International Journal of Physical Education, Sports and Health 2017; 4(6): 15-19

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2017; 4(6): 15-19

www.kheljournal.com
Received: 05-09-2017
Accepted: 06-10-2017

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Biomechanical analysis of spiking skill in volleyball

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Abstract
The aim of the study to find out the Biomechanical analysis of spiking skill in volleyball. In this research total Ten Inter-University level male volleyball players were randomly selected from north zone as subjects for the study. The separate data will collected as for all counter spikers. The subjects were explained about the objective of the study. Age of subjects ranging between 19 to 24 years. For this study ten variables selected, these variables are: angle of wrist joint, angle of elbow joint, angle of shoulder joint, angle of hip joint, angle of knee joint, angle of ankle joint, horizontal velocity of wrist joint, horizontal acceleration of wrist joint, vertical velocity of wrist joint and vertical acceleration of wrist joint. Motion capture technique was used in this study. The films were analyzed by using standard "Quintic coaching v-17 software" approved by Human kinetics. After collection of data Karl Pearson's product moment coefficient correlation statistical technique was used. In order to check the significance, level of significance was set at 0.01. The outcome of the study proved that the significant relationship were found in these variables: Angle of ankle joint, Horizontal velocity of wrist joint, Vertical velocity of wrist joint, Horizontal acceleration of wrist joint & Vertical acceleration of wrist joint and insignificant relationship were found in these variables: Angle of wrist joint, Angle of elbow joint, Angle of shoulder joint, Angle of hip joint & Angle of knee joint.

Keywords: Kinematics, biomechanics, acceleration and velocity

Introduction
Biomechanics can be defined as 'the science that examines forces acting upon and within a biological structure and effects produced by such forces'. The 'biological structure' in this context can be wide spread and covers systems of different levels: cells, tissue, joints, segments, the entire body or even a complex system consisting of several bodies or the human body in combination with the surroundings (water, air, equipment, floor etc.).
Sport bio mechanists have also directed efforts at improving the technique components of athletic performance. They have learned, for example, that factors contributing to superior performance in the long jump, high jump and pole vault include large horizontal velocity going into take-off and a shortened last step that facilitates continued elevation of the total-body centre of mass. Examples of well-known athletes easily display the importance of biomechanical technology in improving performance (Zahalka F et. al., 2017) [3].
Biomechanical principles are applied by scientists and professional in a number of fields in addressing problems related to human health and performance. Knowledge of basic biomechanical concepts is also essential for the competent physical education teacher, physical therapist, physician, coach, personal trainer or exercise instructor. An introductory course in biomechanics provides foundational understanding of mechanical principles and how they can be applied in analyzing movements of the human body. The knowledgeable human movement analyst should be able to answer many basic questions related to biomechanics like what are the mechanical principles behind variable resistance exercise machines. What is the safest way to lift a heavy object? Which movement is more/less economical? At what angle should a ball be thrown for maximum distance? From what distance and angle is it best to observe a patient walk down a ramp or a volleyball player execute a service? What strategies can an elderly person or a volleyball lineman employ to maximize stability?
Kinematics is the study of bodies in motion without regard to the causes of the motion. It is concerned with the describing and quantifying both the linear and angular positions of the bodies and their time derivatives. Kinematics is the preferred analytical tool for researchers interested in questions such as, who is faster. What is the range of motion of a joint?

How do two motion patterns differ? Kinematic analysis may be an end in itself or an intermediate step that enables subsequent kinetic analysis. The most common method for collecting kinematic data uses an imaging or motion-caption system to record the motion of markers affixed to a moving subject, followed by manual or automatic digitizing to obtain the coordinates of the makers. These coordinates are then processed to obtain the kinematic variables that describe segmental or joint movements.

Statement of the Problem

Biomechanical analysis of spiking skill in volleyball.

Hypotheses

There will be a significant difference between the angle of wrist joint, angle of elbow joint, angle of shoulder joint, angle of hip joint, angle of knee joint, angle of ankle joint, horizontal velocity of wrist joint, horizontal acceleration of wrist joint, vertical velocity of wrist joint and vertical acceleration of wrist joint at time of spiking with the performance of player.

Selection of Subjects

Ten Inter-University level male volleyball players were randomly selected from north zone as subjects for the study. The separate data will collected as for all counter spikers. The subjects were undergoing training for a considerable period. Therefore it was ascertained that subjects possess reasonable level of technique. The subjects were explained about the objective of the study. Age of subjects ranging between 19 to 24 years.

Selection of Variables

1. (W*Φ)* The angle of wrist joint at time of spiking
2. (E*Φ)* The angle of elbow joint at time of spiking.
3. (S*Φ)* The angle of shoulder joint at time of spiking.
4. (H*Φ)* The angle of hip joint at time of spiking.
5. (K*Φ)* The angle of knee joint at time of spiking.
6. (A*Φ)* The angle of ankle joint at time of spiking.
7. *(WHv)* The horizontal velocity of wrist joint during the course of spiking.
8. *(WHa)* The horizontal acceleration of wrist joint during the course of spiking.
9. *(WVv)* The vertical velocity of wrist joint during the course of spiking.
10. *(WVa)* The vertical acceleration of wrist joint during the course of spiking.

