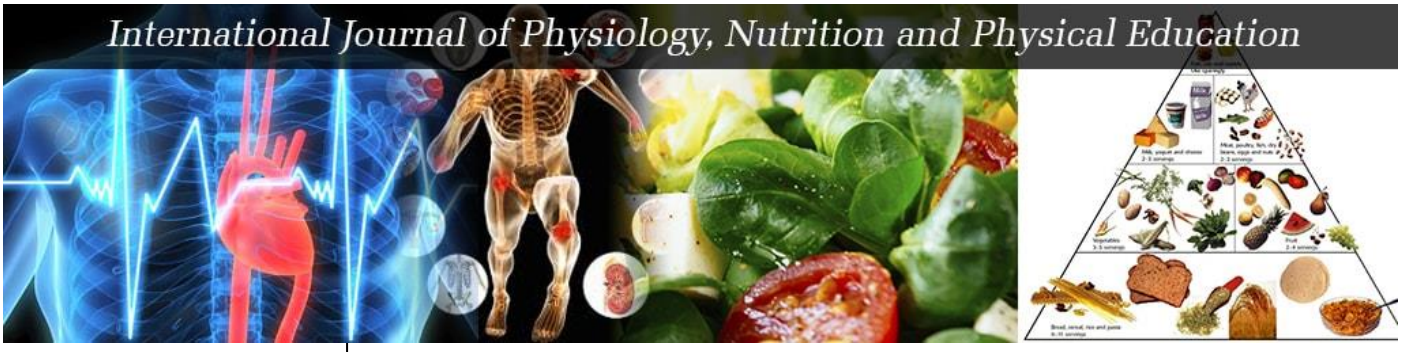

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Dr. Nawaf Owaid Abood Al-Obaidy
Assistant Professor, College of Physical Education and Sports Sciences, University of Mosul, Individual Games Branch, Mosul, Iraq

Corresponding Author:
Dr. Nawaf Owaid Abood Al-Obaidy
Assistant Professor, College of Physical Education and Sports Sciences, University of Mosul, Individual Games Branch, Mosul, Iraq

Biomechanical analysis of a number of kinematic and kinetic variables and the last step in the volleyball jump serve

Dr. Nawaf Owaid Abood Al-Obaidy

Abstract
The aim of the research is to find out:

1. Evaluate a number of kinematic and kinematic variables for the last step of the skill of smashing serve in volleyball for the sample
2. The relationship between the values of a number of kinematic and kinetic variables for the last step of the skill of the aces in volleyball for the sample.

The human field consisted of a number of members of the University of Mosul volleyball team for the academic year 2020/2021 with (6) students who were chosen by the intentional method. A (canon) camera with (60) frames per second was used the height of the lens (1.40 m) from ground level and the distance of the camera from the player was (5) meters as it was perpendicular to the field of movement on the right side of the player to study the kinematic variables, as well as the use of a force measurement platform the pivot reaction is a function (force - time) measuring (1 m x 1.20 m) and placing it at the last step of the sending player, which reflects the force applied to the device Equipped with a data reader connected to a computer (laptop) to convert the readings of the function into graphic forms to facilitate highlighting its kinetic variables, as the platform was placed in one of the sides of the volleyball court by placing wooden staves with a length of (3) meters, including the platform and covered with a piece of tartan with the same length of movement, so that the player would stand on top of the skates when he was serving for the hitter. The study used several programs, each according to its function, to reach the research results, such as (Kenova), (ACDSee 10 Photo Manager) and (Microsoft Office Excel 2010 and (paint)). To reach the results, the researcher used the statistical bag. (SPSS) to extract the arithmetic mean, standard deviation, the Pearson simple correlation coefficient, and the coefficient of variation %.
The researcher concluded: The values of the variables under study achieved significant positive and negative correlations between the kinematic and kinetic variables by 39.29% in general. The short time and length of the last step have a very important role in preparing and preparing for the process of getting up and lifting the body up quickly and optimally The variables of the angle of rise and the angular velocity of the body between the moment of impact and the push, and the highest height of center of gravity of body mass Getting up with the whole foot is best to reach the highest height of the body in the air and take advantage of the force of the reaction of the ground and bending in the knee joint in terms of recording the maximum force recorded by collision and pushing and prolonging the time taken to reach the maximum force.

