COMPARATIVE KINEMATIC ANALYSIS OF ENQVIST AND MOYA'S TENNIS SERVE TECHNOLOGY

Yirong Li[1] ;Jihe Zhou[2] and Luyao Wang[3]

Chengdu Sport University, Chengdu, Sichuan Province, China[1,2]
Chengdu computer equipment co., LTD[3]

Serving occupies a more important role in the modern tennis. The tennis serve of two players, Thomas Enqvist and Carles Moya, were filmed in the semifinals of Chengdu Open-ATP Champions Tour and analysed with three-dimensional video analysis. The serve was divided into three stages as follows: throwing ball rising racket stage, backward swing stage, forward swing hitting stage. It is found that: in the first stage, the maximum value of shoulder-hip level projection angle of Enqvist and Moya are 18.5° and 28.7° respectively. In the second stage, Enqvist and Moya's extension range of left knee joint were 55.1° and 34.6°.Their e angular velocity were 182.6°/s and 170.4°/s. In the third stage, Enqvist and Moya's hitting height were 2.23m and 2.15m, Hitting height and body height ratio were 1.18 and 1.13, there are significant differences.

KEY WORDS: tennis; serve technology; kinematics

INTRODUCTION ： Serving occupies a more important role in the modern tennis. It is the only hitting method controlled by the player himself against opponents approach, it is the beginning of a point and it is also an important offensive weapon. Thus it can maximize play individual technical characteristics. High-speed, accurate serving could create favorable conditions to win the game.

METHODS ： This research mainly uses three dimensional camera analytic methods. Two JVC9800 cameras (50fps) were used to record the serve technique of players in Chengdu ATP tour (camera position is shown in figure 1). Video footage of two players, Thomas Enqvist and Carles Moya, was selected for analysis, examining three services for each player in the semifinals. The selection standard was as follows: Firstly, serving position in the same area; secondly, first service; thirdly, serve success.

Video resolution using Signal TEC V2.0C three-dimensional video analytical software, coordinate system setting shown in figure 2, and choose Japanese Matsui's human body model (16 links, 21 articulation point). As the research needs, the two test points, racket head and tennis ball, were added when digitizing.

Smoothing the original data with optimization line low pass filter and the truncation frequency is 8Hz.
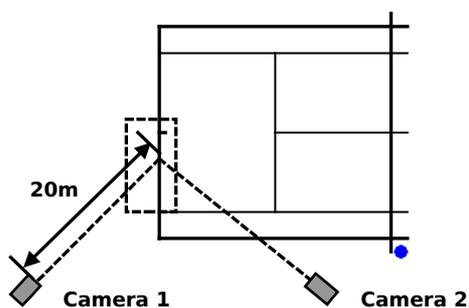
Figure 1 Camera Position
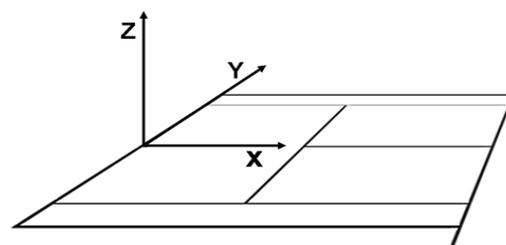
Figure 2 Coordinate System
coordinate system schematic diagram

RESULTS
rising
maxim
the lo
point

: throwing ball
left knee is at
racket head at
d at the lowest
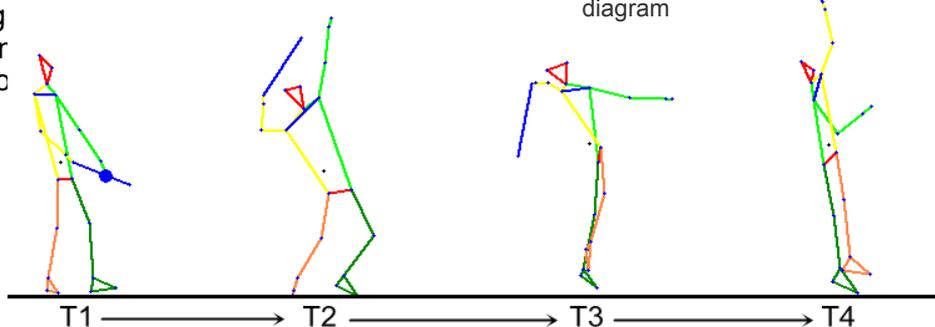
Figure 3 Serve movement Stage Division

