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Some bio-kinematic variables of the parallel serve stance and their relationship to accuracy for Middle Euphrates tennis players

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Abstract
The purpose of this paper is to identify the values of some biomechanical variables of the parallel stance ready position for the serve in Middle Euphrates tennis players, and identify the relationship between the values of some biomechanical variables of the parallel stance ready position for the serve and accuracy in Middle Euphrates tennis players. The researcher selected the descriptive method, as it suits the nature and problem of the research.The sample was selected randomly and included (7) players from the Middle Euphrates advanced players. The researcher analyzed three attempts for each stance position, making the research sample consist of (21) attempts per player for the main experiment. One of the most important results reached by the researcher is that: There is a significant correlation between the variables of trunk inclination angle and elbow joint angle in their preparation stance and accuracy in the parallel stance, and there is a significant correlation between the variable of ball strike height and accuracy in the parallel stance. One of the most important recommendations recommended by the researchers is that: In the parallel stance, emphasize bringing the hitting arm closer to the player's body behind the back. This is achieved by increasing the angle of the shoulder joint of the hitting arm, placing it level with the elbow joint. This increases the angular acceleration with which the racket moves to achieve high speed, and increases the flexion of the right and left knee joints to lower the body's center of gravity for balance.

Keywords: Chhani, consumption, fuel-wood, households, Lanchaan

Introduction
Tennis is one of the sports that has witnessed remarkable development. It is both enjoyable for players and spectators, and one of the best ways to spend leisure time on a social level. Tens of millions of men and women of all ages play the game. It also plays an important role in preparing individuals physically, mentally, psychologically, and socially by developing their abilities and potential for positive participation in community service (Saleh, *et al*., 2021) [8].
Biomechanics is one of the sciences that has led to many appropriate solutions, whether for cases related to the game's equipment, its movement paths, or the forces affecting the athlete themselves, helping them reach their optimal level (Madloul, 2025: Fadhil, *et al*., 2025) [7, 5].
Kinematic analysis of an athlete's movements during performance also contributes to revealing the strengths and weaknesses of their technique. New and appropriate methods for technique can be found, helping to achieve optimal performance. It can also be used to solve technical problems related to learning and training, as it diagnoses and compares movements, relying on precise measurement to reveal the technical details of the performance in their true form. Hence, the importance of the research lies in analyzing the readiness position for the parallel transmission mode and discovering the appropriate readiness position and some variables related to it and compatible with good transmission from the best position and its accuracy.

Research Problem
Through the researcher's observation of matches in Iraqi tennis tournaments, it was noted that some Iraqi players only change the serve's placement without changing their ready stance positions.

This reveals the type of serve to the receiver and reduces the effectiveness of serving strategy. This contrasts with international players, who change their ready stance to alter the ball's landing areas. Therefore, the researcher decided to analyze the ready stance to determine its impact on the effectiveness and accuracy of the serve.

Research Objectives

- To identify the values of some biomechanical variables of the parallel stance ready position for the serve in Middle Euphrates tennis players.
- To identify the relationship between the values of some biomechanical variables of the parallel stance ready position for the serve and accuracy in Middle Euphrates tennis players.

Research Hypotheses

There is a statistically significant correlation between some biomechanical variables of the parallel stance ready position for the serve and accuracy in Middle Euphrates tennis players

Research fields

- **Human field:** Male players of the Middle Euphrates in tennis.
- **Time field:** 30/7/2024 to 15/11/2024.
- **Spatial field:** The outdoor tennis courts at the College of Physical Education and Sports Sciences-University of Kufa.

Terminology Definition

Parallel Stance: The position taken by the server where his feet are parallel to the baseline of the service court, as shown in Figure 1.

