

Analysis of Kinematic and Anthropometric Variables of the Spike Execution Technique of Volleyball

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ABSTRACT

The research aimed to analyze the kinematic and anthropometric variables of the spike execution technique of volleyball. 36 junior India level players from all over India of 16 - 20 years, age group were to be selected as subjects for the study. Purposive sampling technique was used for the selection of subjects. Participants were required to deliver five relevant spiked execution attempts as well as the perfect trial used for the analysis. Elite coaches who were available during the evaluation for grading. The moment execution of the spike was measured based on certain criteria (10 point system). A Go Pro Hero 5 (camera) with a frequency of 240 frames per second was placed on the sagittal plane to measure kinematic parameters. Based on sequence photographs the scholar developed stick figures from which selected biomechanical variables were calculated. The stick figures, angle of different joints, the center of gravity were developed by kinovea version 0.8.27 software. Body segments (i.e., standing height, upper arm, lower arm, palm length, upper leg, and lower leg length) were measured by the anthropometric kit. The multiple regression analysis was to be used to find out the prediction of kinematic & anthropometric variables of the spike execution technique of volleyball at 0.05 level of significance. Results of this study shows the value of R^2 is 0.883 in selected kinematic variables and 0.119 in selected anthropometric variables. It may be interpreted that all the four kinematic variables selected in the model namely, angle at right wrist, angle at right elbow, angle at right shoulder, and ball velocity and the anthropometric variable selected in the model name, palm length have significant predictability in estimating the value of the moment execution technique of spike in volleyball. The result concluded that the kinematic variables i.e., ball velocity, angle at right wrist, angle at right elbow, angle at right shoulder and palm length in anthropometric measurement are contributed in the moment execution to create a maximum speed, force and accuracy in the spike technique of volleyball. This study also contributed in the best way to execute the technique of spike for performance enhancement of volleyball players. It is suggested that the results of this study provide useful information for coaches to training in upper body strength & flexibility levels for attempting to increase range of joint movement, hitting with accuracy of the spike technique and its helps in injury prevention of volleyball players.

Keywords- Kinematic, Technique, Anthropometric.

I. INTRODUCTION

Sport and fitness biomechanics comprise the scientific field concerned with the study of human movement dynamics (Hall, 2019). It refers to the description, detailed analysis, and assessment of human movement during sports activities (Brukner, 2012). Biomechanics is divided mainly into disciplines of kinematics, a division of science which deals with the physics of object motion, which include displacement, velocity and acceleration, without recognizing the forces producing motion, while kinetic studies is the analysis of the relationship between force system acting on a body and the changes it generates in body motion (Hall, 2019). According to (Knudson, 2007) the efficiency of human movement can be improved in many ways as successful movement requires physical influences, neuromuscular ability, physiological strengths and psychological / cognitive abilities. Biomechanics is basically the study of the mechanism of movement and as such appears to be found most in sports where mechanism is a primary factor rather than the physical structure or physiological capabilities.

Biomechanics provides essential scientific knowledge which can enhance the output of an person. The spike of the volley ball is an offensive strike or a ball attack. Spiking requires significant amount of movement and ability to concentrate with precise timing (Pacific Coast Volleyball Camps, 2014). The goal is to generate just as much power through the ball to complete the point. By studying biomechanical principles, the power produced in the ball can be maximized to effectively conduct a spike at sufficient speed.

While the volleyball spike is divided down into parts of movement, a biomechanical method may be used to examine the individual body movements. This strategy would help enhance an individual's output through quantitative analysis. Quantitative approach can be described by numerous biomechanical principles to provide relevant statistical information about the examined movement (Wuest & Fisette, 2012). Detailed information is provided concerning issues including the joint angles through motion, the force produced and the speed of movement. The study of the volleyball spike should adopt a quantitative approach, which will

hopefully enhance the execution of the skill by an person (Skoumbros, 2014).

Due to the various things relevant to volleyball biomechanics not every ball strike is fine. Many errors created by players were due to the complexity of accurately performing hundreds of small movements every single time. Understanding when to spike properly is key to being a successful offensive volleyball player. A biomechanical study of the ability is one way to improve athletes spiking technique. In this case, we will look explicitly at the key movement phases involved in a good volleyball spike and discuss the key biomechanical principles required for an effective shot ("Biomechanical Analysis for the optimal technique of the Volleyball Spike", 2015).