Keywords: Force function – time, last step, maximum recorded force, kinematics

Introduction

The kinetic analysis plays an effective and distinctive role in the application of biokinematics conditions by calculating the variables of speed, angles, distances and heights, which are among the important variables that determine the shape and path of the path. Especially in the game of volleyball, which is part of the games distinguished by its many offensive and defensive skills, and the variety of ways and methods of its performance, especially the crushing strike, which is the most distinguished serve in determining the result, therefore the mechanical analysis of the skill of overwhelming beating can provide those in charge of the training process with a greater understanding of the movement's minutes by accommodating the distinctive biomechanical variables in performance, especially the goal of smashing is to hit the ball at the highest point to avoid the rise of the net and the blocking wall [1], and then

direct it to the empty areas in the opposing team's court [6], kinetic analysis has also been developed This is due to the development of modern technical devices and by using the available laboratory equipment as a function of force-time to give real meanings of the values of the force imposed on the ground and its time for the method of performing each of the mathematical skills, including the skill of jump serve is under study. Hence the importance of studying the kinetic variables of the force-time curve of the skill of hitting the jump serves in volleyball. For the sample, and the extent to which the biomechanical variables under study are affected in showing the strengths and weaknesses when performing the skill, the higher the player rises to perform the serve and to know how much force he will need to rise to the top necessary for the success of the service and achieving A direct point on the opposing team. We can define the research problem by answering the following questions: Do you think the player, when he jumps to the top when performing the smash serve, jumps to his highest height? Is the hitter's performance technique affected by the strength of the rise, the length or shortness of the last step, or the higher jump? What are the value of the force that the player sheds on the ground to enable him to jump to the top? And its knowledge of the existence of a platform for measuring the force of the reaction of the earth is a function (force - time).

Search procedures

Research Methodology: The researcher used the descriptive method to suit the nature of the research

Research sample: The sample was chosen in a deliberate way their number is (6) players from members of the University of Mosul volleyball team for the academic year 2021/2022, and Table (1) shows some of the statistical parameters of the sample.

Table 1: Shows some statistical parameters of the sample

Sq.	Statistical parameters / Sample	Age/ year	arm length/cm	Total body length/cm	Weight /kg
1	first player	23	71	179	79
2	second player	22	74	182	82
3	The third player	24	75	184	89
4	The fourth player	22	73	180	87
5	The fifth player	23	71	186	84
6	The sixth player	22	76	187	90
Arithmetic mean x -		22,667	73,333	183	85,333
Standard deviation ±p		0.817	2,066	3,225	4,457
Variation coefficient %		3,602	2,817	1,762	5,223

Means of data collection and equipment used

The following means were used to collect data:

Technical Scientific Observation: A (canon) camera was used with (60) frames per second, and the height of the lens was (1.40 m) above ground level, and the distance of the camera from the player was (5) meters if it was perpendicular to the field of movement is to the right of the player avalanche performer, as the transmission process consists of the following steps:

1. The student stands behind the service line and prepares to send the ball to the opponent's court.
2. Lifting the ball in the air.
3. Take two steps forward.
4. Jumping to the ball while it is in the air (jumping over the force-time function platform).
5. Hitting the ball to send it to the other side of the net (the opponent's yard).

Drawing scale

A drawing scale with a length of (1) meter was used to convert the values in the image into real distances to obtain the conversion factor for extracting the studied variables in a horizontal and vertical manner, as its value was in the horizontal position (67 pks) and in the vertical position (69 pks).

Devices used and research tools

1. A group of (5) volleyballs.
2. Metric tape measure.
3. Adhesive tape.
4. Medical scale.
5. Laptop and its accessories with a laser printer.

