EVALUATION OF ATHLETIC PERFORMANCE THROUGH GAME ANALYSIS OF TENNIS

Sang Yeon Woo, In Shik Shin[1] and Eugene W. Brown[2]
Soonchunhyang University, Chungnam, Korea
[1]Seoul National University, Seoul, Korea
[2]Institute for the Study of Youth Sports, Michigan State University, East Lansing, USA

The purpose of this study was to explore the use of three-dimensional (3D) analysis techniques for match analysis in tennis. It was determined that temporal and kinematic parameters obtained from 3D video analysis of the 32 finalists in the 1997 Korean Cup provided insight into successful performance. These parameters induded success of first service, distance of receiving player from the ball, height of stroke impact, and player movement pattern.

KEY WORDS: game analysis, tennis, athletic performance.

INTRODUCTION: Typically, analyses of sport performances are conducted to obtain quantitative data on the temporal and kinematic characteristics of the sport skills of different athletes. From this type of data, characteristics that are common to elite level athletes can be identified. Subsequently, this provides coaches and researchers with comparative parameters for their athletes to strive to attain. For example, analysis of the various performance parameters of Olympic freestyle swimming competitors was conducted (Arellano. Brown, Cappaert, and Nelson, 1994). Based on the quantitative data of these world class athletes many coaches, researchers, and athletes could obtain valuable information.

Most studies of sport performances have focused on individuals in predictable environments (e.g., weightlifting, track and field, and gymnastics). Relatively few studies have attempted to analyze athletic performance in settings where the environment is dynamic (i.e., individual athletes or teams having to respond to the actions of their opponents). Similarly, there is a limited number of studies that have attempted to analyze sport performance of athletes and teams competing against each other in net games (e.g., badminton, volleyball, and tennis). Among the studies of net games, Colvin and Francis (1984) videotaped matches of the men's U.S.A. volleyball team against foreign national teams. They investigated individual play, team strategies, and opponent play. In more recent studies (Shin, et al., 1997; Lee, 1998), video cameras were used to conduct 3D analyses of the contributions of individual volleyball players to team strategy. Presently, there is a paucity of game analyses of the net game of tennis. Therefore, the purpose of this study was to determine factors that influence the winning of a tennis game and to provide the scientific basis and practical data for researchers and coaches to assist their players.

METHODS: The entire matches of the 32 finalists in the 1997 Korean Final CUP men's singles tennis tournament were recorded on videotape. Before each match, eight range poles were placed in a rectangle around the activity area to provide a 3D coordinate system from which 3D data could be obtained from videotape of each game. Six video cameras (Panasonic S-VHS D-5100 video camcorders) which operated at the rate of 60 Hz were used; two video cameras captured the whole view of the court, two captured one side of the court, and two captured the other side. Six time recorders, with hour, minute, and second fields, were used to synchronize all cameras. The KWON3D Motion Analysis Package (Kwon, 1994) was used for digitizing the video and data processing. The digitizing points were nine (ball, head of racket, wrist, right and left shoulder, top of the head, center of the hips, right and left toe). Data obtained from each camera view were then synchronized with the time interval of 0.01 s between frames. A cubic spline technique was used to interpolate missing data points.

RESULTS: The values of the first and second service success (number and percent of serves successfully entering opponent's service court) and score (number and percent of

points won) from points played are presented in Table 1 for one match. The rate of successful first serves was 78.3% for player A and 45.0% for player B. Player A won 69.4% of the points on his successful first serves and player B won 51.9% of the points on his successful first serves. From Table 1, it is evident that the success of the first service is an important factor in points won. For both players, a minimum of 50% of the points in a set were won on successful first serves. Player A won points on a minimum of 68.8% of the points in a set on his successful first serves. The percent of points won on successful second serves is less than the percent of points won on successful first serves.

Table 1 First and Second Service Success and Score on Points Played

Player	Set	First Service				Second Service			
		success'		score**		success'		score**	
		n	%	n	%	n	%	n	%
A	1	20	71.4	14	70.0	8	28.6	5	62.5
	2	16	88.9	11	68.8	2	11.1	1	50.0
	Total	36	78.3	25	69.4	10	21.7	6	60.0
B	1	13	40.6	7	53.8	19	59.4	9	47.4
	2	14	50.0	7	50.0	14	50.0	6	42.9
	Total	27	45.0	14	51.9	33	55.0	15	45.5

'number (n) and percent (%) of total serves that entered the opponent's service area
**number (n) and percent (%) of successful service points won by the server.

