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Prediction The Skill Performance of The High Long Serve Based on Some Biomechanical Variables For Junior Badminton Players

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Abstract

Badminton is one of the sports that has witnessed significant development through the great efforts made to expand its spread and to develop it from one level to a better level, relying on the science of biomechanics which studies human movement. Due to the absence of a study that has addressed the biomechanical variables of the long high serve skill in badminton, the researcher decided to address and interpret this study. The importance of the research lies in developing predictive equations for the long high serve skill in badminton based on the biomechanical variables of junior badminton players in order to provide important scientific results for players, coaches, and researchers. The research aims to identify some biomechanical variables of the long high serve skill for junior badminton players, identify the percentage of contribution of some biomechanical variables to the long high serve skill of junior badminton players, and develop predictive equations for the long high serve skill in badminton based on the biomechanical variables of junior badminton players. The researcher adopted the descriptive method using the survey approach on badminton players participating in the 2024–2025 sports season, whose number reached (38) junior players under the age of (16) years. Nine biomechanical variables were measured in addition to the long serve test in badminton. After processing the data, a set of conclusions and recommendations was reached, as the results showed the existence of (9) predictive equations with significant values that can be relied upon in explaining the relationship between biomechanical variables and the skill performance of the long high serve in badminton.

Keywords: Prediction, Biomechanical Variables, Long High Serve Skill in Badminton.

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Introduction

One of the sports that has been developed in large part due to the effort it makes to bring Badminton as popular as possible. Since each scientific research is the basis that solves a problem or it also preserves and affects the transfer of what has been accomplished by an athlete from one level to a better level, we find that there are areas in which scientific research plays a major role and contributes to development such as sports area, including badminton games. Realization of this development is based on biomechanics, which examines human movement through in terms of principles, laws and factors shaping the athlete's motion. Another notable determinant of skill performance is the biomechanical variables, which identify an organization's activity and signal scientific research to determine solutions to specific problems.

According to "Motion analysis is one of the main tools through which motor performance can be studied; it is an analytical study of all the individual parts and elements of motion in order to reach a high degree of accuracy, allowing for best improvements and better performance" (Hussein & Shaker, 1998 pp. 41-42). Furthermore, “motion analysis gives the coach and athlete a visual model of the movement, as well as detailed information about errors in order to choose appropriate training methods and means to avoid motor errors, saving time and effort for both coach and athlete” (Abdel-Khaliq, 1999).

The long high serve skill in badminton is regarded as one of the main offensive skills, which, if mastered correctly may be critical to win a game for each team since there are no studies on the biomechanical variables of the long high serve skill in badminton so it is very necessary to investigate and rationalize what factor contributes to this skill performance in badminton and developing equations that would predict it for the coaches by knowing its biomechanical variables.

One of the studies that treatment biomechanical variables, which are the study of Rana Hadi (2013) was conducted on junior players Armenian Club in badminton aged (10-13) years and (12) players. The Findings Results showed that special exercises positively affected some physical variables in the inferential favor of the experimental group. Specific exercises also improved some biomechanical parameters (vertical momentum of the body at maximum height, body angular velocity, striking arm angular velocity, speed of shuttlecock launch and applied force) in the experimental group. In addition, previously mentioned special exercises positively impacted the forehand stroke in badminton for the experimental group. However, there was no significant difference in the variables (trunk angle at contact moment, the angular momentum of striking arm, knee joint angle at contact point moment, knee joint angular velocity, shuttlecock release angle, altitude of hitting points for shuttlekocks and shuttlecock release angle) between groups undergoing special exercises and those who did (Jabbar,2013 pp. 50–110).

In another study by Reem Salam (2009), conducted on (4) players from the Iraqi national men’s tennis team, it found that we find that tangential velocity of the striking arm between ’swing’ and ‘hitting' stages has a significant relationship compared to knee joint angle, height of the body center of gravity at hitting point, ball release angle at hitting point along with ball release speed and angular momentum in relation with level of technical performance in forehand stroke exertions during tennis. The result also showed that mechanical levels of the knee and hip joints in tennis

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did not reach a sufficient level corresponding to the technical performance level of forehand stroke (Ibrahim, 2009; pp. 58 & 132).