Volleyball acts are a dynamic combination of energy, endurance, agility, and finesse. That of these components consists of complex, small gestures, the summations of which are coordinated actions of striking a desired fashion of volleyball. The volleyball spike is a prime example of that, and is one of the game's most entertaining shots when properly executed. This includes a powerful 'spike' downward motion over a net with the goal of the opposition being unreturnable ("Biomechanical Analysis for the optimal technique of the Volleyball Spike", 2015).

Knowledge of anthropometric properties is needed to establish their importance for competitive sport success (Viswanathan J, Chandrasekaran K. 2011). Volleyball is a part of sporting activities in which its participants' anthropometric characteristics affect the degree of sporting success. It has been known that volleyball players have distinctive anthrop-morphological characteristics compared with most other athletes (Ugarkovic D. 2004). In other words, next to the high level of technical and tactical skills, successful participation in volleyball games also requires the appropriate anthropometric characteristics of each player. Therefore, anthropometric features are almost exclusively determined genetically and large measurements cannot be modified with preparation. (Norton K, Olds T. 2001).

The purpose of this study was to analysis of kinematic and antropometric variables of the spike execution technique of volleyball.

II. METHODOLOGY

2.1. Source and selection of subject

For the study 36 junior India level players from all over India of 16 - 20 years, age group were to be selected as subjects for the study. All participants were healthy, in the good physical condition and all were right-handed. It was assumed that they possess a good level of spike execution technique of volleyball. The purpose of the research was explained to all the subjects and subjects were motivated to put their best during each trial. Each participant provided consent before participation in testing procedures.

2.2. Criterion Measure

Participants were required to deliver five relevant spiked attempts at the execution stage as well as the perfect trial used for the analysis. Elite coaches who were available during the evaluation for grading. The execution phase of the spike was measured based on certain criteria (10 point system). The high point of the execution phase was included in the analysis. A Go Pro Hero 5 (camera) with a frequency of 240 frames per second was placed on the sagittal plane to measure kinematic parameters. Moment execution phase in spike technique of volleyball was being selected for analysis. Based on sequence photographs the scholar developed stick figures from which selected biomechanical variables were calculated. The stick figures, angle of different joints, the center of gravity were developed by kinovea version 0.8.27 software.

2.3. Selection of Variable

Based on literary evidence, the research scholar selected the following anthropometric characteristics and kinematics variables for the analysis from correspondence with the expert and scholar's own understanding and with the feasibility criterion in mind.

(A) Anthropometric Characteristics

- i Standing Height
- ii. Upper arm length
- iii. Forearm length
- iv. Palm length
- v. Upper leg length
- vi. Lower leg length.

(B) Kinematics Variables

1. Linear Kinematics

- i. Center of Gravity
- ii. Ball Velocity.

2. Angular Kinematics

- i. Angle of Right Ankle Joint
- ii. Angle of Right Knee Joint
- iii. Angle of Right Hip Joint
- iv. Angle of Right Shoulder Joint
- v. Angle of Right Elbow Joint
- vi. Angle of Right Wrist Joint.

2.4. Kinovea Software (Version - 0.8.27)

It was free software that was utilized to analyze videos. Kinovea was used by athletes and coaches to fine-tune techniques. It could measure distance, speed, and height, angle of different segments, a center of gravity, etc. on a particular video with the assistance of Kinovea. The integrated file explorer allowed us to browse the video collection visually. These files, which were displayed as animated thumbnails and as a shortcut manager it lets you preserve bookmarks of frequently accessed directories for a quick lockup. The video controls permit you to closely observe a specific action within the video and examine the motion frame by frame in slow motion because Kinovea operated almost any file natively; one did not need to care too much about formats and codes. There were several amazing, interesting, and diverse features of Kinovea, such as Analysis,

Measurement, Comparison, and Observation. The observation was the feature of Kinovea which entails the close examination of motion on a video frame by frame in slow-motion. The comparison was comparing performances simultaneously in other words, synchronizing the videos. The analysis was enriching the video with arrows and descriptions and other key positions.