The platform for measuring the strength of the fulcrum reaction (force-time function) used in this study

A platform was used to measure the force of the pivot reaction (force-time function) (1 m × 1.20 m), which reflects the force applied to the device, equipped with a Japanese-made computer (laptop) to meet the needs of the researcher and the subject of the research his problem is to be studied, and it operates on electric current with a voltage of 220 V (AC-DC) while maintaining electric charge for a period of (6 hours), as the platform transmits electrical indicators to the computer (laptop) by means of a number of one of the stress gauges that starts working from the moment the player hits the serve touches the outer board and stops reading the data the moment his foot leaves the platform [12], as the platform was placed on one side of the volleyball court by placing 3 meters of wooden staves, and the platform is including it and covered with a piece of tartan with the same length of movement, so that the player will stand on the staves when he is performing the service for the hitter. As for the parts of the platform, it consisted of the parts shown in Figure (1):

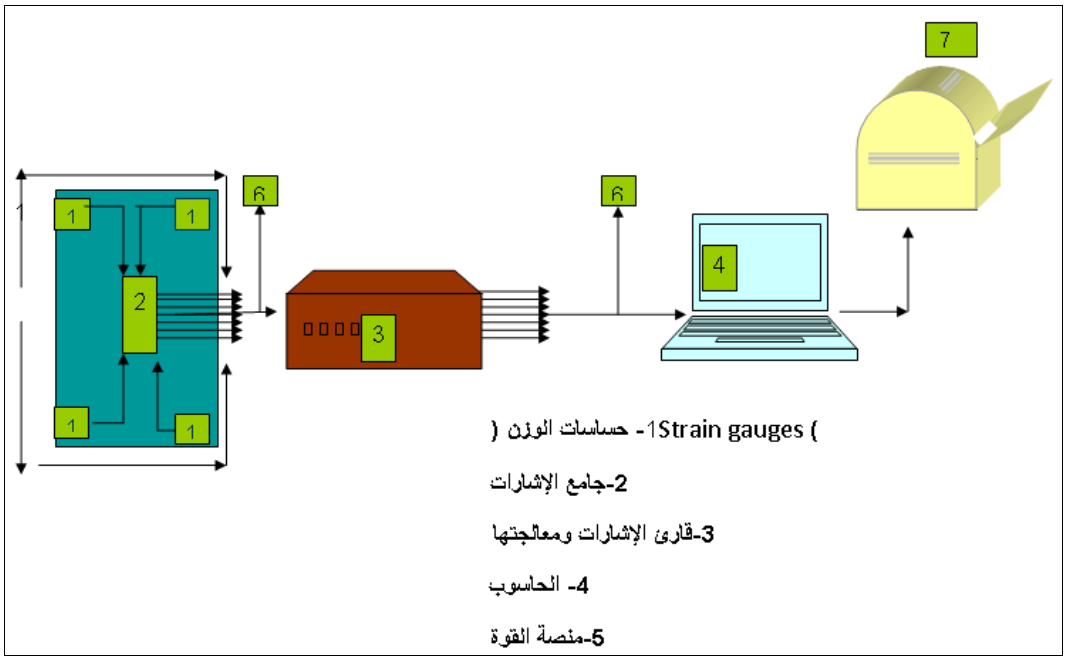

Fig 1: It shows the parts of the platform for measuring the force of the fulcrum reaction (force-time function) and its accessories

The exploratory experiment

The researcher conducted an exploratory experiment on (25/11/2021) in the team games hall on two students from the College of Physical Education and Sports Sciences, as their results were excluded from the experiment the main purpose of the pilot experiment was: - Ensure that the camera is working correctly, its height and distance from the sending player. - Preparing the procedures and requirements of the platform and making sure of their readings to make the main experiment. - Ensure that the assistant work team is trained (Annex 1) on the duties assigned to them.

The main experiment

The researcher conducted the main experiment on (28/11/2021) on the research sample after giving them three attempts to perform the smash service and then calculating the best performance.