A study by Habib Ali Taher (2004) on the Iraqi national volleyball team (11) concluded that some biomechanical variables such as knee angle and hip angle at preparation to implement the performance jump serve skill in volleyball, mechanical power variable, an important correlated variable with this angular velocity of the arm. The parameters of launch (angle, velocity, and initial height) proved weakly correlated with mechanical power. We also observed significant relationships with knee angle at preparation for jump serve and hip angle at the same time point, as well as between launch angle and height of center of gravity during ball release. Moreover, strong correlations were noted between the trunk angle and arm + trunk angular velocity, as well as to the launch angle. The trunk angular velocity was a contributor (0.903) for the ball launch, and this factor was raised to (0.999) when mechanical power was imparted to it (Al-Husseini, 2004, pp. 31,50).

The present research is unique in its establishing predictive equations for the long high serve skill obtained from biomechanical variables of junior badminton players, and such important scientific results are expected to be provided for players, coaches and researchers. So, this study identified some biomechanical variables associated with the long high serve skill in junior badminton players, determined the contribution of selected biomechanical variable to percentage long high serve skill and established predictive equations for badminton long-hitting high skills by using biomechanics variables in junior badminton players. The time frame of the study was between 6/10/2024 and 22/1/2025.

Methods and Tools

The researcher used the descriptive approach because it fits the research objectives and the survey method. It is defined as “the study of phenomena among members of a specific population as they are, without the researcher intervening to implement any alterations in the values of these phenomenon or impact on them in any manner” (Abdel-Fattah, 2022, p.218). The research sample, according to the championship regulations prepared by the Iraqi Central Badminton Federation, included (38) junior players under age (16) years among badminton players participating in the 2024–2025 sports season.

The researcher used more than one method of information collection, devices and tools in the form of (Arabic and foreign sources, observation and experimentation, personal interview, a assistive work team, workin on information gateway at international level). The remaining equipment comprised of (10) Yonex badminton rackets, (20) Yonex shuttlecocks, a high-speed camera (Casio) which had the capability to capture images at an interval of about (1000) frames per second, measuring scale (1 m), rubber rope (100 cm), and colored adhesive tapes. The biomechanical factors included elbow angle of the striking arm, the inclination angle of the trunk at hitting, knee joint angle of the supporting leg at hitting, shoulder joint angle, angular velocity of the striking arm/ angular velocity trunk, shuttlecock release speed and shuttlecock release Angle and height. The long serve test in badminton was the test implemented (Al-Bakri, 2000, p. 64).

Subsequently, a pilot study was implemented by the researcher on (5) junior badminton players under (16) years in order to extract the scientific bases of the test for suitability, stability and objectivity despite this test having scientific foundations that have been previously tested in Iraqi environment. The researcher gained content validity by providing the questionnaire forms to experts and specialists in biomechanics and badminton so that they were able to identify the most appropriate tests for measuring the long high serve skill in badminton, as well as determining which were considered the most important biomechanical variables contributing to this skill. As explained by Thaer Dawood (2020), "content validity measures how good a test is at representing all the facets or behaviours that make up a certain trait or phenomenon according to whether the test covers only part of the phenomenon or it covers the entire phenomenon" (Al-Qaisi, 2020, p. 25).

The reliability of the long serve test was also calculated in terms of the test–retest method. The reliability of the test was shown to be high, by Pearson's simple correlation coefficient between the values obtained in both measurements; the calculated significance value (Sig = 0.000) turned out smaller than the adapted level of significance (0.05). The objectivity of the test was also determined based on Pearson's simple correlation coefficient between the results obtained by both judges, and high objectivity was demonstrated because the calculated value of significance (Sig = 0.000) of which was lower than adopted significance level (p>0.05).

The researcher also using this analytical statistic software program, (IBM SPSS Version 26), the researcher also obtained arithmetic mean and standard deviation, median, skewness coefficient moments method: and Multiple Linear Regression Stepwise methods.

Results

The researcher calculated the values of the arithmetic means, standard deviations, medians, and skewness coefficients for all biomechanical variables and the long serve test in badminton. The results indicated that all skewness coefficient values were less than (+3), which reflects a good distribution of the sample and its homogeneity across all variables, as shown in Table (1).

Table 1. *Arithmetic Means, Standard Deviations, Medians, and Skewness Coefficients for the Biomechanical Variables and the Long Serve Test in Badminton*

No.	Variables	Mean	Median	Std. Deviation	Skewness
1	Elbow Angle of the Striking Arm	114.947	115.500	4.764	-0.255
2	Trunk Inclination Angle at the Moment of Shuttlecock Hit	27.657	28	2.485	0.827
3	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit	144.078	144	3.122	0.406

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4	Shoulder Joint Angle at the Moment of Shuttlecock Hit	40.894	40.500	1.060	0.794
5	Angular Velocity of the Striking Arm	578.605	578	7.726	0.244
6	Angular Velocity of the Trunk	94.500	95	2.617	-0.076
7	Shuttlecock Release Speed	35.500	35.500	2.617	-0.038
8	Shuttlecock Release Angle	20.736	20	2.126	0.471
9	Height of the Shuttlecock Hitting Point	2.171	2.160	0.041	0.567
10	Long Serve Test	28.289	29.500	3.109	-1.042

Results of the Predictive Equations for the Long High Serve Skill in Badminton Based on Biomechanical Variables

Using the long high serve skill in badminton as the dependent variable, the researcher applied Multiple Linear Regression using the Stepwise method to calculate the predictive equations, as shown in Table (2).

