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A Three-Dimensional Cinematographic Analysis of Badminton Strokes

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INTRODUCTION

Badminton and tennis are two of the most popular striking activities. Broer & Zernicke (1979) stated that one evident difference between the two sports skills was the degree to which the wrist snap was used. They stated that the wrist snap just before impact was the most essential action of badminton strokes and it was enabled by the lightness of the badminton racket.

Gowitzke & Waddell (1979) analyzed forehand and backhand smash strokes, representative of the most powerful overhead striking motions in badminton. They concluded that medial rotation of the humerus at the shoulder joint and pronation of the forearm at the radio-ulnar joints were the principal contributing movements for the forehand smash.

In badminton strokes, many joint actions in three planes are involved in the striking motion, so that two-dimensional procedures are insufficient for analyzing the stroke motion of badminton. Relatively small numbers of biomechanical studies have been completed on kinematic parameters of badminton strokes. Quantitative studies with three-dimensional procedures have been even more limited.

The purpose of this investigation was to determine the changes of joint angles of the upper body during the execution of the drop shot and the cut shot in badminton using three dimensional cinematography.

METHODS

Five male university badminton players were used as subjects. Their age, height, and body mass are 21±1 yrs, 1.69±0.05 m, and 63±3 kg, respectively (mean ± SD). The subjects were instructed to perform the drop shot and the cut shot using the eastern-style grip.

Two 16 mm phase-locked cameras (Photo-Sonics, 16-1PL) were set up 18 m away from the subject. The angle between the two axes of the cameras was about 90 degrees (Fig. 1). A reference structure containing 12 markers of known coordinates was used for three dimensional calibration. After filming the reference structure and then removing it, each subject performed drop shots and cut shots and was filmed at a film speed of 100 f.p.s. Two-dimensional coordinates of markers of the reference structure and landmarks on each subject's body and on the

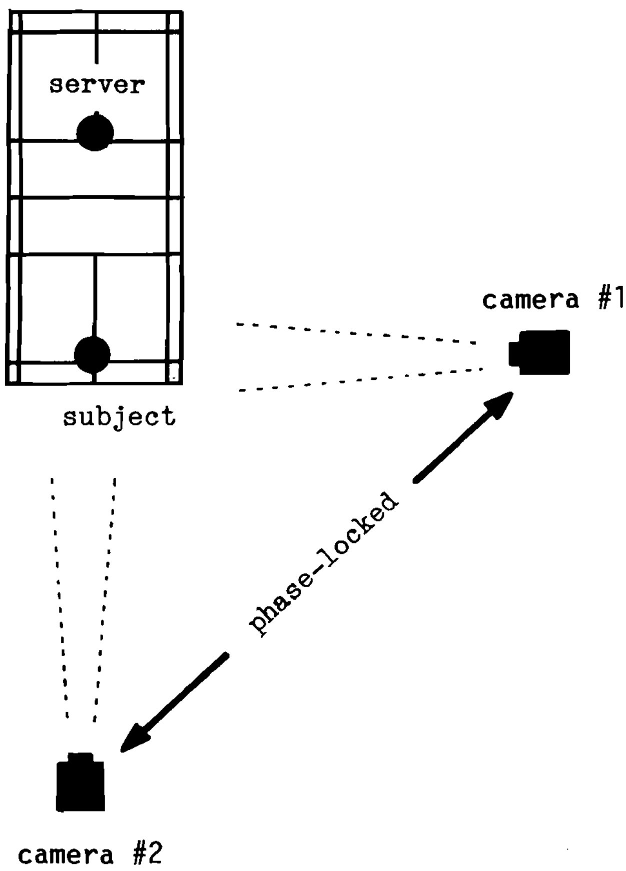

Fig. 1: The testing environment.

racket were obtained by digitizing the images on film from the two cameras. From these digitized data, three-dimensional coordinates of the landmarks on the subject's body and on the racket were reconstructed by means of the Direct Linear Transformation (DLT) method (Abdel-Aziz and Karara, 1971).

The angles at the joints of the striking arm were determined as shown in Fig. 2. Angles and angular velocities at the joints were calculated throughout the swing action using three dimensional coordinates of the landmarks of the subject and the racket:

(1) Adduction / Abduction at shoulder joint,
(2) Horizontal Abduction / Adduction at shoulder joint,
(3) Medial / Lateral Rotation at shoulder joint,
(4) Extension / Flexion at elbow joint,
(5) Pronation / Supination at radio-ulnar joints,
(6) Ulnar / Radial Flexion at wrist joint, and
(7) Palmar / Dorsi Flexion at wrist joint.

The film digitizing and the data processing were undertaken using a film motion analyzer (NAC Inc.) and minicomputer system (MV/4000, Data General Co.).