Programs used in the analysis

The following programs were used, each according to his function, to reach the research results:

- **(Kenova):** It is a service program known worldwide for its uses in the aspect of kinematic analysis.
- **Program:** (ACDSee 10 Photo Manager) through this program, each of the cut images can be displayed so that we can determine the beginning and end of the important parts to be analyzed.
- **Program (Microsoft Office Excel 2010):** This program has been used in the mathematical processing of raw data.
- **(Microsoft Office Word 2010):** It is a universal program used for printing and has useful features and characteristics for the student in terms of printing. Paint program: It is a program within the computer system that was used to process some images

Research Variables

The kinematic variables under study: Through the researcher's experience in the field of biomechanics and reviewing the literature, studies and previous articles ones as [5, 6, 7, 8], the research variables and methods of measuring each variable were identified, as in Table (2).

Table 2: It shows the kinematic variables and ways to obtain them under study for the sample

Sq.	The name of the variable	is its definition
1	Last step length/m	It is the horizontal distance between the front of the back foot at the beginning of the last step to the front of the front foot.
2	The time of the last step / sec	It is the time taken to take the last step
3	The speed of the last step / m / s	It is the horizontal distance of a step divided by its time.
4	Impact angle/degrees	It is the angle between the line joining (center of gravity of body mass) of the body to the fulcrum base on one side and the ground level on the other. This angle is measured at the beginning of the moment of impact.
5	Angle of body rise / degree	It is the angle between the line connecting (center of gravity of body mass) to the fulcrum on one side and the ground level on the other. This angle is measured at the moment the player leaves the ground.
6	Angle of flight of the body / degree	It is the angle between the line connecting from the center of gravity of body mass at the moment of the last leaving the ground to the center of gravity of body mass of after two images on one side and the level of the horizontal imaginary line from center of gravity of body mass at the moment of the last departure.
7	Larger angle of flexion of the knee joint while advancing absorption / degree	It is the angle of the knee between the thigh bone on one side and the shin bone on the other, the moment of greatest bending of the leg that touches the ground first while getting up.
8	The horizontal distance of the body at the moment of impact and the end of the thrust / cm	It is the horizontal distance measured from the moment of touching the ground until the moment the ground leaves the max body.

9	The vertical distance of the body center of gravity of body mass at the moment of impact and to the end of the thrust /cm	It is the vertical distance measured from the moment of touching the ground until the moment the ground leaves the center of gravity of body mass.
10	The resultant distance to center of gravity of body mass at the moment of impact and to the end of the thrust / m	It is the total distance measured from the moment of touching the ground until the moment of leaving the ground by the sum of the square of the horizontal and vertical distances under the root
11	The total distance of the transmission performance / m	It is the distance traveled by the serving player from the moment the ball is started until the moment the ball is hit in the air.
12	The total time to perform the transmission / sec	It is the time taken by the serving player from the moment of starting until the moment the ball is hit in the air.
13	The average total speed of transmission performance m/s	It is the result of dividing the total transmission distance by the total performance time
14	The instantaneous distance of the ball / cm	It is the distance the ball is launched from the moment it is hit and after one or two pictures
15	The instant time of the ball / sec	It is the time of the ball's release from the moment it was hit and after one or two pictures
16	The instantaneous speed of the ball m/s	It is the speed of the ball starting from the moment it is hit and after one or two pictures.
17	The kick-off angle / degree	It is the angle between the line of the ball after hitting it by the player on the one hand and the level of the horizontal imaginary line issued from the moment the ball is left
18	The angular change of the body at the moment of impact and the end of the thrust / degree	It is the distance traveled by the center of gravity of body mass from the moment of impact to the moment of the end of the thrust.
19	Angular time of the body / s	It is the time taken by the max body from the moment of impact to the moment of the end of the thrust.
20	The angular velocity of the body at the moment of impact and at the end of the thrust is degrees/s	It is the velocity that the max body travels from the moment of impact to the moment of the end of the thrust divided by its time.
21	Height of the center of gravity of the mass of the body center of gravity of body mass the body in collision / m	It is the height for center of gravity of body mass from the moment of the first collision with the leg above the platform for measuring the force of the fulcrum reaction (force-time function).
22	The highest height of the center of mass of the body in the air / m	It is the highest height of the center of gravity of body mass from the moment of starting to get up from the platform measuring the force of the pivot reaction (force-time function) until the highest height reached (center of gravity of body mass) to the batter in the air at the moment the ball is hit

