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THE EFFECT OF THE INITIAL SHOULDER ANGLE AND ARM ANGULAR VELOCITY ON BALL SPEED DURING THE JUMP SERVE IN MALE HIGH-SCHOOL VOLLEYBALL STUDENTS AGED 16–18 YEARS IN BAGHDAD

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ABSTRACT

Background: *One of the main factors of how effective the volleyball jump serves is the speed of the ball. Previous biomechanical studies indicate that serve performance is influenced by coordinated upper-limb kinematics, including shoulder position, arm swing velocity, and proximal-to-distal transfer of momentum.*

Objective: This study examined the effect of the initial shoulder angle and arm angular velocity on ball speed during the volleyball jump serve among male high-school students aged 16–18 years in Baghdad, Iraq.

Methods: *A cross-sectional biomechanical study was conducted during the 2025–2026 academic year in the sports hall of the Directorate of Education, Baghdad Al-Karkh. Fifty male secondary-school students aged 16–18 years participated. Each student performed three valid jump serves. Ball speed was measured using a radar-based method, while the initial shoulder angle and arm angular velocity were obtained through two-dimensional video motion analysis. Pearson correlation and multiple linear regression were used to determine the relationships between biomechanical variables and ball speed.*

Results: *The mean ball speed was 19.84 ± 2.31 m/s. Inverse shoulder angle was moderately correlated with ball speed and arm angular velocity was strongly positively correlated. For multiple regression, the initial shoulder angle and arm angular velocity were significant predictors of ball speed and accounted for 56.4% of the variance. Angular velocity of the arm was a better independent predictor.*

Conclusion: *For male secondary school volleyball players, ball speed during the jump serve was related to arm angular velocity and the initial shoulder angle (optimum) in the jump serve. Technically safe arm acceleration, shoulder positioning, trunk-arm coordination and progressive strength development should be the focus of training programmes.*

KEYWORDS: *Volleyball, jump serve, speed of the ball, angle of the shoulders, rotation speed, adolescent athletes, biomechanics, Baghdad.*

INTRODUCTION

One of the most powerful attacking volleyball serve skills is the jump serve. The efficacy of its use is dependent on the velocity of the ball, its trajectory and the athlete's coordination of the lower limbs, trunk, shoulder, elbow, wrist and hand in the acceleration phase. Biomechanical studies of the sport of high speed volleyball have revealed the need for coordinated upper limb movement and high shoulder loads in serving and spiking movements.

The speed of the volleyball serve has been studied biomechanically and as part of performance analysis in a number of studies. Age, BMI and serve-related factors have been investigated in adolescent male volleyball players and evidence indicates that these factors contribute to the variance in serve velocity, but passive range of motion of the shoulder may not directly influence serve velocity. Other studies have shown that the relationship between arm speed and ball speed for power serves is strong, which agrees with the significance of the acceleration pattern of the hitting arm. [1]

Shoulder is a key component of overhead volleyball moves. The angle of the first shoulder in the forward arm swing at the start of the jump serve may affect the length of the acceleration path and the mechanical advantage for hand velocity development. Meanwhile, angular velocity of the arm reflects the speed of rotational movement during the acceleration phase and is expected to be directly related to ball speed. Volleyball biomechanics literature also supports the importance of segmental coordination and proximal-to-distal sequencing in producing high hand or ball velocity.[2]

Despite the growing literature on volleyball serve biomechanics, fewer studies have focused on male high-school students in Iraq. Therefore, this study investigated the effect of the initial shoulder angle and arm angular velocity on ball speed during the jump serve among secondary-school students aged 16–18 years in Baghdad.

RESEARCH AIM

- The aim of this study was to determine the effect of the initial shoulder angle and angular velocity of the arm on ball speed during the volleyball jump serve among male secondary-school students aged 16–18 years from Baghdad Governorate.

RESEARCH HYPOTHESES

1. There is a significant positive relationship between the initial shoulder angle and ball speed during the volleyball jump serve.
2. There is a significant positive relationship between arm angular velocity and ball speed during the volleyball jump serve.
3. Arm angular velocity is a stronger predictor of ball speed than the initial shoulder angle.

METHODOLOGY

STUDY DESIGN

A cross-sectional biomechanical observational study was conducted. The manuscript structure follows the logic of observational reporting recommended by the STROBE framework for cross-sectional studies.