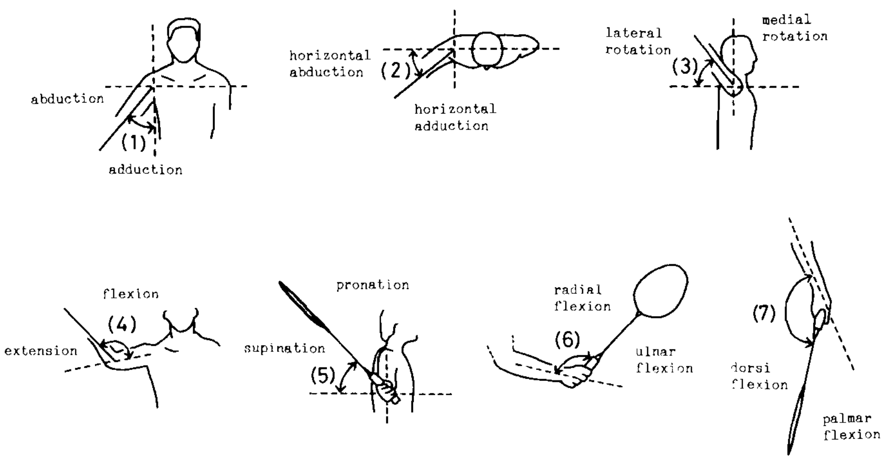

Fig. 2: Definition of the angles of:
(1) Adduction / Abduction at shoulder joint,
(2) Horizontal Abduction / Adduction at shoulder joint,
(3) Medial / Lateral Rotation at shoulder joint,
(4) Extension / Flexion at elbow joint,
(5) Pronation / Supination at radio-ulnar joints,
(6) Ulnar / Radial Flexion at wrist joint, and
(7) Palmar / Dorsi Flexion at wrist joint.

RESULTS AND DISCUSSION

Figure 3 shows the changes of angles (upper) and angular velocities (lower) of the joints of the striking arm for the drop shot motion of subject A (22 yrs., 1.64 m, 60 kg). The ranges of the changes of the joint angles were more than 90 degrees for (1) abduction / adduction at the shoulder, (4) extension / flexion at the elbow, and (5) pronation / supination at the radio-ulnar joints. Highest peak values of the angular velocities were observed in (4) extension of the elbow, (5) pronation of the radio-ulnar joints, and (6) ulnar flexion of the wrist joint. These three joint actions occured at almost the same time. The patterns of the changes of the angles and the angular velocities were similar for all subjects. Table 1 shows the peak values (mean ± SD) of the angular velocity of each joint action.

TABLE 1

Maximum angular velocities of joints of striking arm prior to impact (deg/sec)

SHOULDER			ELBOW	RADIO-ULNAR	WRIST	
(1) abduction/ adduction	(2) horizontal abduct/adduct	(3) medial/lateral rotation	(4) extension/ flexion	(5) pronation/ supination	(6) ulnar/radial flexion	(7) palmar/dorsi flexion
399 (38)	370 (147)	570 (127)	588 (135)	1037 (286)	835 (261)	149 (39)

Values are mean and (SD) of five subjects.

Figure 4 shows the changes of the angles and angular velocities of (4) extension / flexion of the elbow, (5) pronation / supination of the radio-ulnar joints, and (6) ulnar / radial flexion of the wrist joint for the drop shot and the cut shot of subject A. Peak values of the angular velocities of these joint actions were larger in the cut shot motion than in the drop shot motion. The ulnar-flexion of wrist just before impact was the highest and was a characteristic action for the cut shot. Pronation at the radio-ulner joints was also high for the cut shot. The range of motion and peak value of the angular velocity of ulnar-flexion for the cut shot were approximately twice those for the drop shot.

