate the hip rapidly. It might be a key-technique to adduct the pivot hip rapidly in the early period of the third phase in order to increase ball velocity.

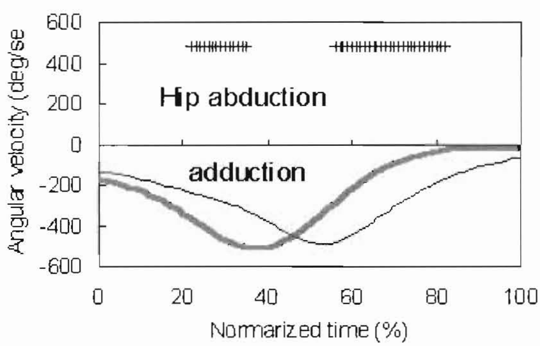

Figure 4. Angular velocity of the hip internal abduction/adduction during third phase.

CONCLUSION: The purpose of this study was to compare kinematic parameters of the pitching motion between high- and low-velocity groups using motion model method. This study revealed many differences of the movements between high- and low-pitch velocity groups. High-pitch velocity group has done the hip rotation, shoulder rotation, shoulder horizontal adduction, and elbow extension with an appropriate sequence, but low-pitch velocity group done the shoulder rotation and elbow extension simultaneously. Furthermore, high-pitch velocity group adducted the pivot hip earlier than low-pitch velocity group.

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