2.5. Procedure for Measuring Selected Angular Kinematics

The selected kinematic variables during the moment execution phase in the spiking technique of volleyball such as angles at the right ankle joint, right knee joint, right hip joint, the right shoulder joint, right elbow joint, and the angle at the right wrist joint were obtain by measuring with the help of Kinovea software.

(Figure 3). In the kinovea software select the image and click on angle icon and click on the joint and join the reference point of the joints and calculate angles.

2.6. Procedure for Location of Center of Gravity

After video recording, the video was played with the help of kinovea version 0.8.27 software and the final position of each selected different moment were be obtained on the screen and kept in pause. Further, the stick figures of the moment execution phase in spike converted into photographs and recorded and saved for all selected subjects (Figure 2). The center of gravity of each subject was determined by the Kinovea software. In the kinovea software select the image and draw a reference line to calibrate and draw a line center of gravity to reference point and calculate center of gravity.



Figure 1: The subject at moment execution of spike in volleyball



Figure 2: Height of center of gravity of subject at moment execution of spike in volleyball

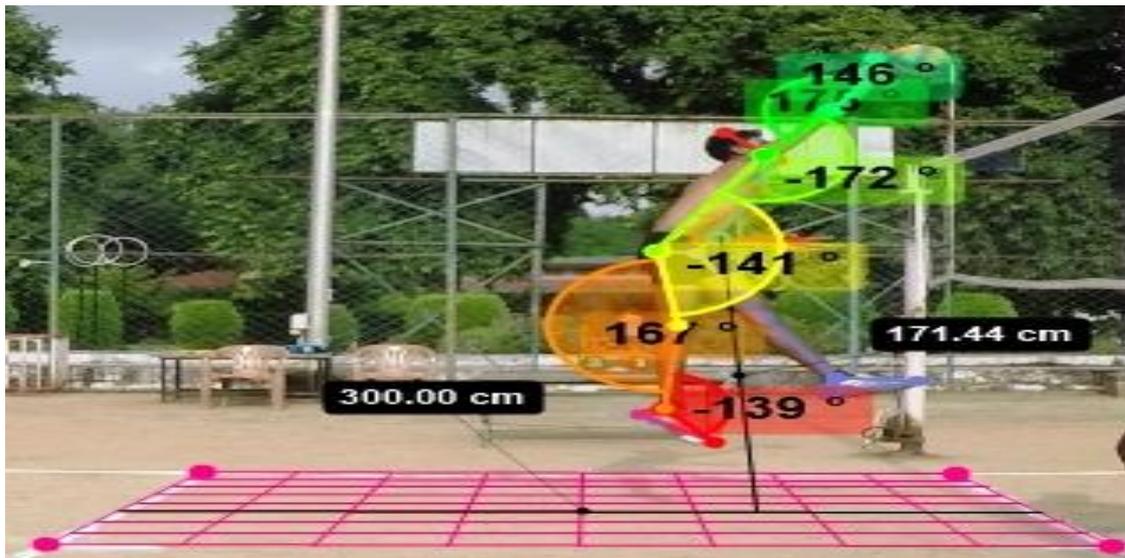


Figure 3: Angles at various joints of the subject at moment execution of spike in volleyball

2.7. Procedure for Measurement of selected Anthropometric landmarks

- i. Standing Height:* The participant was asked to stand straight. The weight of the participant was evenly distributed on both feet. The participant was asked to look straight. The scholar lowers the horizontal bar snugly to the crown of the head with sufficient pressure to compress the hair. The standing height was recorded to the nearest 0.1 cm. (Figure 4).
- ii. Upper Arm:* It was the distance between the Acromiale and Radiale landmarks. On the Acromiale one branch of the caliper or segmometer was placed, while on the Radiale the other branch was put. If the segmometer branches were too short to allow clearance of the Deltoids, a wide sliding caliper (Figure 5) should be used.
- iii. Forearm:* It was the difference between the landmarks of the Radial and Stylium. One caliper (or segmometer) branch against the Radiale was carried, and

