Kinetic analysis of fingers during fastball and curveball pitches

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This study aims to reveal the function of fingers during fastball (FB) and curveball (CB) pitches of a male adult who had played university baseball pitcher by conducting kinetic analysis on throwing motion with a link-segment model including finger segment. There was no apparent difference in the timing of peak finger joint angle between FB and CB pitches. Peak finger adduction torque in CB pitch occurred just before ball release. In addition, there was an apparent difference more than 30 ms in the timing of peak finger flexion and abduction torque between FB and CB pitches. Previous comparisons of kinematic data for shoulder and elbow revealed similarities between FB and CB pitches. These results suggest that skilled pitcher may minimize visible distinguishing characteristics among pitches and generate different amounts of ball spin at release among pitches adjusting the timing of peak finger torque.

KEY WORDS: baseball, fingers joint torque, spin.

INTRODUCTION: An overarm throw in baseball is a complex multi-joint limb movement, and the fingers are the only and final segments that contact the ball. Hore et al. (1996) reported that the timing of finger extension is more important for an accurate throw than the timing of the onset of rotation at a more proximal joint. Stevenson (1985) reported that the fastball (FB) left thumb first followed by either the index or middle finger. On the other hand, in approximately 98 % of the curveball (CB) pitches, the index finger contacted the ball until release. In summary, it is expected that the timing of finger movements is a significant factor in achieving accurate ball release and generating characteristic ball spin among pitches. Hore et al. (1996, 2001) measured the force acting on middle finger in throwing a ball of different weights with force transducers. However, kinetic analyses (joint torque, power and work) of fingers during FB and CB pitches have not been reported. The information about timing of finger joint angle and torque during FB and CB pitches will assist a pitcher, coaches and clinicians in developing skill and preventing injury. This study aims to reveal the function of fingers during FB and CB pitches by conducting kinetic analysis on throwing motion with link-segment model including finger segment.

METHODS: A male adult who had played university baseball pitcher participated in the experiment with informed consent. The subject was instructed to stand with his left foot forward and right toe contacting the ground during ball throwing. The subject threw a baseball with an overarm throw toward a target made of cloth. The size of the target was 0.60 m × 0.60 m. The horizontal distance between the target and left foot was 5.0 m, and the height of the center of the target was set at eye-level. The condition of target during FB and CB pitch was the same. Reflective markers (markers on fingers: 0.014 m in diameter and the others: 0.019 m in diameter) were attached to the most caudal-medial point on ulnar styloid, the most caudal-lateral point on radial styloid, metacarpophalangeal (MP) joint of the index finger, MP joint of the middle finger and the fingertip. Four markers were attached to the ball. Six throwing motions were recorded at a sampling rate of 1000 Hz using eight cameras 3D Motion analysis system (Kestrel Digital System, Motion Analysis Corp., Santa Rosa, CA, USA) with RMS reconstruction accuracy of 1.23 mm. The time at which the ball was released from the fingertips of the first two fingers (REL) was set as 0 ms. Markers were tracked from -50 ms to 20ms in three FB and three CB pitches.

A two segment rigid body 'finger model' of the pitching hand was defined as the combined finger segment (index, middle and ring finger) and the palm (Fig. 1). The resultant force acting on the ball was calculated from ball's acceleration in global coordinate. The center of pressure (COP) of force acting on the ball due to the fingers was defined as being located at the fingertip of the middle finger. After the ball was released, the reaction force on the ball was defined as zero. The obtained positional data were smoothed using singular spectrum analysis (Alonso et al., 2004). Ball spin rate immediately after REL was calculated with the method described by Jinji and Sakurai (2006). The direction of ball spin axis was expressed in the global reference frame, defined by the azimuth θ and the elevation φ. Joint angles were calculated by using Cardan angle definition (x-y'-z" sequence). The angles of finger segment are designated as flexion/extension and adduction/abduction for the first and third rotation, respectively. Joint torque was calculated by an inverse dynamics method calculating proximally from the ball. Finger inertial data for the participant was estimated from de Leva et al. (1996). One throw that has the highest ball velocity was chosen from each pitch condition for analysis.