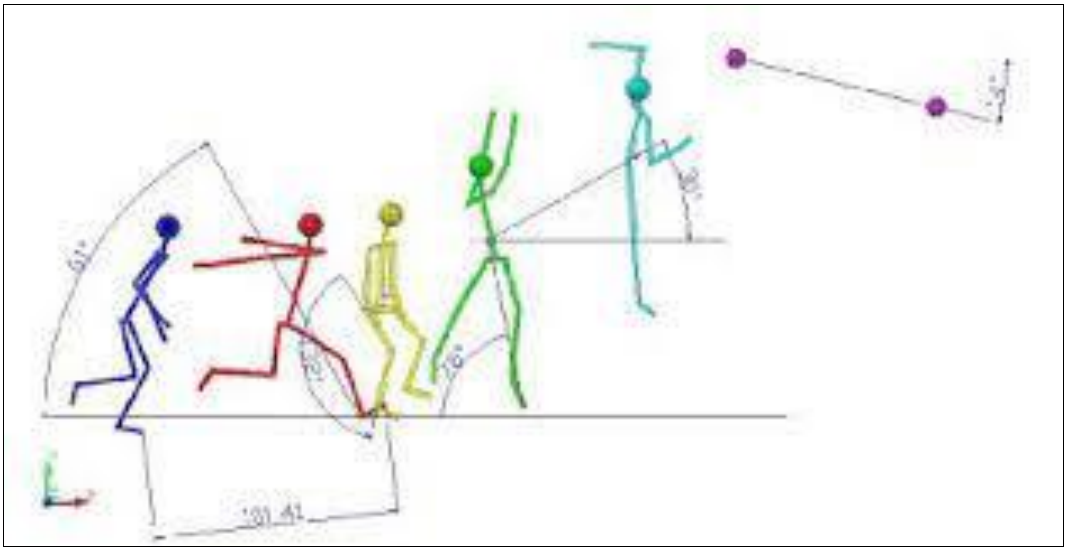

Fig 1: The figure shows an illustration of some kinematic variables

Figure (1) The figure shows an illustration of the kinematic variables

Some of the kinetic (force-time) function variables under study for the sample

Maximum Recorded Force: It is the maximum force applied to the ground by the hitter while he is on the podium at the moment of jumping to the top to hit the ball. Maximum power time: It is the time recorded for the maximum power recorded on the power-time function platform by the batter.

The time taken to reach the maximum strength: the time taken by the batter when jumping on the platform of the force function - the time to reach the maximum strength (the period of foot stay on the platform). (procedural definitions)

Extracted variables

Average Speed: The average speed was calculated through the following law:

Average speed = distance traveled/time [2]

Angular velocity and velocity of the body: Calculate the angular velocity by using the following law:

Angular velocity = angular change / time = degrees / second [3]

Statistical means

To reach the results of the research, the researcher used the statistical bag (spss) to extract:

- Arithmetic mean.
- Standard deviation.

- Simple correlation coefficient (Pearson).
- Coefficient of variation %

The coefficient of variation % was extracted from the equation which states: (Standard deviation divided by the arithmetic mean x 100) (when its value is less than 30%, this indicates the homogeneity of the sample).