- the other branch was put on the landmark of Stylium. (Figure 6)
- iv. Palm:* The reading was performed as the nearest point between the designated line Midstylium and the Dactylion. One caliper part or segmometer was put on the defined Midstylium side, whereas the other part was put on the Dactylion. (Figure 7)
- v. Upper Leg:* The difference between both the lateral references marked with Trochanterion and Tibiale has been measured. One region of the anthropometer or segmometer was put on the Trochanterion label, and the other part was placed on the lateral Tibiale marked spot. (Figure 8)
- vi. Lower Leg:* It was the measured length between the Tibiale medial and the Sphyrion tibiale. One branch of the anthropometer or segmometer was situated on the designated Tibiale medial location, and the other branch was located on the designated location of Sphyrion. (Figure 9)



Figure 4



Figure 5



Figure 6



Figure 7



Figure 8



Figure 9

2.8. Analysis of Data

The multiple regression analysis was to be used for find out the prediction of moment execution in spiking technique of volleyball based on anthropometric and kinematic variables. For testing the hypothesis, the level of significance was set at 0.05.

III. RESULTS

Descriptive analysis of Linear and Angular Kinematics Variables at Moment Execution of spike are presented in Table 1.

Table 1: Descriptive Statistics for Linear and Angular Kinematic variables at Moment Execution in Spiking

S. No.	Variables	Mean	Std. Deviation	N
1	Smash Execution (in scores)	8.28	1.39	36
2	Angle at Right Ankle (in degree)	130.81	9.48	36
3	Angle at Right knee (in degree)	152.94	10.89	36
4	Angle at Right hip (in degree)	141.89	14.91	36
5	Angle at Right shoulder (in degree)	170.94	6.09	36
6	Angle at Left shoulder (in degree)	39.28	18.19	36
7	Angle at Right elbow (in degree)	168.58	7.64	36
8	Angle at Left elbow (in degree)	98.42	33.36	36
9	Angle at Right wrist (in degree)	163.69	11.10	36
10	Angle at Left wrist (in degree)	164.08	15.12	36
11	Ball Velocity (in km/hr)	103.43	9.49	36
12	Center of Gravity (in cms)	174.89	9.39	36

The values of mean and standard deviation for all the linear and angular kinematic variables at moment execution in spike are shown in table 1. The value of angular kinematics variables i.e. angle at right ankle is 130.81 ± 9.48 , angle at right knee is 152.94 ± 10.89 , angle at right hip is 141.89 ± 14.91 , angle at right shoulder is 170.94 ± 6.09 , angle at right left shoulder is 39.28 ± 18.19 , angle at right elbow is 168.58 ± 7.64 , angle at left elbow is 98.42 ± 33.36 , angle at right wrist is

163.69 ± 11.10 and angle at left wrist is 164.08 ± 15.12 . The value of linear kinematics variable i.e. ball velocity is 103.43 ± 9.49 ; center of gravity is 174.89 ± 9.39 shown respectively.

The correlation matrix in Table 2 shows the correlations among the Linear Kinematic and Angular Kinematic with execution of spike along with their significance value (p-value).

Table 2: Correlations Matrix of Linear and Angular Kinematic Variables at Moment Execution in Spike

S. No.	Variables	Pearson Correlation (r)/ P-value (sig.)	Smash execution technique
1.	Spike execution technique	Pearson Correlation	1
2.	Angle at Right ankle joint	Pearson Correlation Sig. (2-tailed)	-.346* .039
3.	Angle at right knee	Pearson Correlation Sig. (2-tailed)	.467** .004
4.	Angle at right hip	Pearson Correlation Sig. (2-tailed)	-.664** .000
5.	Angle at right shoulder	Pearson Correlation Sig. (2-tailed)	.753** .000
6.	Angle at left shoulder	Pearson Correlation Sig. (2-tailed)	.239 .160
7.	Angle at right elbow	Pearson Correlation Sig. (2-tailed)	.783** .000
8.	Angle at left elbow	Pearson Correlation Sig. (2-tailed)	-.002 .991
9.	Angle at right wrist	Pearson Correlation Sig. (2-tailed)	.845** .000
10.	Angle at left wrist	Pearson Correlation Sig. (2-tailed)	.028 .873
11.	Angle at ball Velocity	Pearson Correlation Sig. (2-tailed)	.718** .000
12.	CG at execution	Pearson Correlation Sig. (2-tailed)	.595** .000

*. Correlation is significant at the 0.05 level (2-tailed). Significant value of r at 0.05 level with 34 df (2 -tailed) = 0.329

