Effects of Joint-Fixing on the Velocity of the Racket Head in the Tennis Serve

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The velocity of the racket head in a tennis serve is one of the significant factors in a match. The fastest velocity of the racket head before impact may be performed by the appropriate sequence of segmental rotations. Anderson (1979) and Miyashita et al. (1980) reported that there was a close relationship between the muscular activities patterning in the overarm throw and the tennis serve. Elliott (1983) observed the movement pattern for the power serve in tennis using kinematic data. However, there were no reports concerning effects of joint fixing on the velocity of the racket head in a tennis serve.

The purpose of this study was first to investigate the serving motion in tennis by means of a kinematic method. Second, it was to more clearly define the appropriate sequence of segmental rotations employed.

PROCEDURE

One highly skilled Japanese college tennis player and two unskilled college students served as subjects.

The motion of a tennis serve was filmed at 64 fps. with a 16 mm cine camera. The position of body segments, racket and ball were determined

by using a digitizer (No. DT 1000, Graphtec, Japan) and calculations were made by a computer system (PC 9801E, NEC, Japan) (Figure 1).
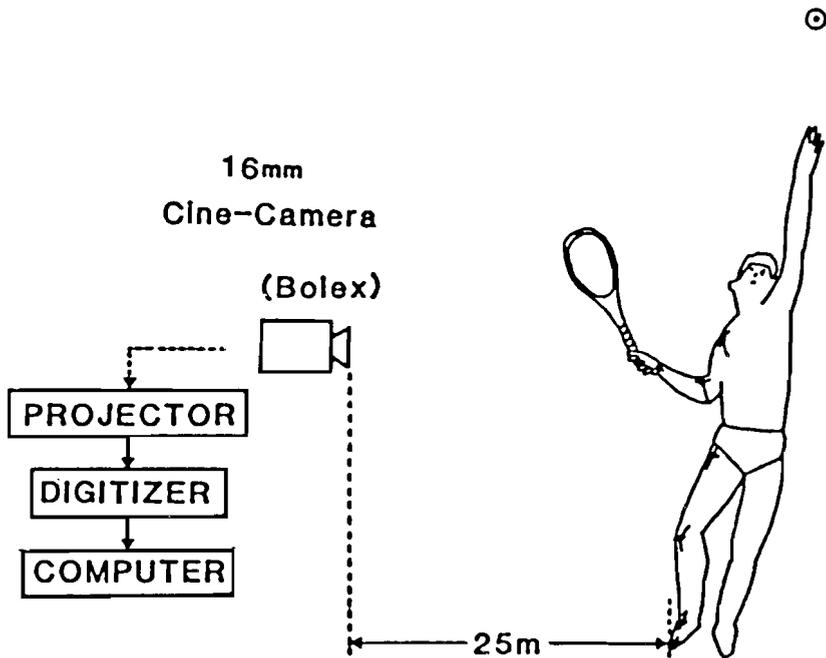
Fig. 1 Experimental setup.

Subjects were requested to perform a tennis serve with maximal effort under nine different conditions as follows:

1 swing the racket (without ball).
2 hit the ball.
3 hit the ball to target area accurately.
4 hit the ball with both ankle joints fixed.
5 hit the ball with both ankle joints and knee joints fixed.
6 hit the ball with both ankle joints, knee joints and trunk fixed.
7 hit the ball with both ankle joints, knee joints, serving shoulder joint and trunk fixed.
8 hit the ball with both ankle joints, knee joints, serving shoulder joint, serving elbow joint and trunk fixed.
9 hit the ball with serving elbow joint fixed.

RESULTS AND DISCUSSION

The velocities of racket head before impact under conditions 1, 2 and 3 are shown in Table 1. Setting the value at condition 1 (swing the racket) as 100%, the other two values at the conditions 2 (hit the ball) and 3 (hit the ball to target area accurately) are shown as percentages of 1. The velocity of the racket head of unskilled players (both male and female) decreased rapidly by about 50% with the difficulty of the task, while in skilled player the decrement was only 5%.

The velocity of racket head before impact and that of ball after impact under seven conditions (1, 2, 4, 5, 6, 7 and 8) are indicated in Figure 2-1, 2-2.