Presentation and discussion of the results

Display the arithmetic means and standard deviations of some kinematic variables during the performance of the jump serve of the sample

Table 3: Shows the statistical parameters of some kinematic variables during the performance of the sample jump serve

Sq.	Statistical parameters / Arithmetic	Mean variables -x	Standard deviation ± std.
1	**The length of the last step**	1,71	0,141
2	The time of the last step	0,33	0,012
3	The speed of the last step	5,02	0,569
4	Impact angle	60, 59	2,693
5	The angle of rising of the body	68, 86	2,898
6	Angle of flight for the body	42, 83	1,472
7	Greater angle of bending of the pedestal joint during hiking	119,15	1,206
8	The horizontal distance of the center of gravity of body mass at the moment of impact and to the end of the thrust	0,98	0,053
9	The vertical distance of the center of gravity of body mass at the moment of impact and to the end of the thrust	0,32	0,053
10	The resultant distance to the body center of gravity of body mass at the moment of impact and to the end of the thrust	103, 83	1,602
11	The total distance of the transmission performance	1,327	0,172
12	Registering for the menstrual cycle	1,74	0,085
13	Average speed of transmitter performance	0,761	0,090
14	The instantaneous distance of the ball	0,84	0,030
15	The instant time of the ball	0,025	0,009
16	Instantaneous speed of the ball	38,92	14,463
17	The kick-off angle of the ball	8,7	0,849
18	The angular change of the body at the moment of impact and the end of the thrust	45,667	2,582
19	Angular time of the body	0,333	0,387
20	The angular velocity of the body at the moment of impact and at the end of the thrust	514,983	174,165
21	Height of the center of gravity of the mass of the body in collision	1,22	0,036
22	The highest height of the center of gravity of body in the air	1,59	0,069

Presentation of the arithmetic means and standard deviations of some kinetic variables of the (force - time) function in the collision and thrust phases during the performance of the jump serve of the sample

Table 4: It shows the statistical parameters of some kinetic variables of the (force-time) function in the collision and thrust phases during the performance of the sample jump serve

Sq.	Statistical parameters / Variables	Arithmetic mean -x	standard deviation ± std.
In the collision phase			
1	Maximum registered force / Newton	1788,167	182,355
2	Maximum force time/sec	0,040	0,000
3	The time taken to reach the maximum power /sec	0,035	0,01
in the payment stage			
1	Maximum registered force / Newton	2311,667	130,281
2	Maximum force time/sec	0,040	0,000
3	The time taken to reach the maximum power / sec	0,193	0,063

Presenting and discussing the results of the significant and probabilistic correlations for the research variables under study

Presenting and discussing the results of the significant correlations and the probability ratio • among the kinematic variables during the performance of the jump serve of the sample

Table 5: shows the significant correlations and the probability ratio between the kinematic variables during the performance of the jump serve of the sample.

Sq.	Significant	Correlations Value (r)	Probability ratio
			0.05
1	The length of the last step x the speed of the last step	0.984	0.016
2	The angle of rise of the body x the angle of flight of the body	0.972	0.028
3	The total distance of the transmission performance x the average total speed of the transmission performance	-0.991	0.009
4	The perpendicular distance of the center of gravity of body mass at the moment of impact and to the end of the thrust x the resultant distance to the body at the moment of impact and to the end of the thrust	0.954	0.046
5	The instantaneous time of the ball x the instantaneous velocity of the ball	0.978	0.022
6	The angular velocity of the body at the moment of impact and the end of the thrust x the horizontal distance of the body at the moment of impact and the end of the thrust	0.986	0.014
7	Height of the center of gravity of the body in collision x the highest height of the center of mass of the body in the air	0.958	0.042

(Table value (r) at the degree of freedom (n - 1) and a probability ratio of 0.05 ≥ = (0.755)