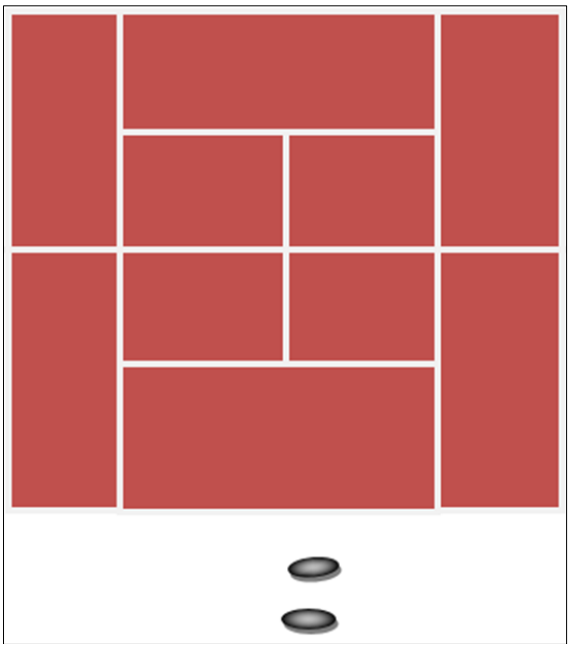

Fig 1: Shows the parallel ready stance

Research Methodology and Field Procedures

Research Methodology

The researcher chose the descriptive method, "which is an investigation that focuses on a phenomenon as it exists in the present with the aim of diagnosing it, revealing its aspects, and determining the relationships between its elements or between it and other phenomena" (Al-Azzawi, 2008) [1], due to its suitability to the nature and problem of the research.

Community and sample research:

The researcher defined the research community as (11) advanced tennis players from the Middle Euphrates region.

Research Sample

The sample is "the part that represents the original community or serves as the model upon which the researcher bases the overall focus of his work" (Al-Kazemi, 2013) [3].

The research sample was randomly selected, including (7) advanced tennis players from the Middle Euphrates region. The researcher analyzed three trials for each position. Thus, the research sample consisted of (21) trials for each player on whom the main experiment was conducted.

Methods, Devices and Tools Used

The researcher utilized several devices and tools, including the following.

Research Methods

The researcher utilized the following research methods:

Arabic and foreign sources and references, observation, analysis, personal interviews, tests, and measurement.

Equipment and Tools Used

The researcher used the following tools and devices:

Three high-resolution (Exilim-Casio) cameras with a frequency of (300) images per second, a (Canon-Sx40 Hs) camera with a frequency of (25) images per second, (4) tripods for camera analysis, an electronic height and weight measuring device, (1) Chinese-made (Acer) laptop calculator, (1) mechanical analysis software (kinovea), a legal tennis court equipped with tools, (40) (Ford) legal tennis balls, (1) basket of balls, (7) tennis rackets, (1) colored adhesive tape, (1) meter drawing scales, (1) fluorescent markers to determine the body's joints, numbered sportswear from (1-15), (2) wooden poles, (14) meter rope, (2) measuring tapes with a length of (1.5) meters, and (25) meter).

Field Research Procedures

The most important biokinematic variables under investigation in the performance of the serve skill.

First: Body variables for the technical performance of the serve.

The angles of the right knee and left knee joints in the preparatory position, the hip joint at the moment of preparation, the inclination of the trunk in the preparatory part, the shoulder joint in the preparatory part, the elbow joint angle in the preparatory part, the height of the body's center of mass at the moment of striking (collision), the displacement of the body's center of mass (from the preparatory part to the main part), and the angular and circumferential velocity of the elbow joint:

Angular velocity = (Angle / Time) x degrees / s.

Circular velocity = (Angular velocity / Sector) × r (Al-Hashemi, 1999) [2].

Second: Ball variables for technical performance of the serve:-Ball strike height.

Determining the tests and their specifications
Determining the test
The researcher selected the Hoyt accuracy test, due to its ability to measure the values of the study variables and its suitability for the research community. The researcher was given (10) attempts to perform the serve skill for each of the positions, selecting three attempts from which to achieve the best accuracy for the serve performance, and then analyzing them.

Test Specifications
Test Name: Hewitt Service Placement Test (Jawad, 2002) [6].
This unit has been found to have high validity coefficients in measuring tennis skill ability for groups of players with different skill levels.

Test Purpose: To test serve accuracy
Procedures
- The tennis court is laid out as shown in Figure 2.
- A 1/4-inch drop rope is attached at both ends to the top of the net posts, leaving a distance of (4) feet between it and the net and a distance of (7) feet between it and the ground. It should be tightly taut and completely parallel to the net.

The numbers 1, 2, 3, 4, 5, and 6 are values that refer to areas of dimensions as follows:
A. Number (1) refers to a rectangle measuring 15 x 13.5 feet.
B. Number (2) refers to a rectangle measuring 6 x 10.5 feet.
- The numbers (6.5.4.3) refer to rectangles measuring 1.5 x 3 feet each.
- The same numbers 1-2-3-4-5-6 refer to the scores assigned to each of the zones in which the ball lands.
- The test is explained and a model is created before administering it to the players.
- The test is preceded by a warm-up of no less than (10 minutes on a tennis court).