The velocity of the racket head before impact and the ball velocity after impact decreased with the extent of segmental fixing. However, the velocity decrease was not seen in unskilled players under conditions 2 (hit the ball), 4 (hit the ball with both ankle joints fixed) and 5 (hit the ball with both ankle joints and knee joints fixed).

TABLE 1
Velocity of the racket head during a tennis serve in relation to the difficulty of the task

(m/sec.)

	CONDITION 1 Swing the racket (without ball)	CONDITION 2 Hit the ball	CONDITION 3 Hit the ball to target area accurately
skilled (male)	39.7±1.1 (100%)	36.4±0.9 (96.0%)	36.3±1.9 (95.8%)
unskilled (male)	43.5±3.1 (100%)	35.8±2.6 (82.2%)	20.2±1.3 (46.4%)
unskilled (female)	32.7±1.3 (100%)	26.1±3.5 (79.8%)	13.2±1.5 (40.4%)

Values are mean ± SD.
Setting the value of condition 1 as 100%, the other two values of condition 2 and 3 are shown as percentages.
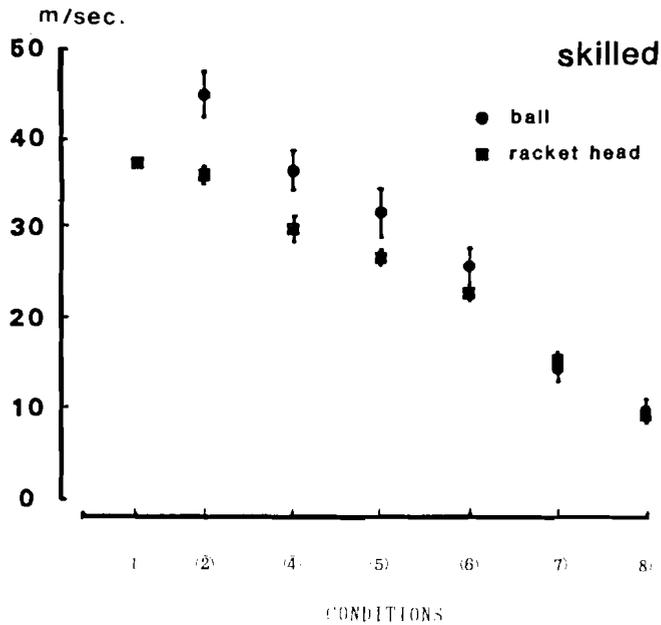
Fig. 2-1. Velocity of the racket head and ball during a tennis serve in relation to the extent of joint-fixing for the skilled player.
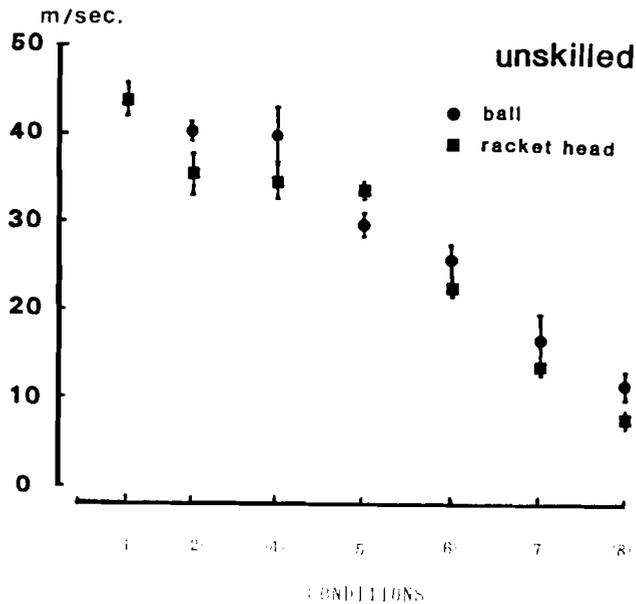
Fig. 2-2. Velocity of the racket head and ball during a tennis serve in relation to the extent of joint-fixing for the unskilled player.

352

The angular velocity of wrist joint under conditions 2 (hit the ball), 5 (hit the ball with both ankle joints, knee joints fixed) and 8 (hit the ball with both ankle joints, knee joints, serving shoulder joint, serving elbow joint and trunk fixed) is shown in Figure 3-1, 3-2. Skilled player had his wrist joint extended at 100 msec. before the impact of racket and ball and then flex in time for the impact under condition 2. However the range of this pattern of wrist movement becomes smaller under condition 5. Furthermore this wrist movement was not indentified under condition 8. This shows that this wrist movement requires the appropriate leg movement.

