KINEMATIC ANALYSIS OF THE TENNIS SERVE IN YOUNG TENNIS PLAYERS

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Abstract
Tennis serve is one of the most important elementary techniques that make a tennis player successful. Model that analyzes optimal technique of tennis serve was constructed based on analyses of professional ATP players and it was used in this research as well. The purpose of this study was to identify if young tennis players who have been professionally active between 1-3 years of trainings are using serve technique in the right way and if there are any differences in their practice compared to "Kinetic Service New MODEL" that we represented in previous work. For this research we used 63 young tennis players between 7-9 years old that had one, two or three years of experience. In order to see if the serve is correctly or incorrectly performed they ware analyzed through sophisticated 3-D Motion Analysis System with accompanying Software. Results of analyses show us that none of these young tennis players are able to serve correctly. Results also tell us that through "Kinetic Service New MODEL" their OCG movement while serving is totally different from the OCG movement within professional players, and that also certain actions that professionals do while serving in succession, young players could not demonstrate.

Key words: *tennis, center of gravity, kinematic service analysis*

Introduction

Tennis belongs to the category of poly-structural complex movements of the acyclic type. Success in tennis depends on many different factors. Some of them would be morphology (structure and physique of the human body and its working function), psychomotor, cognitive and conative sphere and its activators, motivational structure, physio-functional characteristics of the player (mixed measurement of aerobic and anaerobic capacity, dynamic's micro social area or pose of individual in group and response of the group to that position), technique, tactics and strategy of the game. Tennis serve is one of the most important elementary techniques of this sport and without its perfect performance the success in this sport is not possible (Elliott, Marsh, and Blanksby, 1986; Emmen et al, 1985; Rose, Heath and Megale, 1990). This is why we decided to do research and explain importance of the tennis serve even though we know we are covering only one segment that makes player successful (Elliott, Marshall and Noffal, 1995; Van Wieringen, Emmen, Bootsma, Hoogesteger and Whiting, 1989). Even small step on special plan it is always a big step in a bigger picture, and that was our intention.

Methods

Sample of subjects
Study sample included 63 young tennis players between 7-9 years old that had one, two or three years of experience in training.

Method of collecting data
63 Digital snapshots of serve with selection of 6 quality and successfully performed serves

Methods of processing data
Sophisticated 3-D Motion Analysis System with accompanying Software was used for analyzing data (APAS – Ariel Performance Analysis System 2000).Classification criteria for the correct performance serve was defined by eight crucial elements defined by the MODEL of a tennis serve we used in our prior work.

Model
A. GRF (Ground Reaction Force) - summation of forces towards racket starts after significantly flexing the knees (Van Gheluwe, and Hebbelinck, M., 1986)
B. HIPS Disturbed balance, extended arm position in a way that allows hips moving forward

C. SHOLD Shoulders begin to rotate aside from the net position (Elliott, B, Marshall, R. N., and Noffal, G.J. 1995.)
D. PRON Internal rotation of the upper arm and forearm pronation
E. FLEX Hand flexion that accelerates the ball additionally and ends the mechanic chain when racket hits the ball (Blackwell, J.R. & Cole, K.J. 1994.)
F. TFF Body lands inside the baseline with trunk significantly flexed forward
G. CG LRH Left and right hip follow OCG trajectory
H. CG OCG continues to move forward until gaining balance for new activity

Performance evaluation

A 2 performance succeed, 1 failed
B 15 performance succeed, 10 failed
C 101 performance succeed, 100 failed
D 55 performance succeed, 50 failed
E 250 performance succeed, 200 failed
F 350 performance succeed, 300 failed
G 401 performance succeed, 400 failed
H 550 performance succeed, 500 failed

The matrix of original results has been formed. Matrix of successful and unsuccessful parts of technique while serving in succession has been calculated within every age group (7, 8 and 9 years old).Statistics of all estimated variables used in MODEL has been calculated, as well as correlation of all variables in the system, finally, the interpretation of the results has been done.

Results and Discussion

Based on analyses of central and dispersion parameters of all the variables we came to the conclusion: Among eight variables, successively done one after another (MODEL), all players have been graded upon their basic serving technique, by correct or incorrect parts of technique.

Also players aged 7, 8 and 9 have been graded based on the same scale. Central and dispersion parameters of all variables have been showed in Table 3.as well as the graphical sketch including variables with zero values (constant). From the results of the survey it can be seen that players with only one year of playing cannot make 6 out of 8 elementary technique elements.

Young players with 2 to 3 years of playing experience cannot make 5 out of 8 elementary technique elements, though we can see a slight but not significant progress after each year of playing. From Table 2.it can be seen that just a small number of players (one in first and second year and four of them in third year of training) are able to perform some parts of elementary technique elements. Most likely the reason is that player's use the motion learned during the first year of playing and after that they are just repeating that motion but not well enough. In graph 3.is showed typical OCG trajectory on tested tennis players.