T1 : The ball to the lowest point phase
T2 : The left knee arthrosis maximum flexion phase
T3 : Racket head to the lowest point behind back phase
T4 : Hitting phase
T1-T2 : Throwing ball rising racket stage
T2-T3 : Backward swing stage
T3-T4 : Forward swing hitting stage

1. Analysis of throwing ball rising racket stage: The purpose of this stage is to put the ball into the air at a predetermined position with a relatively accurate speed, resulting in a certain space and time for the subsequent phase.

Table 1
Comparison of player's main characteristics in the throwing ball rising racket stage

players	ball leaving from hand height (m)	ball leaving from hand and body height ratio	Ball leaving from hand phase			The end of throwing ball rising racket phase		shoulder hip level projection maximum Angle (deg.)
			Left elbow Angle (deg.)	Left shoulder joint Angle (deg.)	Left hip joint Angle (deg.)	Left knee joint Angle (deg.)	Right knee joint Angle (deg.)	
Enqvist	2.02	1.06	174.5	126.7	165.9	116.8	141.6	18.5
Moya	1.76	0.92	166.1	106.2	160.0	127.2	160.3	28.7

Table 1 shows the height of the ball when leaving the hand of Enqvist and Moya were 2.02m and 1.76m respectively, and the corresponding body height ratios were 1.06 and 0.92. It is believed that a relatively higher height of ball leaving from hand, a longer control distance of hand to ball, and a stronger control of hand to ball results in a more relatively stable ball throw route. At the ball leaving from hand phase, Enqvist's left elbow angle, left shoulder joint angle and left hip joint angle were 174.5°,126.9°and 165.9° respectively, all greater than Moya's. It can be seen that Enqvist's throwing arm stretched a straighter elbow.
The maximum value of shoulder-hip level projection angle of Enqvist and Moya are 18.5° and 28.7° respectively, and it is observed that Moya's body torsion amplitude is bigger than Enqvist's. A bigger torsion amplitude causes stretch of ipsilateral internal oblique and contralateral external oblique abdominal muscles, causing the stretch reflex and stored elastic energy, thereby increasing the speed and power of torso twist to hitting direction, as create better conditions for the next action that increases the swing distance and magnitude. Accordingly, a slight advantage of the magnitude of torsion is Moya.

2. Analysis of backward swing stage: At this stage players' knee and hip were stretching rapidly and the upper body rising rapidly, while the elbow of racquet arm flexion and arm external rotation.

Table 2
Comparison of player's main characteristics in the backward swing stage

players	left knee joint stretching Range (deg.)	Stretching average angular velocity (deg./s)	The minimum right elbow joint angle (deg.)	The end of backward swing phase			
				left hip Angle (deg.)	Right hip angle (deg.)	Left knee angle (deg.)	Right knee angle (deg.)
Enqvist	55.1	282.6	59.5	170.2	145.7	172.0	156.8
Moya	34.6	170.4	73.8	142.4	132.6	165.1	179.6

As shown in Table 2, Enqvist and Moya's extension range of left knee joint were 55.1° and 34.6°.Their e angular velocity were 182.6°/s and 170.4°/s. The knee fast stretching make the racket descend relative to player's back with the inertance, while the swing torque increased. The greater stretching range of left knee joint, the faster movement, the better for the follow actions. Therefore, the advantages of Enqvist are more obvious.

At this stage, Enqvist's left hip Angle, right hip angle, left knee angle and right knee angle were more extended than Moya's. that shows that Enqvist stretching more sufficient, his left leg plays a leading role because of left knee angle is greater than right.