In general, «the cracking the whip effect of arm» meaning quick wrist movement from extension to flexion. It seems to be playing a major role in providing velocity to the racket at the impact. Since the movement of using the whole body, one segmental movement influence others. The maximum angular velocity of wrist joint is attained by an appropriate leg movement well combined with the arm's. Also, the closest joint, the elbow, seems to be playing a major role in «cracking the whip effect of arm».
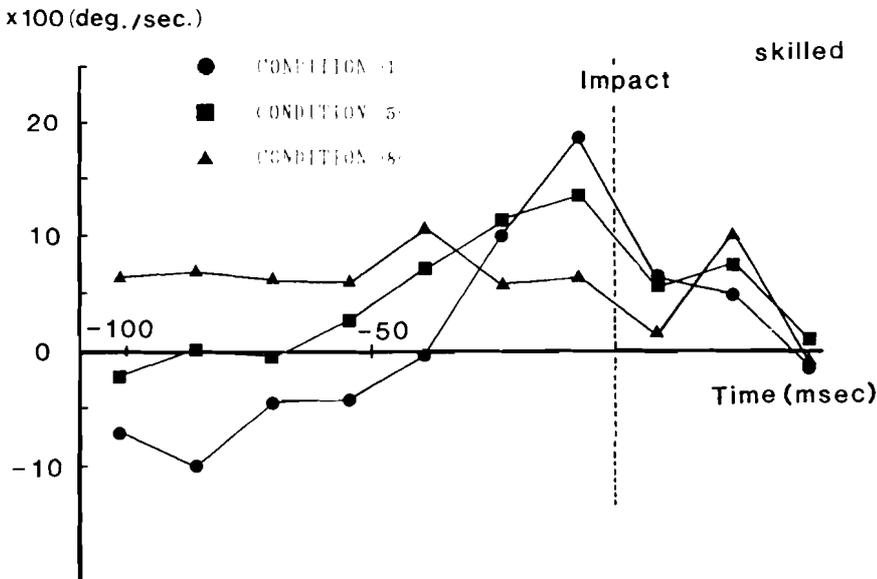
Fig. 3-1. Angular velocity of the wrist joint with the extent of joint fixing for the skilled player.
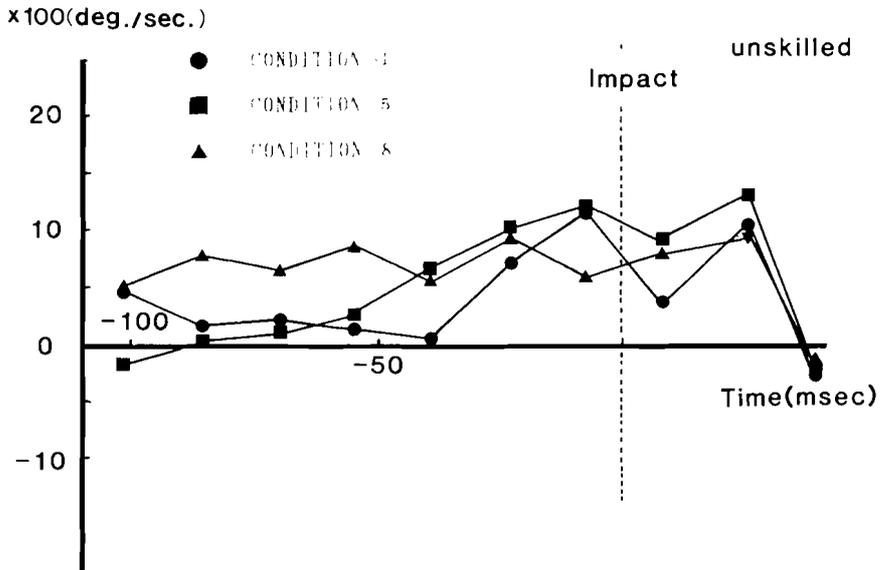
Fig. 3-2. Angular velocity of the wrist joint with the extent of joint fixing for the unskilled player.