**.. Correlation is significant at the 0.01 level (2-tailed). Significant value of r at 0 .01 level with 34 df (2 -tailed) = 0.424

SET: Smash Execution Technique (in scores), **ARA:** Angle at Right Ankle (in degree), **ARK:** Angle at Right Knee (in degree), **ARH:** Angle at Right Hip (in degree), **ARS:** Angle at Right Shoulder (in degree), **ALS:** Angle at Left Shoulder (In Degree), **ARE:** Angle at Right Elbow (in degree), **ALE:** Angle at Left Elbow (in degree), **ARW:** Angle at Right Wrist (in degree), **ALW:** Angle at Left Wrist (in degree), **BV:** Ball Velocity (in km/h) and **CG:** Center of Gravity (in cms).

Table 2 shows the correlation between the Linear Kinematic and Angular Kinematic Variables with Moment Execution technique of spike in volleyball along

with their significance value (p-value). From Table 2, it can be seen that moment Execution technique of spike in volleyball is significantly correlated with angular kinematic variables i.e., angle at right ankle, right knee, right shoulder, right elbow and angle at right wrist. Moment Execution technique of spike in volleyball is also significantly correlated with linear kinematic variables i.e. ball velocity after execution and center of gravity of the body at 0.05 level of significance.

Table 3: Model Summary along with the value of R, R² and adjusted R² with Moment Execution in Spike Technique

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.845 ^a	.714	.706	.75181	.714	84.932	1	34	.000
2	.898 ^b	.807	.795	.62675	.093	15.923	1	33	.000
3	.926 ^c	.857	.843	.54894	.049	11.018	1	32	.002
4	.940 ^d	.883	.868	.50322	.027	7.079	1	31	.012

a. Predictors: (Constant), Angle at Right wrist

b. Predictors: (Constant), Angle at Right wrist, Angle at Right elbow

c. Predictors: (Constant), Angle at Right wrist, Angle at Right elbow, Ball Velocity

d. Predictors: (Constant), Angle at Right wrist, Angle at Right elbow, Angle at Right shoulder, Ball Velocity

The four regression models generated by the SPSS have been presented in Table 3. In the fourth model, the value of R² is .883, which is maximum and therefore, fourth model should be used to develop the regression equation. It can be seen from Table 3 that in the fourth model, four independent variables namely, Angle at Right wrist, Angle at Right elbow, Angle at Right shoulder and Center of Gravity have been

identified and therefore, the regression equation shall be developed using these four variables only. The R² value for this model is .883, and therefore, these four independent variables explain 88.3% variations in score of moment execution of spike technique of volleyball. Thus, this model can be considered appropriate to develop the regression equation.

Table 4: ANOVA Table showing F-value of Models for Moment Execution of Spike

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	48.005	1	48.005	84.932	.000 ^b
	Residual	19.217	34	.565		
	Total	67.222	35			
2	Regression	54.259	2	27.130	69.066	.000 ^c
	Residual	12.963	33	.393		
	Total	67.222	35			
3	Regression	57.580	3	19.193	63.694	.000 ^d
	Residual	9.643	32	.301		
	Total	67.222	35			
4	Regression	59.372	4	14.843	58.615	.000 ^e
	Residual	7.850	31	.253		
	Total	67.222	35			

a. Dependent Variable: Smash execution technique

b. Predictors: (Constant), Angle at Right wrist, Angle at Right elbow, Ball Velocity

c. Predictors: (Constant), Angle at Right wrist, Angle at Right elbow, Ball Velocity, Angle at Right shoulder, Ball Velocity

d. Predictors: (Constant), Angle at Right wrist

e. Predictors: (Constant), Angle at Right wrist, Angle at Right elbow

In table 4, F -value for all the models have been shown. Since F -value for the fourth model is highly significant, it might be concluded that the model selected is also highly efficient.