No matter is it All – court or Serve – volley player the movement of the OCG during the serve must be forward at all times. Left and right hip follow the trajectory of the OCG of both players, but serve volley player has a more distinct movement towards, since his aim is to be on net as soon as possible, while the trajectory of the all-court player goes upwards as his intention is to remain on a base line after serving.

This happens only because professional players can make OCG movement forward and in the same time their left and right hip can follow that movement. Tested players from all age groups are not able to perform that movement correct. Their right hip goes inappositely and pronouncedly to the front, more then its needed, while the left hip lags and is behind the right hip (viewed towards the net). Children did not learn that for successful serve the left hip needs to be in front of the right hip at all times (right hand player).

The other consequence is OCG trajectory goes back in the last part of the serve, which can also be seen from the kinematic curves. As the players at this age make very bad first movement it is hard to expect better force transfer from legs trough the trunk-hand and the racquet. It is obvious use of upper body compensation as a way to make it easier to serve, probably spontaneously action, because they have not been taught correctly. If during learning process we pay more attention to criteria number 7 (CG LRH) we think that it will directly affect criteria 8-CG, criteria 6-TFF and also the serve as a whole. Pronation and hand flexion are crucial 2 elements which would take special focus in last stage of teaching and perfecting tennis serve.

Table 1.Original results

AGE	GRF	HIPS	SHOLD	PRON	FLEX	TFF	CG LRH	CG	CASE NUMBER
7	2	10	101	50	200	350	400	550	1
7	1	10	101	50	200	350	400	550	2
7	1	10	101	50	200	350	400	550	3
7	1	10	101	50	200	300	400	550	4
7	1	10	101	50	200	300	400	550	5
7	1	10	101	50	200	300	400	550	6
7	1	10	101	50	200	300	400	550	7
7	1	10	101	50	200	300	400	550	8
7	1	10	101	50	200	300	400	550	9
7	1	10	101	50	200	300	400	550	10
7	1	10	101	50	200	300	400	550	11
7	1	10	101	50	200	300	400	550	12
7	1	10	100	50	200	300	400	550	13
7	1	10	100	50	200	300	400	550	14
7	1	10	100	50	200	300	400	500	15
7	1	10	100	50	200	300	400	500	16
7	1	10	100	50	200	300	400	500	17
7	1	10	100	50	200	300	400	500	18
7	1	10	100	50	200	300	400	500	19
7	1	10	100	50	200	300	400	500	20
7	1	10	100	50	200	300	400	500	21
8	2	10	101	55	200	350	400	550	22
8	1	10	101	50	200	350	400	550	23
8	1	10	101	50	200	350	400	550	24
8	1	10	101	50	200	350	400	550	25
8	1	10	101	50	200	350	400	550	26
8	1	10	101	50	200	350	400	550	27
8	1	10	101	50	200	350	400	550	28
8	1	10	101	50	200	350	400	550	29
8	1	10	101	50	200	350	400	550	30
8	1	10	101	50	200	350	400	550	31
8	1	10	101	50	200	350	400	550	32
8	1	10	101	50	200	350	400	550	33
8	1	10	101	50	200	300	400	550	34
8	1	10	100	50	200	300	400	550	35
8	1	10	100	50	200	300	400	550	36
8	1	10	100	50	200	300	400	500	37
8	1	10	100	50	200	300	400	500	38
8	1	10	100	50	200	300	400	500	39
8	1	10	100	50	200	300	400	500	40
8	1	10	100	50	200	300	400	500	41
8	1	10	100	50	200	300	400	500	42
8	1	10	100	50	200	300	400	500	43
8	1	10	100	50	200	300	400	500	44
9	2	10	101	55	200	350	400	550	45
9	2	10	101	55	200	350	400	550	46
9	2	10	101	55	200	350	400	550	47
9	2	10	101	50	200	350	400	550	48
9	1	10	101	50	200	350	400	550	49
9	1	10	101	50	200	350	400	550	50
9	1	10	101	50	200	350	400	550	51
9	1	10	101	50	200	350	400	550	52
9	1	10	101	50	200	350	400	550	53
9	1	10	101	50	200	350	400	550	54
9	1	10	101	50	200	350	400	550	55
9	1	10	101	50	200	350	400	550	56
9	1	10	101	50	200	350	400	550	57
9	1	10	101	50	200	300	400	550	58
9	1	10	101	50	200	300	400	550	59
9	1	10	101	50	200	300	400	550	60
9	1	10	100	50	200	300	400	500	61
9	1	10	100	50	200	300	400	500	62
9	1	10	100	50	200	300	400	500	63