● = CONDITION 1 swing the racket (without ball).
■ = CONDITION 5 hit the balle with both ankle joints, knee joints fixed.
▲ = CONDITION 8 hit the balle with both ankle joints, knee joints, serving shoulder joint, serving elbow joint and trunk fixed.

In Figure 4-1, 4-2 show the velocity of racket head, wrist and elbow joints for a skilled player under conditions 2 (hit the ball) and 5 (hit the ball with both ankle joints, knee joints fixed). Under condition 2, the maximum velocities of elbow, wrist and racket head were obtained at 80 msec., 40 msec. and 0 sec. before impact respectively. However, this rerationship is not seen under condition 5.

The point which each part of the body moves quickly seems to be shifting up from the legs and body to the arms. In this study the maximum velocity of each segment shifts from the elbow and to the racket head restricting the leg movement would make the rerationship collaspe in tennis serve. It should be suggested that the appropriate legs movement lead to the effective arm movement in the whole body movement.

354
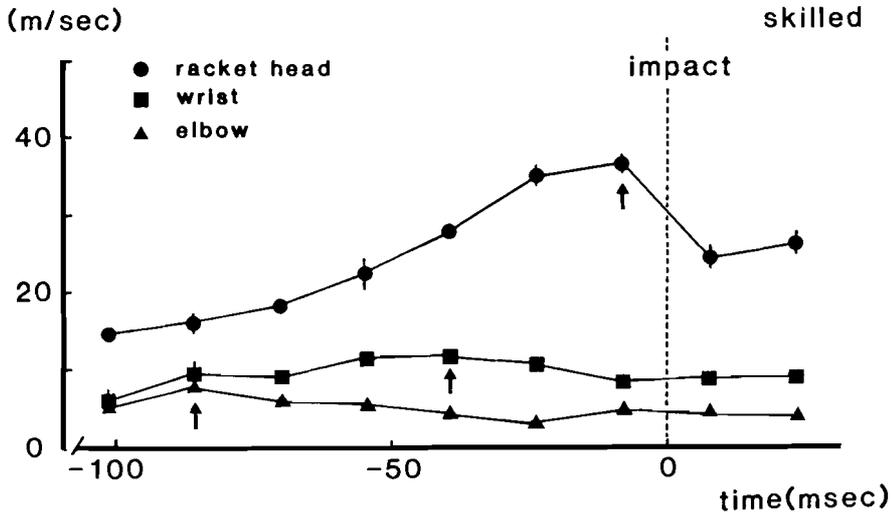
Fig. 4-1. Velocity of racket head, wrist joint and elbow joint under condition of hit the ball for skilled player.
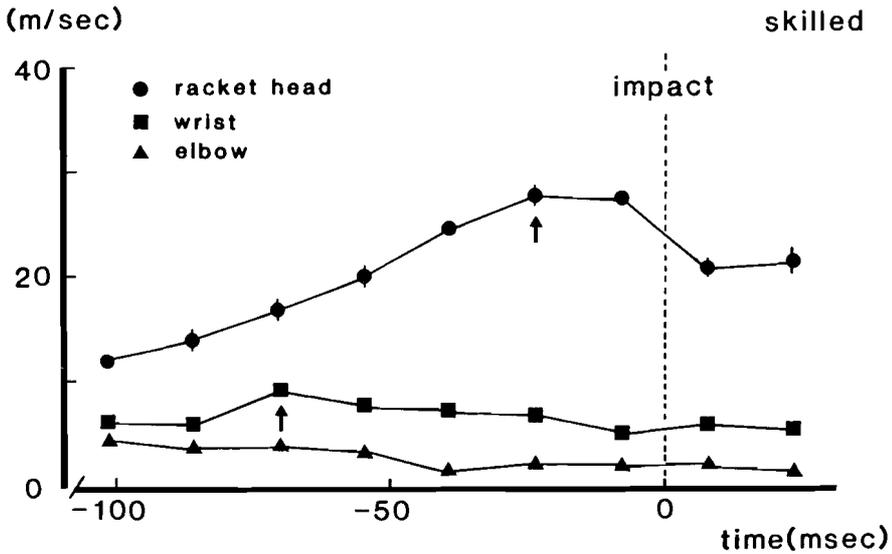
Fig. 4-2. Velocity of racket head, wrist joint and elbow joint under conditions of hit the ball with both ankle joints knee joints fixed for skilled player.

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