Table 2. *Results of the Predictive Equations for the Long High Serve Skill in Badminton Based on Biomechanical Variables*

Model	Requirements (Variables)	Multiple Correlation Coefficient	Coefficient of Determination (R^2)	Constant	F Value	Regression Coefficient	t Value	Contribution Percentage
First	Elbow Angle of the Striking Arm	0.523	0.273	9.123	2.608 (Sig = 0.011*)	0.542	2.652 (Sig = 0.010*)	27.35%
Second	Elbow Angle of the Striking Arm	0.643	0.413	13.567	2.850 (Sig = 0.033*)	0.280	2.430 (Sig = 0.203*)	41.344%
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.599	1.599 (Sig = 0.020*)	
Third	Elbow Angle of the Striking Arm	0.766	0.586	13.439	4.328 (Sig = 0.033*)	0.849	2.649 (Sig = 0.001*)	58.675%
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.131	2.601 (Sig = 0.016*)	
	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit					0.738	2.556 (Sig = 0.004*)	
Fourth	Elbow Angle of the Striking Arm	0.785	0.616	14.526	4.081 (Sig = 0.015*)	0.722	3.511 (Sig = 0.003*)	61.622%
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.022	1.852 (Sig = 0.015*)	
	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit					0.609	2.340 (Sig = 0.026*)	
	Shoulder Joint Angle at the Moment of Shuttlecock Hit					0.517	1.401 (Sig = 0.026*)	
Fifth	Elbow Angle of the Striking Arm	0.792	0.627	15.223	4.326 (Sig = 0.023*)	0.571	2.346 (Sig = 0.011*)	62.726%
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.691	2.601 (Sig = 0.004*)	
	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit					0.278	2.335 (Sig = 0.014*)	
	Shoulder Joint Angle at the Moment of Shuttlecock Hit					0.612	3.410 (Sig = 0.006*)	

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	Angular Velocity of the Striking Arm					0.715	3.281 (Sig = 0.034*)	
	Elbow Angle of the Striking Arm					0.522	3.185 (Sig = 0.006*)	
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.492	2.189 (Sig = 0.002*)	
	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit					0.712	3.677 (Sig = 0.012*)	
Sixth	Shoulder Joint Angle at the Moment of Shuttlecock Hit	0.823	0.677	16.471	4.167 (Sig = 0.022*)	0.364	4.120 (Sig = 0.031*)	67.732%
	Angular Velocity of the Striking Arm					0.331	3.528 (Sig = 0.026*)	
	Angular Velocity of the Trunk					0.348	4.186 (Sig = 0.011*)	
	Elbow Angle of the Striking Arm					0.678	3.152 (Sig = 0.020*)	
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.348	3.615 (Sig = 0.031*)	
	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit					0.164	3.725 (Sig = 0.012*)	
Seventh	Shoulder Joint Angle at the Moment of Shuttlecock Hit	0.841	0.707	17.261	4.215 (Sig = 0.031*)	0.912	4.181 (Sig = 0.017*)	70.728%
	Angular Velocity of the Striking Arm					0.677	3.512 (Sig = 0.005*)	
	Angular Velocity of the Trunk					0.542	2.616 (Sig = 0.002*)	
	Shuttlecock Release Speed					0.564	2.716 (Sig = 0.041*)	
	Elbow Angle of the Striking Arm					0.461	2.705 (Sig = 0.018*)	
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.816	3.241 (Sig = 0.003*)	
	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit					0.347	3.164 (Sig = 0.011*)	
	Shoulder Joint Angle at the Moment of Shuttlecock Hit					0.268	4.253 (Sig = 0.023*)	
Eighth	Angular Velocity of the Striking Arm	0.876	0.767	18.205	4.562 (Sig = 0.028*)	0.951	4.277 (Sig = 0.018*)	76.737%
	Angular Velocity of the Trunk					0.248	2.613 (Sig = 0.031*)	
	Shuttlecock Release Speed					0.269	2.440 (Sig = 0.019*)	
	Shuttlecock Release Angle					0.367	3.612 (Sig = 0.021*)	
	Elbow Angle of the Striking Arm					0.615	1.687 (Sig = 0.003*)	
	Trunk Inclination Angle at the Moment of Shuttlecock Hit					0.348	3.442 (Sig = 0.026*)	
	Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit					0.159	2.672 (Sig = 0.031*)	
	Shoulder Joint Angle at the Moment of Shuttlecock Hit					0.624	3.677 (Sig = 0.011*)	
Ninth	Angular Velocity of the Striking Arm	0.942	0.887	20.235	4.891 (Sig = 0.019*)	0.528	4.121 (Sig = 0.002*)	88.736%
	Angular Velocity of the Trunk					0.348	3.691 (Sig = 0.035*)	
	Shuttlecock Release Speed					0.297	3.988 (Sig = 0.034*)	
	Shuttlecock Release Angle					0.728	4.292 (Sig = 0.019*)	
	Height of the Shuttlecock Hitting Point					0.688	4.519 (Sig = 0.006*)	