Table 2 Mean Time Intervals

Player	Set	First Service Time Intervals*				Second Service Time Intervals*			
		(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
A	1	0.557	0.558	0.991	0.428	0.638	0.704	1.021	0.504
		(0.06)	(0.10)	(0.08)	(0.09)	(0.05)	(0.06)	(0.19)	(0.16)
	2	0.515	0.519	0.990	0.520	0.633	0.533	0.800	0.417
		(0.05)	(0.12)	(0.15)	(0.10)	(0.00)	(0.09)	(0.14)	(0.07)
	Total	0.538	0.541	0.990	0.470	0.637	0.670	0.977	0.487
		(0.06)	(0.11)	(0.11)	(0.10)	(0.04)	(0.09)	(0.20)	(0.15)
B	1	0.477	0.486	1.23	0.570	0.653	0.567	1.004	0.515
		(0.08)	(0.09)	(0.19)	(0.08)	(0.05)	(0.12)	(0.20)	(0.09)
	2	0.474	0.446	1.170	0.552	0.651	0.531	1.024	0.531
		(0.08)	(0.09)	(0.21)	(0.13)	(0.05)	(0.10)	(0.14)	(0.13)
	Total	0.476	0.465	1.196	0.561	0.656	0.554	1.009	0.516
		(0.08)	(0.09)	(0.20)	(0.11)	(0.05)	(0.11)	(0.18)	(0.11)

* mean time interval and standard deviation in parentheses.
(a) time from service contact to service court contact.
(b) time from service court contact to return contact.
(c) time from return contact to court contact.
(d) time fmm return court contact to racket contact.

The temporal results for one tennis match are shown in Table 2. The temporal analysis is based upon five sequential events: racket contacts ball on serve, ball contacts the opponent's service court, opponent contacts ball on return, returned ball contacts server's

court, and rebounding ball contacts server's racket (see Figure 1). These five events determine four time intervals described in Table 2 and Figure 1. The mean times for the first services for intervals (a) and (b) were 0.538s and 0.541s for player A and 0.476s and 0.465s for player B, respectively. Without regard for distance, it appears that the first serves of player B were faster and reached his opponent's racket more quickly. However, on the second services, time intervals (a) and (b) for player A were shorter.

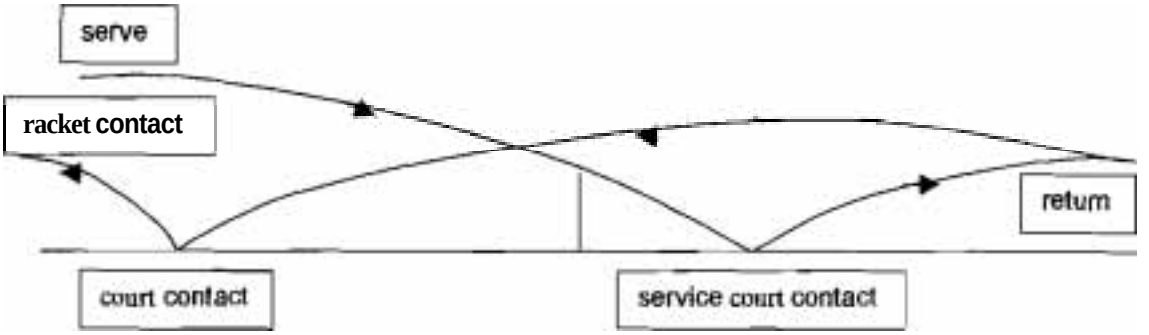

Figure 1 - Events and time intervals analysed.

Figure 2 shows the movement patterns of players A and B during the first game of the first set. From Figure 2, it is evident that the area and distance covered by player B was greater than player A. Interpretation of movement patterns provides insight into potential energy expenditure and location of play. Matches were also analyzed for types of strokes used. For example (see Figure 3), both player A and player B used mostly ground strokes (forehand and backhand) in their match, 230 (87.5% of all strokes) and 211 ground strokes (84.4% of all strokes) for each player, respectively. The volley skill was only used 9 times (3.4% of all strokes) by player A and 11 times (4.4% of all strokes) by player B.

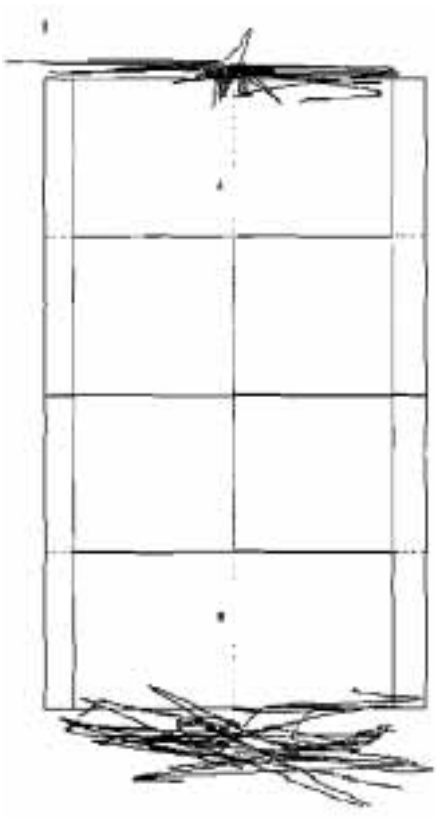

Figure 2 - Movement patterns during one game.