Criterion Measure

The criterion measure for this study was the performance of the Spikers. Total ten attempts will be given to each subject and the successful shots will be marked as single score out of ten.

Filming Protocol

Motion capture technique was used in this study. To recorded the video of the volleyball counter spiker, while they performing the technique, digital video camera (50 fps) was used by a professional photographer. After obtaining the recorded video, the video was analyzed through Quintic coaching v-17 software approved by Human kinetics. First video was digitized through Quintic coaching v-17 software. After the procedure of digitizing, the video was calibrated. The calibrated video gives us the results through makers, stroboscopic effect technique, stick figures, stopwatch programming, angle manual (horizontal, vertical, draw angles), linear and angular analysis manual etc. with the help of "Quintic coaching v-17 software."

Motion capture technique/Digital videography was used to analysis the kinematic variables of male volleyball counter spiker. Digital video camera CASIO EX-FH 100 (50 fps) was used for videography of volleyball counter spiker performance. The performance of the subject was recorded with stroboscopic effect from approach to landing. Digital Video camera was placed 6 meter away at the side of the spikers (lateral axis).

Analysis of Film and Collection of Data

Motion capture technique was used in this study. The films were analyzed by using standard "quintic coaching v-17 software" approved by Human kinetics. Videos analyzed through strobed photo sequence / stroboscopic effect, stick figure analysis, Quick snap shots with the help of software for analysis of selected variables are presented below:-

Statistical Procedure

With regard to purpose of the study Karl Pearson's product moment coefficient correlation statistical technique was calculated between selected kinematical variables with performance of male counter spiker in volleyball. In order to check the significance, level of significance was set at 0.01.

Results

Table 1: Relationship between Angle of wrist joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Angle of wrist joint	170.37	0.95	-0.775
10	Performance	7.10	1.19	

'r' $_{0.05}(18)$ =0.468

Table 1 represents that the mean value of angle of wrist joint of counter spiker in volleyball players was 170.37, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 0.95 respectively. At the time of calculation of relationship between Angle of ankle joint with performance of counter spiker in volleyball players the r value was -0.775. The data does suggest that there is insignificant relationship between angle of wrist joint of counter spiker in volleyball players with performance.

Table 2: Relationship between Angle of elbow joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Angle of elbow joint	174.46	0.91	-0.850
10	Performance	7.10	1.19	

'r' $_{0.05}(18)$ =0.468

Table 2 represents that the mean value of angle of elbow joint of counter spiker in volleyball players was 174.46, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 0.91 respectively. At the time of calculation of relationship between Angle of elbow joint with performance of counter spiker in volleyball players the r value was -0.850. The data does suggest that there is insignificant relationship between angle of elbow joint of counter spiker in volleyball players with performance.

Table 3: Relationship between Angle of shoulder joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Angle of shoulder joint	164.36	7.10	-0.737
10	Performance	7.10	1.19	

'r' $_{0.05}$(18) =0.468

Table 3 represents that the mean value of angle of shoulder joint of counter spiker in volleyball players was 164.36, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 7.10 respectively. At the time of calculation of relationship between Angle of shoulder joint with performance of counter spiker in volleyball players the r value was -0.737. The data does suggest that there is insignificant relationship between angle of shoulder joint of counter spiker in volleyball players with performance.

Table 4: Relationship between Angle of hip joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Angle of hip joint	160.34	0.64	-0.733
10	Performance	7.10	1.19	

'r' $_{0.05}$(18) =0.468

Table 4 represents that the mean value of angle of hip joint of counter spiker in volleyball players was 160.34, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 0.64 respectively. At the time of calculation of relationship between Angle of hip joint with performance of counter spiker in volleyball players the r value was -0.733. The data does suggest that there is insignificant relationship between angle of hip joint of counter spiker in volleyball players with performance.

Table 5: Relationship between Angle of knee joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Angle of knee joint	157.94	1.13	-0.635
10	Performance	7.10	1.19	

'r' $_{0.05}$(18) =0.468

Table 5 represents that the mean value of angle of knee joint of counter spiker in volleyball players was 157.94, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in Volleyball players was 1.13 respectively. At the time of calculation of relationship between Angle of knee joint with performance of counter spiker in Volleyball players the r value was -0.635. The data does suggest that there is insignificant relationship between angle of knee joint of counter spiker in volleyball players with performance.

Table 6: Relationship between Angle of ankle joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Angle Of Ankle Joint	122.47	0.03	0.849
10	Performance	7.10	1.19	

'r' $_{0.05}$(18) =0.468

Table 6 represents that the mean value of angle of knee joint of counter spiker in volleyball players was 157.94, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 1.13 respectively. At the time of calculation of relationship between Angle of knee joint with performance of counter spiker in volleyball players the r value was -0.635. The data does suggest that there is significant relationship between angle of knee joint of counter spiker in volleyball players with performance.