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Results of the Predictive Equations for the Long High Serve Skill in Badminton Based on Biomechanical Variables

The results of the multiple linear regression analysis presented in Table (2) showed that the contribution percentages of the long high serve skill in badminton based on biomechanical variables were as follows:

Variable 1: (Elbow Angle of the Striking Arm)

The multiple correlation coefficient was (0.523) and the determination factor was (0.273). The constant value is reached (9.123), while the calculated F value (2.608) at the significance level of (0.011) indicates statistical significance, because it was less than the adopted significance level (< 0.05). The (t)-value calculated was (2.652) with a significance level of (0.010) which is also significant as it is less than (<0.05). Its contribution percentage was (27.35%). Thus, the elbow angle of the hitting arm serves as a predictor for long high serve skill:

Long High Serve = 9.123 + (0.542 × Elbow Angle of the Striking Arm).

Variable 2: (Elbow Angle of the Striking Arm and Trunk Inclination Angle at the Moment of Shuttlecock Hit)

In addition, the multiple correlation coefficient was (0.643) and the coefficient of determination was (0.413). The constant was (13.567), and the value of calculated F was (2.850) with significance level (0.033), which is considered statistically significant since it is less than (< 0.05). The estimated t values for analysis were (2.430, 1.599) with significance levels (0.203, 0.020), respectively, showing that they are statistical significant at (< 0.05). This variable ranked contribution of (41.344%). Accordingly, the predictive equation is:

Long High Serve = 13.567 + (0.280 × Elbow Angle of the Striking Arm) − (0.599 × Trunk Inclination Angle at the Moment of Shuttlecock Hit).

Variable 3: (Elbow Angle of the Striking Arm, Trunk Inclination Angle at the Moment of Shuttlecock Hit, and Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit)

R squared (0.586), the Multiple correlation coefficient was (0.766). Constant value = (13.439), F calculated value = (4.328) at level of significance, p-value= 0.033 < 0.05 [statistically significant]. The t values calculated were as follows: (2.649, 2.601, 2.556) and the significance levels accomplished were at (0.001, 0.016, 0.004), where those reached are considered statistically significant since they become less than (< 0.05). It reached this variable with a contribution of (58.675%). Accordingly, the predictive equation is:

Long High Serve = 13.439 + (0.849 × Elbow Angle of the Striking Arm) − (0.131 × Trunk Inclination Angle at the Moment of Shuttlecock Hit) − (0.738 × Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit).

Variable 4: (Elbow Angle of the Striking Arm, Trunk Inclination Angle at the Moment of Shuttlecock Hit, Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit, and Shoulder Joint Angle at the Moment of Shuttlecock Hit)

And the multiple correlation coefficient was(0.785), and the coeffecient of determination was (0.616). The constant was (14.526), the f value obtained was (4.081) with a significance level of (0.015), statistically significant because it is less than (< 0.05). The t values were calculated at the significance levels of (3.511, 1.852, 2.340, 1.401) with p value (0.003, 0.015, 0.026, 0.026) respectively which is statistically significant (<p< (^[5]). This variable resulted in a contribution percentage (61.622%) Accordingly, the predictive equation is:

Long High Serve = 14.526 + (0.722 × Elbow Angle of the Striking Arm) − (0.022 × Trunk Inclination Angle at the Moment of Shuttlecock Hit) − (0.609 × Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit) − (0.517 × Shoulder Joint Angle at the Moment of Shuttlecock Hit).