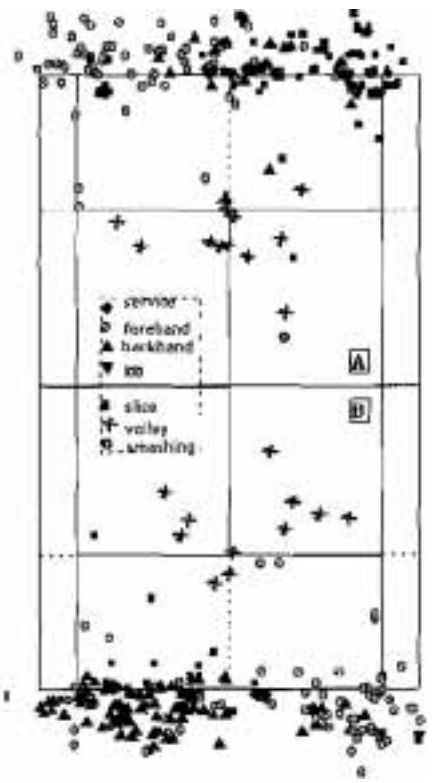

Figure 3 -Position of impact for various strokes during a match.

Figure 3 (included only the data in which both players played the same side court) shows the location on the court at which each racket impact of the ball occurred during the match between players A and B. From Figure 3, it is evident that both players served from a position near the center mark at the base line. Player A predominately used backhand slices to return the ball from the backhand side of the court; whereas, player B predominately used a backhand ground stroke to make returns from his backhand side of the court. Table 3 shows the mean distances (X and Y) between the receiving player and the ball, prior to attempting to return the ball, at the instant the ball rebounds from the court. Also, the mean heights of the rackets' impact with the ball for the service, forehand, and backhand strokes are shown in this table. It is evident that player A is closer to the approaching ball when it rebounds from the court and that his racket impacts the ball at a higher point than player B on his service and backhand strokes. The differences in the impact height on the backhand strokes may be due to player A predominantly using slices on his backhand return.

Table 3 Mean Distances and Heights

Distances (cm) between Receiving Player and Approaching Ball at Point of Rebound from the Ground				Heights (cm) of Impact Above the Ground for Selected Strokes					
Player A		Player B		Player A			Player B		
X*	Y**	X*	Y**	service	fore-hand	back-hand	service	fore hand	back-hand
106.06 (73.31)	473.38 (189.21)	127.70 (87.17)	550.90 (196.60)	267.35 (10.91)	97.47 (40.72)	93.34 (25.61)	247.77 (40.74)	102.90 (28.00)	91.87 (45.39)

*X side-to-side (or side line to side line) distance and standard deviation in parentheses.
**Y forward-backward (or base line to base line) distance and standard deviation in parentheses.

CONCLUSIONS: Decisive factors for winning in tennis were strong stroke skills, first service success, high impact height, and short impact distances. However, the performance of the player in games could be affected by the opponent's ability. Therefore, comparative analyses should include matches in which high ranked players have competed and matches in which high and low ranked players have competed.

REFERENCES:

Arellano, R., Brown, P., Cappaert, J., & Nelson, R.C. (1994). Analysis of 50-, 100-, and 200-m freestyle swimmers at the 1992 Olympic games. Joumal of Applied Biomechanics. 10, 189-199.

Colvin, W.W., & Francis, P. (1984). Video record of foreign competition U.S.A. men's volleyball, *Abstract* of *Biomechanical* Research United States Olympic Committee, pp.114-279.

Kwon, Y. H. (1994). KWON3D Motion Analysis Package (Version 2.1). Seoul: V-TEK Corporation.

Lee, K. C. (1998). The relationship between the team offensive performance and individual technique during men's volleyball competition. Unpublished Doctoral Dissertation, Seoul National University, Seoul.

Shin, I. S., Kwak, C. S., Lee, K. C., Kang. J. H., Lee, Y. S., Moon, Y. J., Hong, Y. H., Kim, K. H., & Chun, Y. J. (1997). Evaluation of the team offensive performance in volleyball using three-dimensional analysis. The Education *Journal* of Seoul National *University,* 55, 135-146.