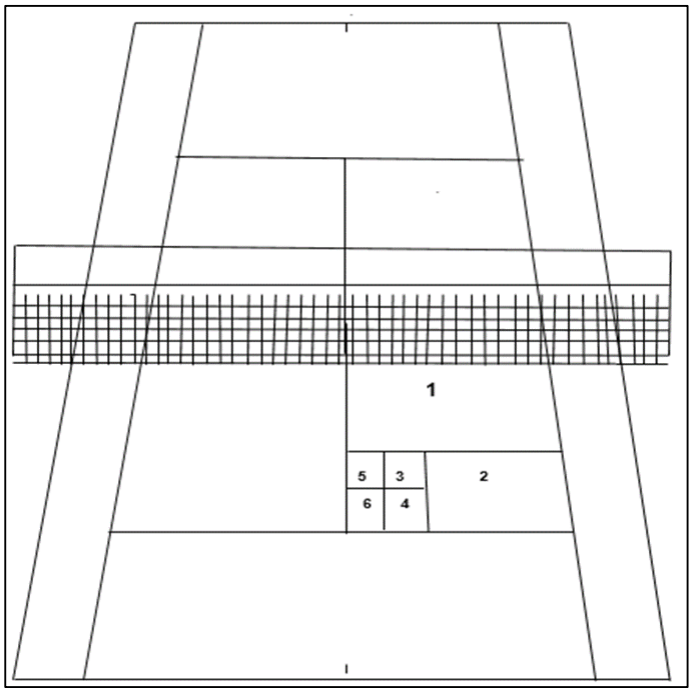

Fig 2: Shows the layout of the tennis court in the serve accuracy test

The player then stands behind the base and hits (10) consecutive balls at the targets designated in the opposite half of the court, provided that all balls pass between the net and the rope. The player attempts to obtain the highest score by landing the ball in zone (6).

Recording
- Balls that touch the net or rope are not counted as attempts and must be repeated.
- A ball that passes over the rope is counted as an attempt and is awarded a score of zero, even if it lands in any of the goals.
- Each valid ball is awarded a score value in the area in which it lands, as shown in Figure 2.
- A player's score is the sum of the points they earn from the ten attempts.
- The maximum score is (60).

Videography
The researcher installed (4) cameras to capture all mechanical aspects related to the skill and to analyze the biokinematic variables of the player's body and equipment. The researcher mounted the cameras on tripods in a manner that allowed for capturing the player's movement perpendicular to the rotation axes and achieving a complete view of the technical performance details of the serve skill, as shown in Figure 3.
- **Camera No 1:** A (Exilim-Casio) camera with a frequency of (300) frames per second was installed perpendicular to the serve performance area on the right side of the player. The camera was located (8.73) meters from the center mark on the court and at a height of (1.28) meters from ground level to the lens focus.
- **Camera No 2:** An Exilim-Casio camera with a frequency of (300) frames per second was installed sideways for the player to the right of the server, (9.50)

meters from the center mark of the field, and at a height of (1.27) meters from ground level to the lens focus.

- **Camera No 3:** An Exilim-Casio camera with a frequency of (300) frames per second was installed vertically for the player to the front of the server, (10.78) meters from the base line of the field, and at a height of (1.05) meters from ground level to the lens focus.
- **Camera No 4:** A Canon-Sx40 Hs camera with a frequency of (25) images per second was installed vertically for the player from the back of the server and at a distance of (5.70) meters from the (Base Line) of the field and at a height of (1.08) meters from the ground level to the lens focus.