From table (5) it is clear that

1. There is a positive significant correlation between the variables of step length and step speed, as the calculated (t) value reached (0.984) at the degree of freedom (n _ 1) and the error probability ratio is ≥ 0.05, which is greater than the tabular value (t) of (0.755)., the researcher attributes it to the fact that the step speed is recognized by each of the distance or displacement traveled per unit time taken to perform the skill, and since the distance or displacement traveled with the rate of speed is directly proportional to the average speed, the player sending the volleyball smasher will need to cut the distance of the last step In the shortest possible time, to obtain a speed that enables him to perform the transmission, according to the speed equation which states: Speed = Distance / Time [7].
2. There is a positive significant correlation between the variables of the angle of rise of the body and the angle of flight of the body, as the calculated (t) value reached (0.972) at the degree of freedom (n _ 1) and the probability of error ≥ 0.05, which is greater than the tabular value of (t) 0.755), the researcher attributes it to the fact that the angle of advancement of the body is an integral part of the performance of the skill of the smash serve in volleyball, through which the sending player will be able to make the optimal use of this angle in the later stage, which will help him to advance as the angle of flight, whose values have been reached from the center of gravity of the body after two pictures.
3. There is a significant negative correlation between the variables of the total distance of the transmission performance and the average total speed of the transmission performance, as the calculated (t) value reached (-0.991) at the degree of freedom (n _ 1) and the error probability ratio ≥ 0.05, which is greater than the value of (t) The tabular value of (0.755), the researcher attributes it to the same reason in the positive moral correlation No. (1).
4. There is a positive significant correlation between the two variables of the vertical distance of the body (center of gravity of body mass) at the moment of impact and the end of the thrust and the sum of the (center of gravity of body mass) of the body at the moment of impact and the end of the thrust, as the calculated value of (t) reached (0.954) at a degree of freedom (n _ 1) and a probability of error ≥ 0.05, which is greater than the tabular value (t) of (0.755), the researcher attributes it to the fact that the vertical distance variable for (center of gravity of body mass) the body at the moment of impact and the end of the push It is part of the summation equation for the body at the moment of impact and for the end of the thrust, according to the summation equation which states: Sum ² = (Horizontal displacement)² + (Vertical displacement)² [2] Therefor by increasing the part, the whole will increase, and vice versa.
5. There is a significant negative correlation between the variables of the instantaneous time of the ball and the instantaneous speed of the ball, as the calculated (t) value reached (-0.978) at the degree of freedom (n _ 1) and the error probability ratio ≥ 0.05, which is greater than the tabular value (t) of (0.755), the researcher attributes it to the same reason in the previous two positive moral correlations, but here is the inverse proportion between the instantaneous time variable and the instantaneous velocity variable according to the equation mentioned in the first positive moral correlation, as the less time the faster the speed will increase the speed The ball directed to the opponent's court, which may confuse the opponent team and achieve a direct point.
6. There is a negative significant relationship between the variables of the angular velocity of the body at the moment of impact and the end of the thrust and the horizontal distance of (center of gravity of body mass) at the moment of impact and the end of the thrust, as the calculated value of (r) reached (-0.986) at the degree of freedom (n_1) The probability of error is ≥ 0.05, which is greater than the tabular value (t) of (0.755), the researcher attributes it to the fact that the angular velocity is reached through the amount of angular change (angular movement of the body) over the amount of angular time change by dealing with the center of mass of the body At that movement or skill studied, the less the angular transition time will help to perform the movement or skill and at an angular speed to overcome the horizontal distance of the body cut between the moments of collision and push, which no matter how long and in the least possible time, and as in the following equation: angular velocity [4] = angular change / time change = degrees/second
7. There is a positive significant correlation between the variables of the height (center of gravity of body mass) of the body with thrust and the highest height of the center of gravity of body mass of the body in the air, as the calculated value of (r) was (0.958) at a degree of freedom (n_1). The probability of error is ≥ 0.05, which is greater than the tabular value (t) of (0.755), the researcher attributes it to the fact that whenever the player sending the volleyball smasher is able to raise (center of gravity of body mass) his body at the moment of payment, the continuity of movement will enable him to raise it to The highest height by the force applied on the ground to raise his body high while he is in the air to reach the ball that he had previously thrown high and hit it towards the opponent's team's [13] yard and exceed the height of the net to direct the ball to the area that can achieve a direct point for the team.

Presenting and discussing the results of the significant and probabilistic correlations between the kinematic and kinetic variables during the performance of the sample jump serve

Table 6: It shows the significant and probabilistic correlations between the kinematic and kinetic variables during the performance of the sample jump serve.