From table 3, regression coefficients of selected variables in the 4th model have 88.3% variation in score along with t-value and partial correlation is presented in table 5:

Table 5: Regression coefficient of selected variables in different models along with their t-values and partial correlations of spike execution technique

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-8.991	1.878		-4.787	.000
	Angle at right wrist	.105	.011	.845	9.216	.000
2	(Constant)	-15.939	2.342		-6.807	.000
	Angle at right wrist	.073	.013	.581	5.753	.000
	Angle at right elbow	.073	.018	.403	3.990	.000
3	(Constant)	-15.868	2.051		-7.737	.000
	Angle at right wrist	.057	.012	.453	4.685	.000
	Angle at right elbow	.063	.016	.349	3.877	.000
	Ball Velocity	.041	.012	.279	3.319	.002
	(Constant)	-21.137	2.731		-7.740	.000
4	Angle at right wrist	.043	.012	.348	3.598	.001
	Angle at right elbow	.060	.015	.328	3.962	.000
	Ball Velocity	.032	.012	.221	2.764	.010
	Angle at right shoulder	.052	.020	.229	2.661	.012

a. Dependent Variable: Smash execution technique

Table 5 shows the unstandardized and standardized regression coefficients in the four models. Unstandardized coefficients are also known as “B” coefficients and are used to develop the regression equation whereas, standardized regression coefficients are denoted by “β” and are used to explain the relative importance of independent variables in terms of their contribution toward the dependent variables in the model. In the fourth model, t-values for all the four regression coefficients are significant as their significance values (p values) are less than .05. Thus, it might be concluded that

the variables angle at right wrist; angle at right knee; angle at right shoulder; ball velocity in execution of spike significantly explain the variations in the moment execution of spike in volleyball.

Regression Equation

Using unstandardized regression coefficient (B) of the fourth models shown in table 5, the regression equation can be developed which is as follows:

$$\text{Moment Execution of Spiking technique} = -21.137 + 0.43 \times (\text{Angle at right wrist at moment execution}) + 0.60 \times (\text{Angle at right elbow at moment execution}) + 0.32 \times (\text{Ball velocity at moment execution}) + 0.52 \times (\text{Angle at right shoulder at moment execution})$$

Thus, it may be concluded that the above regression equation is reliable as the value of R^2 is **0.883**. In other words, the four variables selected in this regression equation explain 88.3% of the total variability in the moment execution of spike in volleyball, which is good. Since the F –value for this regression model is highly significant, the model is reliable. At the same time, all the regression coefficients in this model are highly significant and therefore, it may be interpreted that all the

four variables selected in the model namely, angle at right wrist, angle at right elbow, angle at right shoulder, and ball velocity have significant predictability in estimating the value of the moment execution technique of spike in volleyball.

Descriptive analyses of Selected Anthropometric Variables at Moment Execution in spiking are presented in Table 6.

Table 6: Descriptive Statistics for Selected Anthropometric Variables at Moment Execution of Spike

S. No.	Variables	Mean	Std. Deviation	N
1	Smash execution	8.28	1.39	36
2	Standing Height	185.97	6.40	36
3	Upper arm length	37.49	3.54	36
4	Lower arm length	29.35	3.08	36
5	Palm length	18.22	2.32	36
6	Upper leg length	47.67	4.39	36
7	Lower leg length	49.15	4.02	36

Table 6 shows the values of mean and standard deviation for the selected anthropometric variables of the subject. The value of the selected Anthropometric variables i.e. standing height is 185.97 ± 6.40 , upper arm length is 37.49 ± 3.54 , forearm length is 29.35 ± 3.08 , palm length is 18.22 ± 2.32 , upper leg length was 47.67 ± 4.39 , lower leg length was 49.15 ± 4.02 and the value of

moment execution of spike is 8.28 ± 1.39 shown respectively.

The correlation matrix in Table 7 shows the correlations among the Anthropometric Variables with moment execution of spike along with their significance value (p-value).

Table 7: Correlations Matrix of Anthropometric Variables at Moment Execution of Spike

S. No.	Variables	Pearson correlation (r) / P-value (sig.)	Smash execution phase
1	Smash execution phase	Pearson Correlation	1
2	Standing Height	Pearson Correlation Sig. (2-tailed)	.274 .106
3	Upper arm length	Pearson Correlation Sig. (2-tailed)	.237 .164
4	Lower arm length	Pearson Correlation Sig. (2-tailed)	.311 .065
5	Palm length	Pearson Correlation Sig. (2-tailed)	.345* .039
6	Upper leg length	Pearson Correlation Sig. (2-tailed)	.253 .137
7	Lower leg length	Pearson Correlation Sig. (2-tailed)	.323 .055