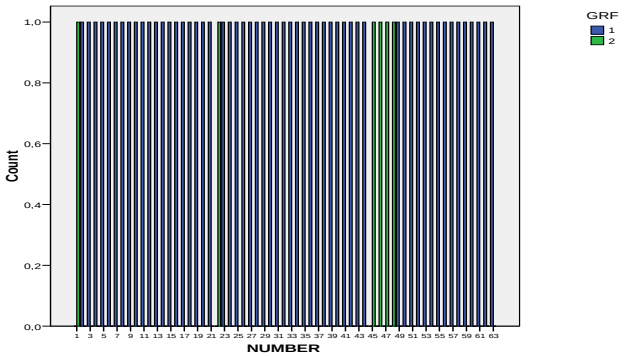
Table 2. Performance success and Performance failure –
Derived parts of technique service for all tested tennis players

SUCCESS	AGE	N	GRF	HIPS	SHOLD	PRON	FLEX	TFF	CGLRH	CG
	7	21	20	21	9	21	21	18	21	7
	8	23	22	23	10	22	23	11	23	8
	9	19	15	19	3	16	19	6	19	3
FAILURE	AGE	N	GRF	HIPS	SHOLD	PRON	FLEX	TFF	CGLRH	CG
	7	21	1	0	12	0	0	3	0	14
	8	23	1	0	13	1	0	12	0	15
	9	19	4	0	16	3	0	12	0	16

Table 3. Descriptive statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	63	7	9	7.97	.803
GRF	63	1	2	1.10	.296
HIPS	63	10	10	10.00	.000
SHOLDERS	63	100	101	100.65	.481
PRONATION	63	50	55	50.32	1.229
FLEXION_HAND	63	200	200	200.00	.000
TFF_BLIB	63	300	350	322.22	25.045
CG_LRH	63	400	400	400.00	.000
CG	63	500	550	535.71	22.769
Valid N (listwise)	63				



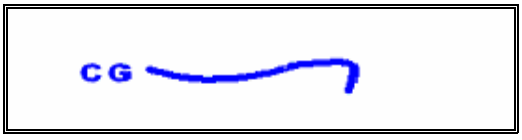
Graph 1. Progress in GRF behavior in relation to training years

Table 4. Correlations between variables in given system without variables of zero values

		Trunk Flex Forward	Ground Reaction Force	Age	Shoulders	Pronation	CG
Trunk Flex Forward	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	63					
Ground Reaction Force	Pearson Correlation	,363*	1				
	Sig. (2-tailed)	,003					
	N	63	63				
Age	Pearson Correlation	,437*	,217	1			
	Sig. (2-tailed)	,000	,088				
	N	63	63	63			
Shoulders	Pearson Correlation	,655**	,238	,222	1		
	Sig. (2-tailed)	,000	,061	,043			
	N	63	63	63	63		
Pronation	Pearson Correlation	,291*	,803**	,256*	,191	1	
	Sig. (2-tailed)	,021	,000	,043	,134		
	N	63	63	63	63	63	
CG	Pearson Correlation	,566**	,205	,151	,863**	,165	1
	Sig. (2-tailed)	,000	,107	,237	,000	,197	
	N	63	63	63	63	63	63

**.Correlation is significant at the 0.01 level (2-tailed).

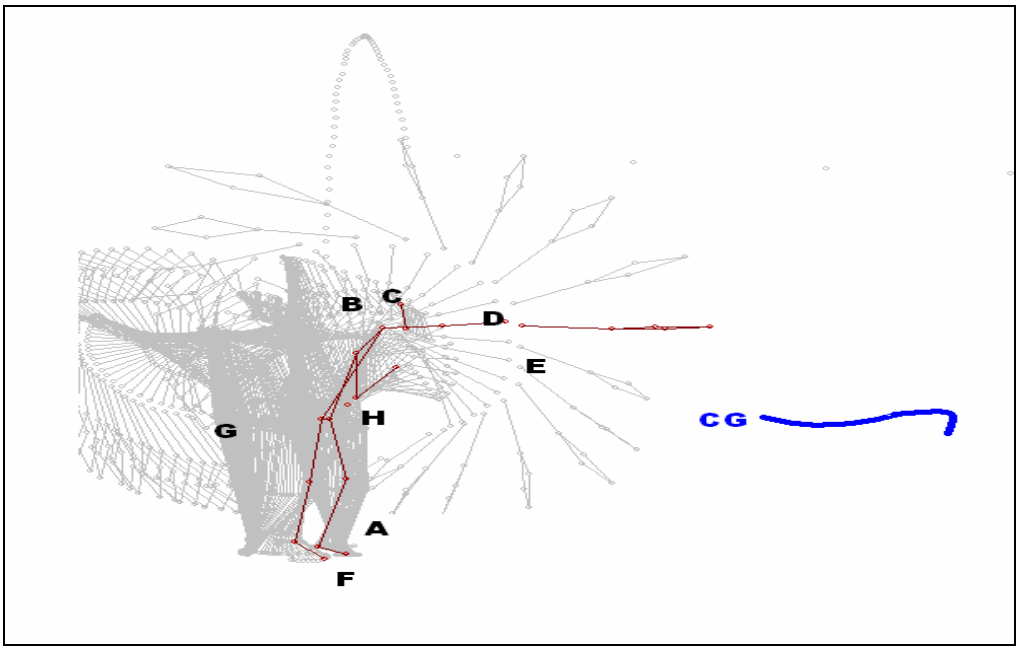
*. Correlation is significant at the 0.05 level (2-tailed).