Table 7: Relationship between Horizontal velocity of wrist joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Horizontal Velocity Of Wrist Joint	7.84	0.15	0.890
10	Performance	7.10	1.19	

'r' $_{0.05}$(18) =0.468

Table 7 represents that the mean value of Horizontal velocity of wrist joint of counter spiker in volleyball players was 7.84, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 0.15 respectively. At the time of calculation of relationship between Horizontal velocity of wrist joint with performance of counter spiker in volleyball players the r value was 0.890. The data does suggest that there is significant relationship between Horizontal velocity of wrist joint of counter spiker in volleyball players with performance.

Table 8: Relationship between Vertical velocity of wrist joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Vertical velocity of wrist joint	7.91	0.09	0.882
10	Performance	7.10	1.19	

'r' $_{0.05}(18)$ =0.468

Table 8 represents that the mean value of Vertical velocity of wrist joint of counter spiker in volleyball players was 7.91, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 0.09 respectively. At the time of calculation of relationship between Vertical velocity of wrist joint with performance of counter spiker in volleyball players the r value was 0.882. The data does suggest that there is significant relationship between Vertical velocity of wrist joint of counter spiker in volleyball players with performance.

Table 9: Relationship between Horizontal acceleration of wrist joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Horizontal Acceleration Of Wrist Joint	53.83	0.53	0.931
10	Performance	7.10	1.19	

'r' $_{0.05}(18)$ =0.468

Table 9 represents that the mean value of Horizontal acceleration of wrist joint of counter spiker in volleyball players was 53.83, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 0.53 respectively. At the time of calculation of relationship between Horizontal acceleration of wrist joint with performance of counter spiker in volleyball players the r value was 0.931. The data does suggest that there is significant relationship between Horizontal acceleration of wrist joint of counter spiker in volleyball players with performance.

Table 10: Relationship between Vertical acceleration of wrist joint with performance of counter spiker in volleyball

Trials	Variables	Mean	Standard Deviation	Correlation (R) Values
10	Vertical Acceleration of wrist joint	48.65	0.55	0.856
10	Performance	7.10	1.19	

'r' $_{0.05}(18)$ =0.468

Table 10 represents that the mean value of Vertical acceleration of wrist joint of counter spiker in volleyball players was 48.65, whereas the standard deviation (SD) of angle of ankle joint of counter spiker in volleyball players was 0.55 respectively. At the time of calculation of relationship between Vertical acceleration of wrist joint with performance of counter spiker in volleyball players the r value was 0.856. The data does suggest that there is significant relationship between Vertical acceleration of wrist joint of counter spiker in volleyball players with performance.

Discussion of the findings

Based on the statistical analysis of data following findings were drawn by the researcher:

The result of the study revealed that there is significant relationship between Horizontal velocity of wrist joint, Vertical velocity of wrist joint, Horizontal acceleration of wrist joint, Horizontal acceleration of wrist joint and Vertical acceleration of wrist joint of counter spiker in volleyball players with their performance. The result of the study revealed that insignificant relationship between angle of wrist joint, angle of elbow joint, angle of shoulder joint, angle of hip joint, angle of knee joint and angle of ankle joint of counter spiker in volleyball players with their performance. On the basis of analysis of the data, investigator found that the earlier study of S. Amritpal and Deol, N.S. (2010) [1]. "Kinematic Analysis of Spikers of Volleyball", Eckenrode BJ *et al*. (2012) [4], Gymnastics", Jurkojc J, Michnik R and Czapla K (2017) [5] Mathematical modelling as a tool to assessment of loads in volleyball player's shoulder joint during spike", West T, Ng L and Campbell A. (2014) [6] The effect of ankle bracing on knee kinetics and kinematics during volleyball-specific tasks", Zahalka F et. al. (2017) [3] Kinematic Analysis of Volleyball Attack in the Net Center with Various Types of Take-Off. J Hum Kinet" and Vaverka F, Jandacka D, Zahradnik D, Uchytil J, Farana R, Supej M and Vodicar J. (2016) Effect of an Arm Swing on Countermovement Vertical Jump Performance in Elite Volleyball Players", supported the present study.

Hypotheses

"There will be a significant difference between the angle of wrist joint, angle of elbow joint, angle of shoulder joint, angle of hip joint, angle of knee joint, angle of ankle joint, horizontal velocity of wrist joint, horizontal acceleration of wrist joint, vertical velocity of wrist joint and vertical acceleration of wrist joint at time of spiking with the performance of player". This hypothesis is partially accepted and partially rejected, this hypothesis is partially accepted in Horizontal velocity of wrist joint, Vertical velocity of wrist joint, Horizontal acceleration of wrist joint, Horizontal acceleration of wrist joint and Vertical acceleration of wrist joint variables and partially rejected in angle of wrist joint, angle of elbow joint, angle of shoulder joint, angle of hip joint, angle of knee joint and angle of ankle joint variables.

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