3. Analysis of forward swing hitting stage: The purpose of this stage is to make the racket hitting ball with the maximum velocity.

Table 3
Comparison of player's main characteristics in the forward swing hitting stage

players	Hitting height(m)	Hitting height and body height ratio	center of gravity Maximum height(m)	Tossing peak and hitting point horizontal distance(m)	Swing distance (m)	Hitting phase		
						Left hip angle (deg.)	Right shoulder angle (deg.)	Right elbow angle (deg.)
Enqvist	2.23	1.18	1.10	0.83	1.75	151.5	150.4	154.8
Moya	2.15	1.13	1.05	0.58	1.68	159.8	142.5	152.6

Table 3 shows that Enqvist and Moya's hitting height were 2.23m and 2.15m, Hitting height and body height ratio were 1.18 and 1.13, there are significant differences. Under the same conditions, the higher hitting height, the greater possibility of getting the ball over the net. The lower hitting height, the greater difficulty to hitting ball, the greater probability to fail.

Enqvist and Moya's tossing peak and hitting point horizontal distance were 0.83m and 1.58m, it is observed that Enqvist tosses the ball over forward, which provides a enough space for the subsequent movement to make it forceful stretch and get a better hitting result. Swing distance is a vertical distance from the racket lowest point to hitting point. Enqvist's is 1.75m,

a little greater than Moya's 1.68m. Swing distance is relying on a coordination of the two pervious movements. The greater swing distance, the longer speed-up distance, the faster hitting velocity. Therefore, Enqvist has a advantage obvious.

DISCUSSION: At the throwing ball rising racket stage, the height of ball leaving from hand of Enqvist and Moya is 2.02m and 1.76m, the ball leaving from hand and body height ratio is 1.06 and 0.92. At the ball leaving from hand phase, Enqvist's left elbow angle, left shoulder joint Angle and left hip joint Angle were 174.5degrees,126.9deg. and 165.9deg. respectively, all greater than Moya's. It can be seen that Enqvist's throwing arm stretched a straighter elbow.

At backward swing stage, Enqvist and Moya's stretching range of left knee joint were 55.1deg. and 34.6deg..Their stretching average angular velocities were 182.6deg./s and 170.4deg. /s. Enqvist's left hip Angle, right hip angle, left knee angle and right knee angle were 170.2deg.and 145.7deg. 、 172.0deg. 、 156.8deg. respectively. The advantages of

Enqvist are more obvious.

At forward swing hitting stage, Enqvist and Moya's hitting height were 2.234m and 2.151m, Hitting height and body height ratio were 1.176 and 1.132, Enqvist and Moya's tossing peak and hitting point horizontal distance were o.833m and 1.583m, Enqvist has a advantage obvious.

Based on the comparative analysis above, Enqvist's serve technology is more reasonable, more standardized, more worthy of learn for tennis coaches and athletes.

REFERENCES:

Liu Beixiang. (2008). Sports Biomechanics(Movement Technical Analysis And Evaluation). *SiChuan Sichuan Science And Technology Publishing House.*

Yan Botao,Wu Yanxi,Wan Tinggang. (2000). Biomechanical Analysis of The Tennis Serve. *Sports Science,* 20(4):80-85.

Yan Botao,Li Zao. (2001). Tennis Movement Mode and Basic Technology. *The Chinese Sports Science and Technology.* 37(10):36-40.

Pan Cheng,Zhang Hongcheng. (2002),Two Tennis Baseline Shot Technology Characteristics and Biomechanical Characteristics of the Comparative Analysis. *Journal Of Suzhou University,* (10).

Tang Xiaolin.Chinese (2006). Tennis Player Serve Technology Using Ability Present Situation Analysis and Countermeasure Research. *Chengdu Sports College Journals*., 32(1):74-77

Zhou Lancui. (2003). Introduction to Tennis Receiving Technique. *Tennis World*.

Liu Hui. (2000). The Tennis Serve Sports Biomechanical Principle. *Journal of Beijing Sport University.* 23(2):173-176,180