Sq.	Significant	Correlations Value (r)	Probability ratio
			0.05
1-	The time of the last step × the time taken to reach the maximum force of the collision	-0.959	0.041
2-	The angle of impact of the collision × the maximum force recorded in the collision	0.977	0.023
3-	The angle of rise of the body x time of the maximum force of the push	-0.968	0.032
4-	Angular change of the body at the moment of impact and at the end of the thrust × the maximum force recorded by the thrust	0.990	0.010
5-	Maximum height of the center of mass of a body center of gravity of body mass of a body in the air x the maximum force recorded by the thrust	0.962	0.038

From table (6) it is clear that

1. There is a negative significant correlation between the variables of the time of the last step and the time taken to reach the maximum recorded force of the collision, as the calculated value (t) reached (-0.959) at the degree of freedom (n _ 1) and the error probability ratio ≥ 0.05, which is greater than The tabular value (t) of (0.755), the researcher attributes it to the fact that the time of the last step ends with the end of the sender's foot touching the ground while it is above the force-time function platform, and the longer the foot stays above the force-time platform, it will increase the time taken to reach The maximum force recorded by the collision, and this is what the researcher noticed through experience, whether it was the beginning of the collision with the heel or the entire foot, which will exceed the time taken to reach the maximum force recorded by the collision if it was the instep, which represents the end of the last step in fact [11], as the time will be short.
2. There is a positive significant correlation between the fulcrum angle variables and the maximum force recorded in the collision, as the calculated (t) value reached (0.977) at the degree of freedom (n _ 1) and the error probability ratio is ≥ 0.05 which is greater than the tabular value (t) amounting to (0.755), the researcher attributes it to the fact that the player performing the skill of the volleyball smasher in the collision phase 9, when performing the skill, there is a flexion in the knee joint at the moment of collision, this will generate an additional force (body weight force) in the collision, which is better than being The body is in a straight state at the moment of collision, and this is a digital evidence of the process of gathering force inside the body in preparation for completing the type of skill that the sending player will need to jump up to reach the ball in the air.
3. There is a positive significant correlation between the variables of the angular change of the body at the moment of impact and the end of the thrust and the maximum force recorded by the thrust, as the calculated value (t) reached (0.990) at the degree of freedom (n _ 1) and the error probability ratio ≥ 0.05, which is greater than the value of (t) tabular amounting to (0.755), the researcher attributes it to the fact that the absorption stage is between the collision stage and the pushing stage [4], which will lower the sent player from (Center of gravity of body mass) his body downwards. What is represented by the angular change of the body (the angular transition of the body) in those phases, which will thus record the maximum force recorded on the force-time platform.
4. There is a positive significant correlation between the variables of the highest height of the body in the air and the maximum force recorded by the push. 05 ≥ which is greater than the tabular value (t) of (0.755), the researcher attributes it to the fact that the highest height of the body in the air comes through the force of jumping to the top, and the jumping force is in fact and the presence of the force-time function platform in the place of performing the skill of the ace, it will be represented by the maximum force recorded by the push, to reach the highest height for the sender to meet the ball in the air [10], the maximum force possible must be recorded for that and vice versa.

Conclusions

The researcher reached the following conclusions: The values of the variables under study achieved significant positive and negative correlations between the kinematics and kinematics variables by 39.29% in general, the short time and length of the last step have a very important role in preparing and preparing for the process of getting up and lifting the body up quickly and optimally, the variables of the angle of rise, the angular velocity of the body between the moment of impact and the push, and the highest height of the center of gravity of body mass body with the push have played an effective role in reaching the dispatched player to his highest height in the air, the jump force represented by the maximum force values recorded by pushing the force-time platform has achieved significant correlations that enabled the sending player to perform the service smoothly and smoothly, Getting up with the whole foot is best to reach the highest height of the body in the air and to benefit from the force of the reaction of the ground and the bending that occurs in the knee joint in terms of recording the maximum force recorded by collision and pushing and prolonging the time taken to reach the maximum force, Recording the maximum force recorded by thrust played an important role in raising the body (mc) in the air.

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