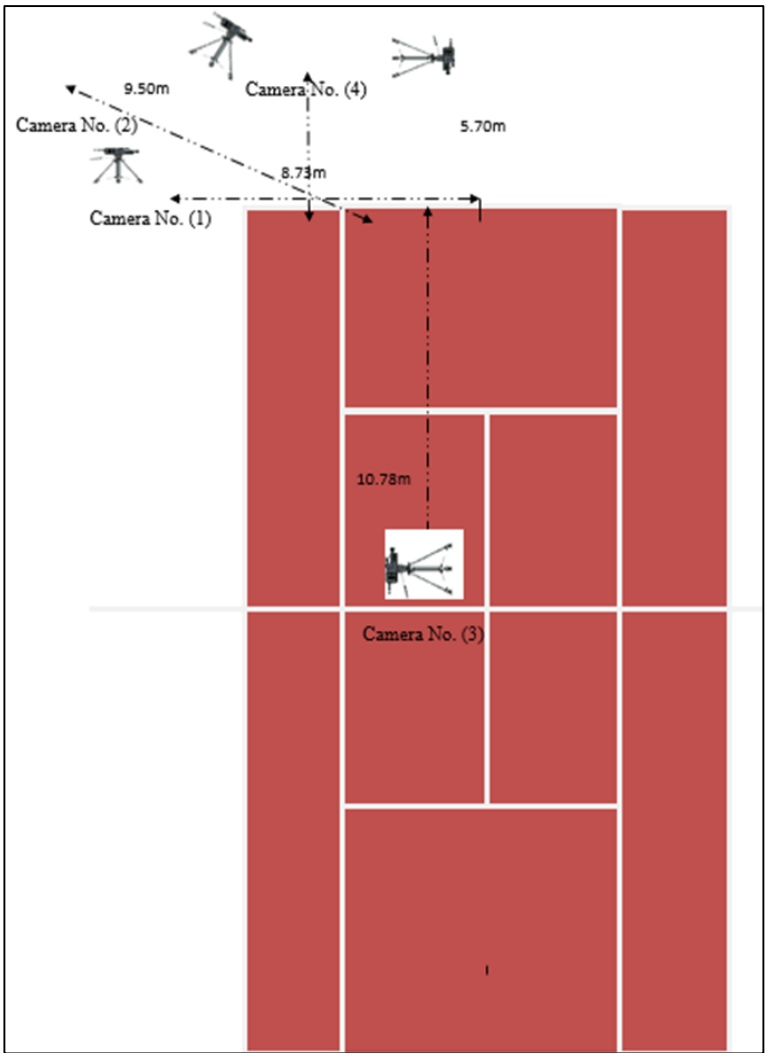

Fig 3: Show the location of the experiment and the research tools used are shown

Exploratory Experiment

The exploratory experiment was conducted on Tuesday, August 6, 2024, at 9:00 AM, at the outdoor stadium of the College of Physical Education and Sports Sciences, University of Kufa, on a sample from outside the research sample. This was to ensure the safety of the cameras and equipment and their operating methods, and to determine the validity and accuracy of the research measurements and tests.

Main Experiment

The main experiment was conducted on a sample of (7) players over two days, Thursday, August 8, 2024, and Friday, September 9, 2024, at 9:00 AM, at the outdoor stadium of the College of Physical Education and Sports Sciences, University of Kufa. The researcher prepared all the necessary equipment for the experiment with the assistance of the support team. He gave the players sufficient time to warm up and perform the technical performance of the serve skill from the parallel readiness position. The researcher was careful to maintain the same conditions as on the first day, in terms of time, location, tools used, implementation method, and support team.

Statistical Methods

To extract the research results, the researcher used the following statistical methods:

- Arithmetic mean.
- Standard deviation.
- Median.
- Skewness coefficient.
- Simple correlation coefficient (Pearson).
- Percentage.

Presentation, analysis, and discussion of the results:

Presentation and analysis of the results of the arithmetic means, standard deviations, and simple correlation coefficient between the values of the bio-kinematic variables, parallel position, and performance accuracy:

Table 1: Shows the arithmetic means, standard deviations, and simple correlation coefficient between the values of the bio-kinematic variables, parallel position, and performance accuracy, and their analysis

Variables	Bio-kinematic variables values		Accuracy		Correlation coefficient value		Type Sig
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Calculation	Tabular	
Right knee joint angle in the preparatory position	122.14	25.16			0.17		Non Sig
					0.31		Non Sig
					-0.34		Non Sig
					-0.52		Sig
10.57					-0.34	0.43	Non Sig
					0.74		Sig
					-0.19		Non Sig
4.47	0.17				-0.09		Non Sig
0.43					0.57		Sig
	Non Sig				0.38		Non Sig
Left knee joint angle in the preparatory position	112.14	13.66			-0.60		Sig

* The table correlation coefficient value is (0.43) at a significance level of (0.05) and a degree of freedom of (19).

