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BIOMECHANICAL ANALYSIS FOR PREDICTION OF TENNIS SERVICE SPEED

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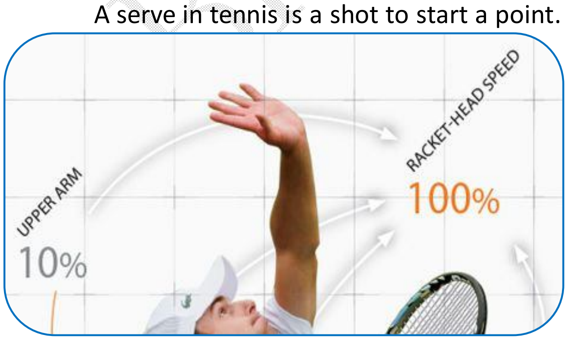
ABSTRACT :
The purpose of the present study was to determine the Kinematic variables for the prediction of speed of tennis serve. A total of 30 male junior AITA ranking players of three different tennis academy of Gwalior were selected by using purposive sampling. Videography method was used to biomechanically analyzes four phases of tennis serve i.e. moment stance position, moment preparatory phase, moment contact and moment follow through. For the purpose of the study, tennis serve speed was selected as dependent variable; and for independent variables; in linear kinematic variables i.e. Height of the Centre of Gravity at four phases of tennis serve and in Angular kinematic variables i.e. Angle at Right Ankle Joint, Angle at Right Knee Joint, Angle at Right Hip Joint, Angle at Right Shoulder Joint, Angle at Right Elbow Joint and Angle at Right Wrist Joint were selected for the present study. Kinovea software was used in order to obtain the values of selected linear and angular kinematic variables and Bushnell Speed Gun was used to measure the speed of the tennis serve. Stepwise multiple regression analysis was conducted based on correlations between variables and the tennis serve speed. Positive correlations were found between the tennis performance and angle at knee & shoulder in preparatory phase and angle at hip in follow through. R^2 *was 0.662; highlighted that the regression equation explained 66.2 % of total variability. It could be said that above mentioned variables may predict the performance of speed of tennis serve.*

KEYWORDS : *Kinematics, tennis service speed, stance position, preparatory phase, moment contact, follow through.*

INTRODUCTION

Tennis techniques were firstly studied from a true scientific perspective in the 1960's. The late Dr. Stanley Plagenhoef was one of the first pioneers in the science of tennis technique. Plagenhoef used high-speed film and mathematical modelling to help educators and coaches to understand the sport of tennis in greater details. His ground- breaking words led many others around the world to study tennis from a scientific perspective. (Roetert & Groppel, 2001)

A serve in tennis is a shot to start a point. Normally players begin a serve by tossing the ball into the air and hitting it (usually near the highest point of the toss). The serve is one of the most difficult shots for a novice, but once mastered it can be a considerable advantage. Advanced players can hit the serve in many different ways and often use it as an offensive weapon to gain an advantage in the point or to win it outright. Because of this, players above beginner level are expected to win most of their service games, and the ability to break an opponent's serve plays a crucial role



in a match.

PURPOSE OF THE STUDY

The purpose of the present study was to determine the Kinematic variables based on biomechanical analysis for the prediction of speed of tennis serve.

METHODS

Selection of the subjects

The subjects for the present study were thirty (N=30) male junior AITA (All India Tennis Association) ranking players of three different tennis academy of Gwalior. As the subjects had been undergoing training for a considerable period, therefore, it was assumed that they possessa good level of technique of service. The purpose of the research was explained to all the subjects and subjects were motivated to put their best during each trial.

Selection of variables

After reviewing the literatures and experts guidance the following kinematical variables were selected:

Dependent Variable: -

Speed of tennis service performance.

Independent Variables: -

Linear Kinematics: - Height of the Centre of Gravity at four phases i.e. moment stance position, moment preparatory phase, moment contact and moment follow through.

Angular Kinematics: - Angle at Right Ankle Joint, Angle at Right Knee Joint, Angle at Right Hip Joint, Angle at Right Shoulder Joint, Angle at Right Elbow Joint and Angle at Right Wrist Joint.

Criterion Measures

1. The speed of tennis serve was assessed through Bushnell Speed Gun and reported in meters per second.
2. The angles were measured in nearest degree at selected joints in all four phases of tennis serve.
3. Center of Gravity was measured in nearest centimeters from the ground at four phases of Tennis serve.

Filming Protocol

Videography method was used to biomechanically analyze the phases of tennis serve. Go Pro Hero 5 with the frequency of 120 frames per second was placed on the sagittal plane of the tennis player during the serve. The four moments were selected for the analysis i.e. stance position, preparatory phase, time of moment contact and follow through. All above mentioned moments were extracted as photograph from the Videography in Kinovea Software. Scholar developed the stick figures and selected kinematic variables were calculated. The subjects performed the technique (flat tennis serves) ten times and the best trail was used for the analysis. For the tennis serve speed, scholar was standing diagonal to the subject with the Bushnell Speed gun. The Bushnell Speed gun was pointed towards the path of the ball during the serve. The readings were recorded in meters per second.