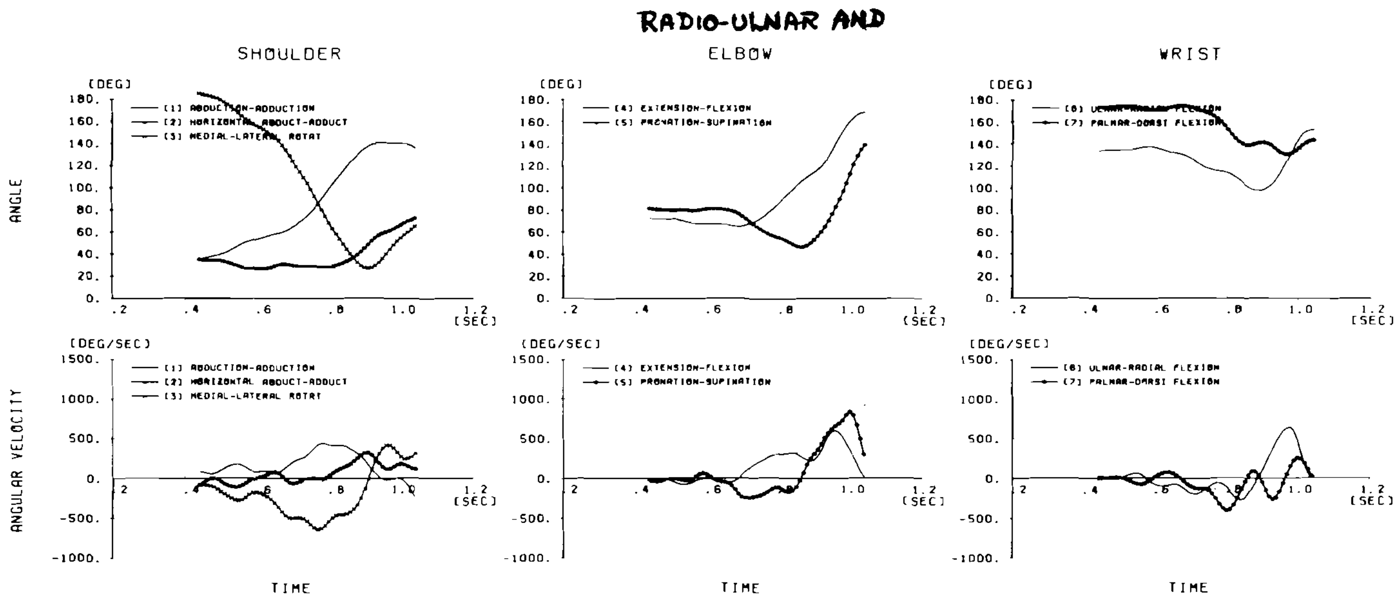

Fig. 3: Changes of angles (upper) and angular velocities (lower) of the joints of the striking arm for the drop shot motion of subject A (22 yrs, 1.64 m, 60 kg). Impact occured at 1.0 second.

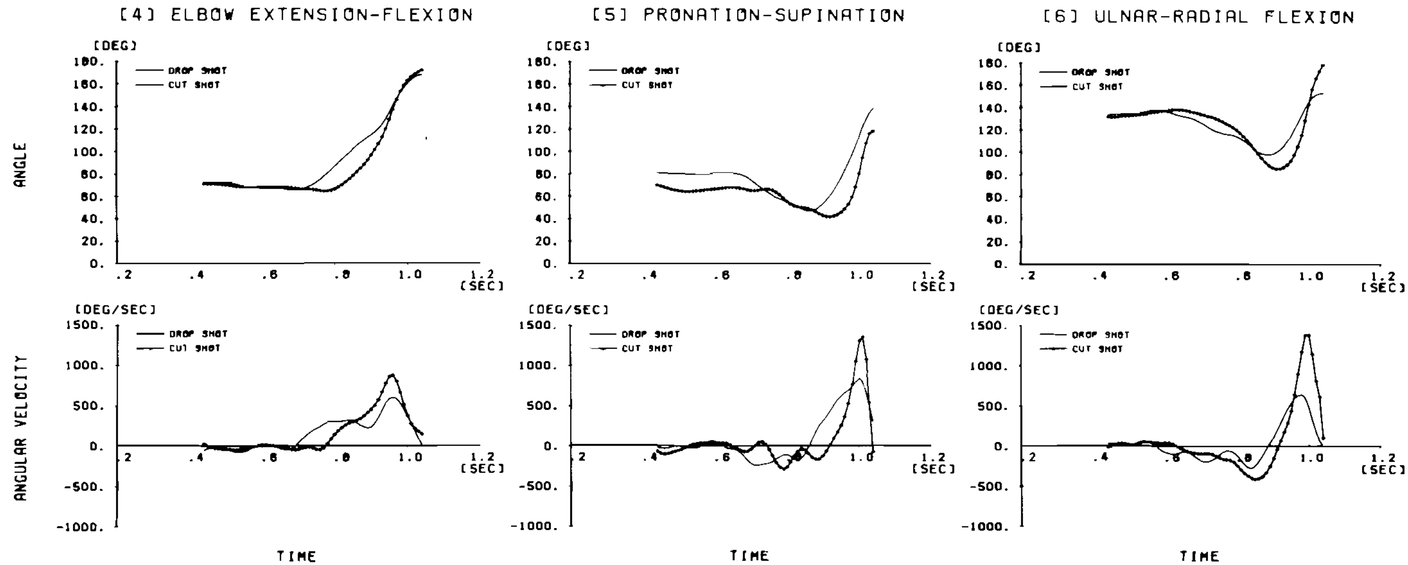

Fig. 4: Comparison of angles and angular velocities of: (4) extension / flexion of the elbow, (5) pronation / supination of the radio-ulnar joints, and (6) ulnar / radial flexion of the wrist joint between drop shot and cut shot of subject A. Impact occurred at 1.0 second.

CONCLUSIONS

Changes of angles and angular velocities of joints of the striking arm were determined during the performance of the drop shot and the cut shot in badminton using the Direct Linear Transformation (DLT) method of three dimensional cinematography. In the drop shot, highest peak values of angular velocity were observed in pronation of the radio-ulnar joints, extension of the elbow joint, and ulnar flexion of the wrist joint. Compared to actions in the drop shot, ulnar flexion of the wrist joint stood out in the cut shot motion. The changes of angles and angular velocities of the joints showed different patterns dependent on the strokes, and the results suggested the effectiveness of three-dimensional film analysis technique in the investigation of badminton strokes.

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