Discussion of the results of the arithmetic means, standard deviations, and simple correlation coefficient values between the values of the biokinematic variables for the parallel position and performance accuracy

From Table 2, we can see the values of the correlation coefficients between the biomechanical variables of the parallel position and accuracy. After comparing them with the tabular value of (0.43) under a significance level of (0.05) and a degree of freedom of (19), it became clear that the values of the correlation relationship for the right knee joint and the left knee in the preparatory position and the angle of the hip joint at the moment of preparation were respectively (0.17, 0.31, -0.34) and accuracy was smaller than the tabular value, i.e. an insignificant correlation. The researcher attributes this to the fact that the accuracy of the serve requires neuromuscular coordination and good balance to achieve the biomechanical variables to direct the ball towards a specific target so that the serve is successful, and that the player in the parallel ready position lost good balance and the lack of bending of the knees keeps the body's center of gravity away from the ground and that the transfer of the body's center of gravity from the front leg (left) to the back leg (right) then transfers the body's center of gravity to the left leg in the wrong forward direction and not in the direction of the field, i.e. in a position Opposite the net and pushing the front of the hip forward, and the player's left leg not being properly stable, and as (Al-Kazemi, Al-Taie, 2014) mentions, one of the common mistakes in performing the serve is "the body not being well balanced due to the left foot not being fully supported on the ground", and thus the player loses control and mastery of directing the serve.

The same table shows that the correlation value for the torso angle in the preparatory portion (-0.52) and accuracy was greater than the table value, i.e., an inversely significant correlation; that is, the smaller the torso angle, the greater the accuracy. The researchers attribute this to the fact that the more the player reduces the torso angle in the preparatory position, the more balanced they are, and thus, the accuracy of the serve increases.

The same table shows that the correlation value for the right shoulder joint angle in the preparatory portion (-0.34) and accuracy was smaller than the table value, i.e., an insignificant correlation. The researchers attribute this to the fact that the greater the shoulder angle in the preparatory portion, the more appropriate the acceleration of the racket prior to the moment of striking, thus decreasing accuracy. The same table shows that the correlation value for the right elbow joint angle in the preparatory portion (0.74) and accuracy was greater than the table value, i.e., a significant correlation. The researcher attributes this relationship to the player's use of a calm, rhythmic movement, as the elbow joint angle helps ensure proper timing when the ball touches the racket (the meeting) and allows the player the freedom to reach the ball by increasing or decreasing its angle. It is preferable to keep the arm extended at the moment of impact to ensure the movement is not fragmented.

The same table shows that the correlation values for the height of the body's center of mass at the moment of striking and for the displacement of the body's center of mass (from the preparatory portion to the main portion) were (-0.19, -0.09), respectively, and accuracy was smaller than the table value, i.e., a non-significant correlation. The researcher attributes this to the fact that the more body parts move, the more difficult it is for the player to maintain rhythmic movement rates and synchronization, and the more difficult it is to achieve optimal results in serve accuracy. The same table shows that the correlation value for the angular velocity of the right elbow joint (0.57) and accuracy was greater than the table value, i.e., a significant correlation. The correlation value for the peripheral velocity of the right elbow joint (0.38) and accuracy was less than the table value, i.e., an insignificant correlation. The researcher attributes this to the mechanical interaction between the body and the tool being adequate, allowing the player to reach the racket in the correct direction and at an appropriate linear velocity (i.e., accuracy is inversely proportional to velocity) before striking the ball, which determines the direction and velocity of the ball to achieve a precise kinetic result.

The same table shows that the correlation value for the height of the ball strike (-0.60) and accuracy was greater than the table value, i.e., an inversely significant correlation. The researcher attributes this to the fact that the higher the point of collision between the ball and the racket, the more accurately the player can direct the ball into the opposing

court, due to the greater ability to control the angle of the ball strike and its release.

Conclusions and Recommendations

Conclusions

- There is a significant correlation between the variables of trunk inclination angle and elbow joint angle in their preparation stance and accuracy in the parallel stance.
- There is a significant correlation between the variable of ball strike height and accuracy in the parallel stance.

Recommendations

- In the parallel stance, emphasize bringing the hitting arm closer to the player's body behind the back. This is achieved by increasing the angle of the shoulder joint of the hitting arm, placing it level with the elbow joint. This increases the angular acceleration with which the racket moves to achieve high speed, and also increases the flexion of the right and left knee joints to lower the body's center of gravity for balance.
- Emphasize increasing the extension of the elbow joint of the free arm in the main serve stance to contribute to the upward ball release process and to allow the hitting arm time to complete the swing.
- Emphasize, at the moment of hitting the ball to serve, that the free arm is brought closer to the player's body through the angle of the free arm's shoulder joint to contribute to the process of torso rotation and contribute to the process of balance, as well as increasing the flexion of the posterior hip joint and tilting the torso slightly forward.

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