STATISTICAL PROCEDURE

Statistical analysis was done with Statistical Package for Social Science (SPSS) version 20.0. The stepwise multiple regression analysis was used to predict the speed of tennis serve based on selected kinematic variables. For testing the hypothesis, the level of significance was set at 0.05.

RESULTS

Model Summary along with the value of R, R^2 and adjusted R^2 with Speed of Tennis Serve in is shown in Table1:

Table 1
Model Summary along with the value of R, R^2 and adjusted R square with Speed of Tennis Serve

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
					R^2 Change	F Change	df1	df2	Sig. F Change
1	.560[a]	.314	.289	7.50440	.314	12.803	1	28	.001
2	.723[b]	.523	.488	6.37200	.209	11.836	1	27	.002
3	.814[c]	**.662**	.623	5.46513	.139	10.704	1	26	.003

a. Predictors: (Constant), Knee (phase2)
b. Predictors: (Constant), Knee (phase2), Hip (Phase 4)
c. Predictors: (Constant), Knee (phase2), Hip (Phase 4), Shoulder (Phase 2)

The third regression models generated by the SPSS on the base of correlation between variables and tennis serve speed has been presented in Table 1. In the 3rd model, the value of R^2 is 0.662, which is maximum; and, therefore, 3rd model was used to develop the regression equation. It can be seen from Table 1 that in the 3rd model, three independent variables, namely, angle at knee and shoulder in preparatory phase and angle at hip in follow through have been identified, and, therefore, the regression equation shall be developed using these three variables only. The R^2 value for this model is 0.662, and, therefore, these three independent variables explain 66.2% prediction in score of speed in tennis serve. Thus, this model could be considered appropriate to develop the regression equation.

Regression coefficient of selected variables in the 3rd model had 66.2% prediction in score along with t- value and partial correlations were presented in table 2:

Table 2
Regression coefficient of selected variables in 3rd model along with their t-values and partial correlations with Speed of Tennis Serve

Model		Unstandardized Coefficients		Standa-rdized Coeffic-ients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
3	(Constant)	-108.701	64.440		-1.687	.104			
	Knee_2	1.688	.355	.543	4.760	.000	.560	.682	.543
	Hip_4	-.372	.083	-.517	-4.474	.000	-.479	-.660	-.510
	Shoulder_2	.158	.048	.378	3.272	.003	.291	.540	.373

Table 2 had shown the unstandardized and standardized regression coefficients in the three models. Unstandardized coefficients are also known as “B” coefficients and used to develop the regression equation whereas standardized regression coefficients are denoted by “β” and used to explain the relative importance of independent variables in terms of their contribution toward the dependent variables in the model. In the thirdmodel, t-values for all the three regression coefficients are significant as their significance values (p values) are less than .05. Thus, it might be concluded that the variables angle at knee and shoulder in preparatory phase and angle at hip in follow through significantly explain the variations in the Speed of tennis serve.

Regression Equation: - Usingregression coefficient (B) of all the eleven models shown in table 2 the regression equation could be developed which was as follows:

Speed Performance of tennis service = -108.701 + 1.688 X (Angle of Knee at Moment Preparatory Phase) + 0.158 X (Angle of Shoulder at Moment Preparatory Phase) –0.372 X (Angle of Hip at Moment Follow Through).

DISCUSSIONS OF FINDINGS

The kinematic variables revealed significant relationship of speed of tennis serve withangle at knee and shoulder in preparatory phase and angle at hip in follow through phase. (Wong F. K., Keung, Lau, Ng, Chung, & Chow, 2014) Gordon & Dapena (2006) reported significant contribution of velocities of hip, knee, shoulder and elbow joints to increase the speed of tennis serve.

The ground reaction force created during the preparatory phase results in an off-center angular impulse, which elevates the body towards racket side and lower the opposite side. This produces a shoulder-over-shoulder rotation as the server explosively moves the arm towards the position of contact and allows greater racket height for contact of serve. These movements transfer angular momentum and ground reaction force from lower limbs to upper limbs. (Baharnonde, 2000). During serve, a player bends his knees so that he can generate more force from the muscles with the extension and higher the range of motion. (Wong F. K., Keung, Lau, Ng, Chung, & Chow, 2014)

Results also indicated significant relationship of speed of tennis serve and angle at hip joint during follow through phase. The follow through phase is the most important stage of tennis serve, requiring deceleration eccentric loads in both the upper and lower body (Kovacs & Ellenbecker, 2011). To stabilize the hip during an unbalanced posture the right erector spina become highly active during the deceleration stage (Chow, Park, & Tikkllman, 2009).

In other hand other variables revealed the insignificant value obtained for all variables may be due to the different patterns adopted by the athlete during training of tennis serve. Majority of the biomechanical variables follow a non-liner relationship with the performance which could have effect the findings. It might also be due to different quality technique used by the athlete during the test.

CONCLUSIONS

Based on the analysis and within the limitations of the present study, following were the conclusions drawn:

1. The kinematic variables i.e. angle at knee and shoulder in preparatory phase and angle at hip in follow through phase will help to predict the performance of tennis serve speed.
2. There are few significant differences in the serve kinematics between tennis players, thereby eliminating the need to teach different mechanics to them.
3. Kinematics variables could be adjusted to improve serve speed; and may allow players to improve towards a world class level in terms of serving.
4. The model of the high performance serve provides a framework for analysis.

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