Graph 3.Tipical OCG trajectory on tested tennis players

Graph 4. Tipical OCG trajectory on professional tennis players

Graph 4. Typical OCG trajectory on professional tennis players



Picture 1.Kinematic-graphic presentation of serve of the young player

Picture 2. Young tested player

Results acquired by MODEL criteria without variables that have zero value (constant) and they are not in correlation with taped and analyzed serve of the beginner are just confirmation of the above stated. Due to research we made, we can conclude that none of the 63 player can successfully perform high – quality tennis serve. That can mean two things, either coaches are not familiar with the model characteristics of the serve technique or they do not even address that issue, which is wrong, because that s crucial part in a success of a player.

Conclusion

Five out of eight crucial elements (Model A-H) tested players do not comply what makes us conclude that serve is not practiced enough with the players and even if it is, it's done incorrectly. It is necessary to impose the biomechanical analyze technique (Model) in all tennis academies as "Conditio Sine Qua Non" when working with young players. No matter is it All – court or Serve – volley player the movement of the OCG during the serve must be forward at all times.

Left and right hip follow the trajectory of the OCG of both players, but serve volley player has a more distinct movement towards, since his aim is to be on net as soon as possible, while the trajectory of the all-court player goes upwards as his intention is to remain on a base line after serving. This happens only because professional players can make OCG movement forward and in the same time their left and right hip can follow that movement. Tested players from all age groups are not able to perform that movement correct. Their right hip goes inappositely and pronouncedly to the front, more then its needed, while the left hip lags and is behind the right hip (viewed towards the net). Children did not learn that for successful serve the left hip needs to be in front of the right hip at all times (right hand player). The other consequence is OCG trajectory goes back in the last part of the serve, which can also be seen from the kinematic curves. As the players at this age make very bad first movement it is hard to expect better force transfer from legs trough the trunk-hand and the racquet. It is obvious use of upper body compensation as a way to make it easier to serve, probably spontaneously action, because they have not been taught correctly. If during learning process we pay more attention to criteria number 7 (CG LRH) we think that it will directly affect criteria 8-CG, criteria 6-TFF and also the serve as a whole. Pronation and hand flexion are crucial 2 elements which would take special focus in last stage of teaching and perfecting tennis serve.

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KINEMATIČKA ANALIZA TENISKOG SERVISA KOD MLADIH TENISAČA

Sažetak

Teniski servis je jedan od najvažnijih elemenata tehnike u tenisu i čini tenisača uspješnim. U svrhu potpore i razvoja servisa, konstruiran je model kojim se analizira optimalna tehnika servisa. Model je utemeljen na analizi profesionalnih ATP tenisača, te je korišten u ovom istraživanju. Svrha ove studije je bilo utvrđivanje koriste li mladi tenisači (koji su 1-3 godine aktivni u sustavnom treningu) tehniku servisa ispravno i postoje li razlike u njihovoj praksi u usporedbi s "Novim modelom teniskog servisa" koji je prethodno razvijen i predstavljen u prethodnom radu. Za ovo istraživanje korišteno je 63 mladih tenisača uzrasta 7-9 godina koji su imali jednu, dvije ili tri godine iskustva. Kako bi utvrdili je li servis korektno ili neispravno izveden, njihovi servisi su analizirani uz pomoć sofisticiranog 3-D Motion Analysis Systema s pratećim softwareom. Rezultati analize su pokazali da ni jedan od ovih mladih tenisača nije u stanju servirati ispravno. Rezultati također sugeriraju da kroz "Novi model teniskog servisa" njihov opći centar težišta kod serviranja je potpuno različit od općeg centra težišta profesionalnih tenisača, kao i da više akcija koje profesionalci izvode sukcesivno u serviranju, mladi tenisači ne mogu izvesti.

Key words: *tenis, opći centar težišta, kinematička analiza servisa*

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