*. Correlation is significant at the 0.05 level (2-tailed). Significant value of r at 0.05 level with 34 df (2-tailed) = 0.329

**. Correlation is significant at the 0.01 level (2-tailed). Significant value of r at 0.01 level with 34 df (2-tailed) = 0.4

Table 7 showed the correlation between the Anthropometric Variables with moment execution in

spiking along with their significance value (p-value). Significant value of correlation coefficient (r) at 0.05 and

0.01 level with 34 (N-2) degree of freedom (df) in two tailed test is 0.329 and 0.424. Thus all those correlation coefficient having values more than 0.329 and 0.424 are significant at .05 and .01 level. Such correlation coefficient have been shown with one (*) or two (***) asterisk mark. From Table 7, it can be seen that moment

execution of spiking is significantly correlated with palm length at 0.05 levels, where as standing height, upper arm length, lower arm length, upper leg length and lower leg length is not significantly correlated with moment execution of spike in volleyball at 0.05 levels of significance.

Table 8: Model Summary along with the value of R, R² and adjusted R² with Moment Execution in Spike Technique

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.345 ^a	.119	.093	1.31991	.119	4.586	1	34	.039

a. Predictors: (Constant), Palm length.

The one regression model generated by the SPSS has been presented in Table 8. In the first model, the value of R² is .119, which is maximum and therefore, first model should be used to develop the regression equation. It can be seen from Table 8 that in the first model, one independent variable namely, palm length have been identified and therefore, the regression

equation shall be developed using these one variable only. The R² value for this model is .119, and therefore, one independent variable explains 11.9% variations in score of moment execution of spike technique of volleyball. Thus, this model can be considered appropriate to develop the regression equation.

Table 9: ANOVA Table showing F-value for Model of Moment Execution of Spike

Model	Sum of Squares	Df	Mean Square	F	Sig.
1					
Regression	7.989	1	7.989	4.586	.039 ^b
Residual	59.233	34	1.742		
Total	67.222	35			

a. Dependent Variable: Smash execution phase

b. Predictors: (Constant), Palm length

In table 9, F -value for moment execution of spike with selected anthropometric variable of the model have been shown. Since F -value for the first model is highly significant, it might be concluded that the model

selected is efficient. From table 9, regression coefficients of selected variable in the 1st model have 11.9% variation in score along with t-value and partial correlation is presented in table 10:

Table 10: Regression coefficient of selected anthropometric variable model along with their t-values and Partial correlations of spike execution technique

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1					
(Constant)	4.524	1.767		2.560	.015
Palm length	.206	.096	.345	2.141	.039

a. Dependent Variable: Smash execution phase

Table 10 shows the unstandardized and standardized regression coefficients in the one model. Unstandardized coefficients are also known as “B” coefficients and are used to develop the regression equation whereas, standardized regression coefficients are denoted by “β” and are used to explain the relative importance of independent variables in terms of their

contribution toward the dependent variables in the model. In the first model, t-values for the first regression coefficients are significant as their significance values (p values) are less than .05. Thus, it might be concluded that the palm length of selected anthropometric variable in execution of spike significantly explain the variations in the moment execution of spike in volleyball.

Regression Equation

Using unstandardized regression coefficient (B) of the first model shown in table 10, the regression equation can be developed which is as follows:

$$\text{Moment Execution of Spike with Anthropometric Variables} = 4.524 + 0.206 \times (\text{Palm Length})$$

Thus, it may be concluded that the above regression equation is reliable as the value of R^2 is **0.119**. In other words, the first variable selected in this regression equation explains 11.9% of the total variability in the moment execution of spike with anthropometric measurement of palm length in volleyball, which is quite good. Since the F-value for this regression model is highly significant, the model is reliable. At the same time, the regression coefficients in this model are significant and therefore, it may be interpreted that the variable selected in the model name, palm length have significant predictability in estimating the value of the moment execution technique of spike in volleyball.

IV. DISCUSSION

The results of this analysis demonstrate the need for ball velocity, angle at right wrist, angle at right elbow, angle at right shoulder in the variables of linear and angular kinematics of moment execution in spike technique. Thus, these may conclude that the selected linear and angular kinematics variables significantly explain the 88.3% of total variability of moment execution in spike technique of volleyball players.