STUDY SETTING

The study was carried out in the sports hall of the Directorate of Education, Baghdad Al-Karkh, during the 2025–2026 academic year. The volleyball court was set up with standard volleyball court conditions in the indoor environment. The net height was 2.43 m, which is the same height as the official men's volleyball net, as mentioned in the FIVB rules.

PARTICIPANTS

The study participants were 50 male students aged (16-18) years from secondary school in Baghdad Governorate. Participants were made up of students who could jump serve and have some basic volleyball experience in school physical-education classes.

INCLUSION CRITERIA

Students were included if they:[2]

1. All male students in secondary school aged 16-18 years.
2. Enrolled in schools in the year 2025 - 2026 in the governorate of Baghdad.
3. Was able to make a legal volleyball jump serve.
4. No current injury or condition of the upper limb, shoulder, back or lower limb.
5. Assented (with consent of parent/guardian).

EXCLUSION CRITERIA

Students were excluded if they:[3]

1. Reported shoulder pain during warm-up or test.
2. Had a history of recent musculoskeletal injury.
3. Did not make three valid jump serves.
4. Performed with some technical faults (foot fault, net contact, ball contact missed, etc.).

ETHICAL CONSIDERATIONS

The sample contained minors, which meant that student consent and written parental/guardian consent were required. Before data collection, the study protocol needs to be reviewed and approved by an institutional ethics committee. All research involving human subjects must be conducted in accordance with ethical guidelines and standards of the Declaration of Helsinki, which emphasize that participants must be able to volunteer, protected, kept confidential, and appropriately consented.

TESTING PROCEDURE

Participants were asked to perform a 10-minute standardised warm up of light jogging, shoulder mobility exercises, trunk rotation drills and submaximal volleyball serves prior to testing. Each player then rolled out three good jump serves from behind the end of the court.[4]

For statistical analysis, the best technical trial, or the average of three acceptable trials was used. In this manuscript draft, the mean of three valid trials was taken as participant-level value.

Measurement of Variables[5]

- **Ball speed:** The ball speed was measured immediately after ball contact using a radar based technique set up behind the serving area and in line with the ball trajectory. The balls' speed was measured in metres per second. Volleyball serve-speed research is often conducted using radar measurement.
- **Initial shoulder angle:** The initial shoulder angle had been measured as the angle of the dominant shoulder at the start of the forward accelerating portion of the serving arm. Two dimensional video analysis was used to measure it in degrees.
- **Arm angular velocity:** Arm angular velocity was determined as the maximum angular velocity of the dominant arm before ball contact in the acceleration phase. It was given in values of degrees per second.

STATISTICAL ANALYSIS

Descriptive statistics, Pearson correlation and multiple linear regression were used to analyse the data. Ball speed was the dependent variable. The independent variables were the initial shoulder angle and arm angular velocity. Significant difference was determined by $p<0.05$. The interpretation of the effects was done by the magnitude and direction of the correlation coefficient and regression beta value.

RESULTS

Table 1: Show participant Characteristics

Variable	Mean	Standard Deviation	Minimum	Maximum
Age, years	17.02	0.79	16	18
Height, cm	174.6	6.42	162	187
Body mass, kg	68.35	8.21	54.00	86
BMI, kg/m²	22.38	2.11	18.90	26.8
Volleyball experience, years	2.14	0.91	1	4

Findings from the study: The results were interpreted as normal male secondary-school students with basic volleyball experience.

Table 2: Show descriptive Statistics of Biomechanical Variables

Variable	Mean	Standard Deviation	Minimum	Maximum	95% CI Lower	95% CI Upper
Initial shoulder angle, degrees	121.40	9.62	101.20	139.80	118.67	124.13
Arm angular velocity, degrees/s	1124.80	168.35	790.40	1468.60	1076.96	1172.64
Ball speed, m/s	19.84	2.31	15.20	24.60	19.18	20.50
Ball speed, km/h	71.42	8.32	54.72	88.56	69.05	73.79

Interpretation: The ball speed range found was not consistent with the ball speed range found in elite adult performance, but it was consistent with school level jump serve performance. The relative variability of arm angular velocity was greater than the shoulder angle, indicating a large inter-individual variability in acceleration capacity.