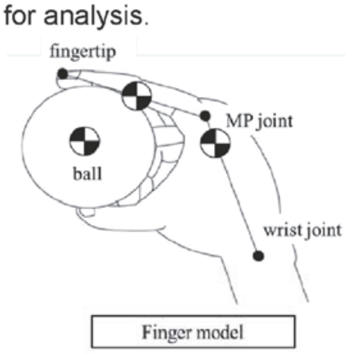

Fig. 1 Finger model

RESULTS AND DISCUSSION: The resultant velocity of the ball at REL during the FB and CB pitches were 16.6 m/s and 12.0 m/s, respectively. Ball velocity was restricted so that the infrared camera can capture finger motion accurately. Ball spin rate during the FB and CB pitches were 10.9 Hz and 15.8 Hz, respectively. The values of angle θ were 52.0 ° and -21.5 °, respectively. The values of angle φ were -15.4 ° and -39.2 °, respectively.

The variation of finger adduction/abduction torque in FB pitch was relatively constant compared to CB pitch (Fig. 2). Peak finger adduction torque in CB pitch occurred just before REL. The timings of peak finger adduction/abduction angle were similar in the FB and CB pitches (Table. 1). There was an apparent difference more than 30 ms in the timing of peak finger flexion and abduction torque between FB and CB pitches, respectively.

Peak finger adduction torque during CB pitch decreased after REL rapidly. It was considered that this was caused by the setting of finger model that the reaction force from the ball acting on finger was zero after REL. There was no apparent difference more than 30 ms in the timing of peak finger joint angle between FB and CB pitches. There was an apparent difference more than 30 ms in the timing of peak finger flexion and abduction torque between FB and CB pitches. Previous comparisons of kinematic data for shoulder and elbow (Escamilla et al., 1998) revealed similarities between FB and CB pitches. These results suggest that skilled pitcher may minimize visible distinguishing characteristics among pitches and generate different amounts of ball spin at release among pitches adjusting the timing of peak finger torque. Elliott et al. (1986) suggested that fingers in CB pitch were aligned the top outer quadrant of the ball before ball release. Stevenson (1985) reported that 72.7 % of CB pitch was thrown in a thumb-middle-index finger release sequence, and the middle finger comes off the ball at approximately 2 ms before ball release. Probably, the ball moves from middle finger to index finger and starts topspin. This time is almost identical to that when peak fingers adduction torque occurred. From these results, it is anticipated that producing finger adduction torque just before ball release leads to imparting topspin to the ball.

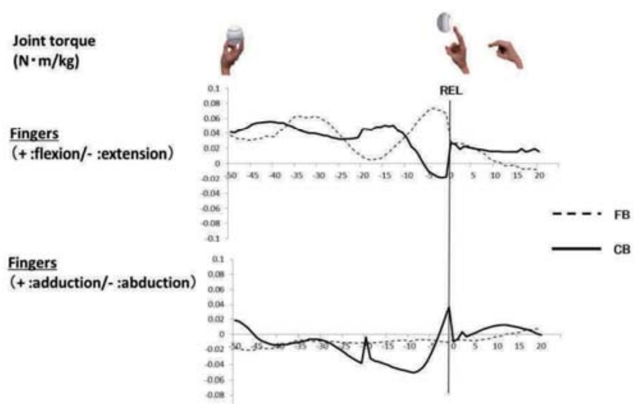

Fig. 2 The typical curve of fingers joint torque.

Table. 1

Parameter	FB (ms)	CB (ms)
Peak angle		
fingers flexion	−20	−3
fingers adduction	9	12
fingers abduction	−50	−50
Peak torque		
fingers flexion	−4	−41
fingers extension	20	−2
fingers adduction	19	−1
fingers abduction	−46	−9

Table. 1 The typical temporal data for kinematic and kinetic events relative to ball release

CONCLUSION: There was an apparent difference more than 30 ms in the timing of peak finger flexion and abduction torque between FB and CB pitches. This result suggests that skilled pitchers may generate different amounts of ball spin at release among pitches adjusting the timing of peak fingers torque, although this hypothesis needs to be confirmed with additional research with more subjects and more detailed finger models.

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