Several studies show role of different angles and body part while performing moment execution in spike technique. Blazeovich, (2012) examined biomechanics of spike technique and concluded that the aim of spiking the volleyball is to transfer the force that has been built up in the previous phases into the ball to create maximum speed. As well as speed, accuracy is paramount in a spike execution. Newell and Lauder (2005) expressed that hand and wrist motion in spike was one of the important factors affecting the ball velocity. It was remarkable in this research that the factors that affected ball velocity during the spike were hand and wrist motions rather than the strength. Given that sport rules stipulate the characteristics of the ball (type, pressure, etc.) and because players have a consistent hand position in the spike, the different ball speeds that players achieve are due to their ability to produce speed with their hitting hand (Vint & Hinrichs, 2004). The hand's hitting speed is determined by the execution of movements of a kinetic chain, which involves the hips, trunk, shoulders, the elbow, and the wrist (Cisar & Corbelli, 1989; Gutiérrez, et al., 1994; Rokito, Jobe, Pink, Perry, & Brault, 1998), and it depends on the elbow and shoulder extension velocity (Chung, Choi, & Shin, 1990; Ferris, Signorile, & Caruso, 1995; Singh & Rathore, 2013). The effect of different factors on spike speed performance in volleyball players has been evaluated in various studies. Vint and

Hinrichs (2004) found, while analyzing the female U.S. National Volleyball Team 2 strategy (n=9) using a 3D model, much of the spike pace came from the elbow (44.9%) and shoulder (30.5%) acts. The destructive force and pronation that happens in the forearm is like a whip. This position extends the spiked arm (lever arm) and thus maximizes the hand's possible velocity (Cisar & Corbelli, 1989). Forthomme, Croisier, Ciccarone, Crielaard, and Cloes (2005), confirmed that there was a major relationship here between velocity of the spike and the strength of the dominant shoulder's internal rotator cuffs and the strength of the elbow's flexors and extensors. Wagner et al. (2014) and Coleman, Benham and Northcott (1993) defined that high ball speed is related to maximum humeral speed. The major factor of the spiking strategy is the change in the range of motion of the elbow joint.

Variables showed insignificant role in predicting the linear and angular kinematics of moment execution in spike technique i.e. angle at right & left ankle, angle at right & left knee, angle at right & left hip, angle at left shoulder, angle at left elbow, angle at left wrist and center of gravity are also contributing to technique but doesn't significant due to the low correlation, less sample size and lack of sophisticated equipment.

The result of moment execution in spike technique analysis with the selected anthropometrics that is palm length significantly explains the 11.9% of the variability of selected volleyball players. When regression analysis used to explain in dependent variable moment execution in spike technique based on the selected anthropometric variables to assess the prediction value of moment execution in spike technique of men volleyball players shows that, in the first model, the value of R^2 is 0.119, which includes one independent variable i.e. palm length.

Das, Roy, Let & Chatterjee (2015) the fact that greater the palm length at the time of contact with the ball, greater will be the force, a contributory factor for the velocity of spike. The basis for this is that if the length of the power arm is more that more force can be generated. Also if the palm length is longer than one will have larger area to cover the ball. As we know at the moment the ball is contacted the greater linear velocity in the direction of the flight of the ball is desired. The greater linear velocity is the only possible when radius of rotation is the maximum possible. These results are also supported by (Barut, 2008; Öcal Kaplan, Defne & melekoglu, tuba & Baydil, Bilgehan., 2010; Yuyi , 2010; Rajasingh, 2015; Sandeep, 2015)

The results of moment execution in spiking technique showed insignificantly role with any selected variables of anthropometric measurement i.e. standing height, upper arm length, lower arm length, upper leg length, and lower leg length but they also play important role in technique because of the low correlation, less sample size and lack of sophisticated equipment.

V. CONCLUSION

The result concluded that the kinematic variables i.e., ball velocity, angle at right wrist, angle at right elbow, angle at right shoulder and palm length in anthropometric measurement are contributed in the moment execution to create a maximum speed, force and accuracy in the spike technique of volleyball. This study also contributed in the best way to execute the technique of spike for performance enhancement of volleyball players. It is suggested that the results of this study provide useful information for coaches to training in upper body strength & flexibility levels for attempting to increase range of joint movement, hitting with accuracy of the spike technique and its helps in injury prevention of volleyball players.

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