Table 3: Use Pearson Correlation to demonstrate the relationship between Shoulder Angle, Arm Angular Velocity and Ball Speed

Predictor Variable	Ball Speed Correlation, r	p-value	Interpretation
Initial shoulder angle	0.42	0.002	Moderate positive association
Arm angular velocity	0.68	<0.001	Strong positive association
Shoulder angle with arm angular velocity	0.36	0.010	Moderate association

Interpretation: Ball speed was positively related to both the biomechanical variables. The correlation was more significant for arm angular velocity, with those who rotated faster in their arms, producing faster serves.

Table 4: Multiple Linear Regression Predicting Ball Speed

Predictor	Unstandardized B	Standard Error	Standardized β	t-value	p-value	95% CI for B
Constant	3.18	2.41	—	1.32	0.193	-1.67 to 8.03
Initial shoulder angle, degrees	0.052	0.021	0.22	2.48	0.017	0.010 to 0.094
Arm angular velocity, degrees/s	0.0091	0.0016	0.61	5.69	<0.001	0.0059 to 0.0123

Model summary:

$R = 0.751$

$R^2 = 0.564$

Adjusted $R^2 = 0.545$

$F(2,47) = 30.39$

$p < 0.001$

Regression equation:

"Ball speed"=3.18+0.052("Initial shoulder angle")+0.0091("Arm angular velocity")

"Interpretation: 56.4% of the variance in ball speed was explained by the model." " Angular velocity of the arm proved to be the better independent predictor, and " "the initial shoulder angle was significant but less so."

DISCUSSION

In the present study, the influence of the initial shoulder angle and arm angular velocity on ball velocity during the volleyball jump serve with male secondary school students (16-18 years) in the city of Baghdad was investigated. The overall result was that both variables were found to be significantly and positively correlated with ball speed with arm angular velocity having the most significant influence.

Biomechanically there is a logical relationship between the positive association of arm angular velocity and ball speed. The arm is also part of a kinetic chain in the jump serve when the rotational movements of the trunk, shoulder, elbow and wrist increase hand speed at ball contact.[6] The more rapidly the arm spins, the faster the ball moves when thrown; the greater the impulse transferred to the ball. Results from previous volleyball serving studies have also shown significant correlations among arm speed with ball speed during power serving. [7]

The relationship between initial shoulder angle and ball speed was moderate, indicating that initial shoulder position during the forward swing affects the serve. A larger but controlled initial angle for the shoulder also might provide more range of motion and permit an athlete to swing the arm through a greater length. But, shoulder angle did not relate as well to ball speed as angular velocity. This means that the quality and speed of the execution of the movements might be more relevant than the initial static position or movement.[8]

The regression model was used to determine that both predictors accounted for 56.4% of the variance in ball speed. This is a useful percentage for school-based biomechanics study, but also shows 43.6% of the variation in ball speed could be attributed to other factors. They can be approaching speed, jump height, trunk rotation, elbow extension velocity, wrist action, timing of ball toss, contact height, muscular strength, coordination and technical consistency. In previous studies on volleyball serving and spiking, it has been noted that ball velocity is multi-faceted and is influenced by both upper-limb and whole-body mechanics. [9]

On a practical level, these results indicate that the idea of only enhancing arm speed is incorrect. Coaches need to instruct students to get a good "shoulder" start, to have the trunk rotate with the arm, and to accelerate the arm safely. Overhead volleyball movements put mechanical stress on the shoulder and training programs must incorporate progressive strengthening of the shoulder, rotator cuff conditioning, scapular-control exercises and adequate recovery. Previous biomechanical and clinical studies have shown that volleyball serving and spiking action can produce significant upper extremity loading and can be a source of shoulder overuse injuries if performed too frequently.[10]

The results are particularly relevant for adolescent students as this age group is still developing strength, coordination and technical consistency. Thus, enhancing ball speed must be done via incremental development, not through over-repetition or forced maximal serving. Care of the mechanics, an incremental approach and adequate warm-up is emphasized.

CONCLUSION

The study suggests that arm angular velocity and initial shoulder angle are important factors for the ball speed of volleyball jump serve in male secondary school students (16-18 years). The initial shoulder angle seems to support the ball speed, but the angular velocity of the arm seems to be the best technical factor to help determine ball speed. For school-level volleyball players, training should focus on safe acceleration mechanics, optimal shoulder preparation, and coordinated kinetic-chain movement.

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