Variable 5: (Elbow Angle of the Striking Arm, Trunk Inclination Angle at the Moment of Shuttlecock Hit, Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit, Shoulder Joint Angle at the Moment of Shuttlecock Hit, and Angular Velocity of the Striking Arm)

The multiple correlation coefficient was (0.792) and the coefficient of determination was equal to (0.627). The value of the constant was (15.223), while the calculated F value was (4.326) and at a significance level of (0.023) which indicates that the results are statistically significant because it is less than (< 0.05). The t values calculated were (2.346, 2.601, 2.335, 3.410, 3.281) for significance levels (0.011, 0.004, 0.014, 0.006, and.034), respectively which indicates statistical significance as they lead to being lesser (< 0.05). It had a contribution percentage of (62.726%) variable. Accordingly, the predictive equation is:

Long High Serve = 15.223 + (0.571 × Elbow Angle of the Striking Arm) − (0.691 × Trunk Inclination Angle at the Moment of Shuttlecock Hit) − (0.278 × Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit) − (0.612 × Shoulder Joint Angle at the Moment of Shuttlecock Hit) − (0.715 × Angular Velocity of the Striking Arm).

Variable 6: (Elbow Angle of the Striking Arm, Trunk Inclination Angle at the Moment of Shuttlecock Hit, Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit, Shoulder Joint Angle at the Moment of Shuttlecock Hit, Angular Velocity of the Striking Arm, and Angular Velocity of the Trunk)

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The multiple correlation coefficient was (0.823) and the coefficient of determination reached (0.677). The constant was (16.471) and the computed F value (4.167) at significance level (.022), denoting statistical significance as it is less than (The contribution percentage of this variable was (67.732%). Accordingly, the predictive equation is:

Long High Serve = 16.471 + (0.522 × Elbow Angle of the Striking Arm) − (0.492 × Trunk Inclination Angle at the Moment of Shuttlecock Hit) − (0.712 × Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit) − (0.364 × Shoulder Joint Angle at the Moment of Shuttlecock Hit) − (0.331 × Angular Velocity of the Striking Arm) − (0.348 × Angular Velocity of the Trunk).

Variable 7: (Elbow Angle of the Striking Arm, Trunk Inclination Angle at the Moment of Shuttlecock Hit, Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit, Shoulder Joint Angle at the Moment of Shuttlecock Hit, Angular Velocity of the Striking Arm, Angular Velocity of the Trunk, and Shuttlecock Release Speed)

Whereas, the multiple correlation coefficient was (0.841) and the coefficient of determination was (0.707). Its constant value (17.261), calculated F value (4.215) at significance level (0.031). The statistically significant because it is less than (< 0.05). The calculated t values were (3.152, 3.615, 3.725, 4.181,3.512,2.616,2.716) at significance levels (0.020,0.031,0.012,0.017,0.005, 0.002, and 0.041), indicating statistical significance since they are lesser than (< 0/05). This variable resulted in a contribution percentage of (70.728%). Accordingly, the predictive equation is:

Long High Serve = 17.261 + (0.678 × Elbow Angle of the Striking Arm) − (0.348 × Trunk Inclination Angle at the Moment of Shuttlecock Hit) − (0.164 × Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit) − (0.912 × Shoulder Joint Angle at the Moment of Shuttlecock Hit) − (0.677 × Angular Velocity of the Striking Arm) − (0.542 × Angular Velocity of the Trunk) − (0.564 × Shuttlecock Release Speed).

Variable 8: (Elbow Angle of the Striking Arm, Trunk Inclination Angle at the Moment of Shuttlecock Hit, Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit, Shoulder Joint Angle at the Moment of Shuttlecock Hit, Angular Velocity of the Striking Arm, Angular Velocity of the Trunk, Shuttlecock Release Speed, and Shuttlecock Release Angle)

The multiple correlation coefficient was (0.876) and the coefficient of determination value (0.767). The constant (18.205), the calculated F (4.562) at a p-value (engerrule rtium tuitent 0.028 showed statistical significant since it is less than (< 0.05). The obtained t values were (2.705, 3.241, 3.164, 4.253, 4.277, 2.613, 2.440, 3) at significance levels (0.018 //;0:003 //;0:011 //;0:023 //;0:018//;0:031//;0:019//;021), respectively which was statistically significant as they are less than

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(<.05). It has a contribution percentage of (76.737%) for this variable. Accordingly, the predictive equation is:

Long High Serve = 18.205 + (0.461 × Elbow Angle of the Striking Arm) − (0.816 × Trunk Inclination Angle at the Moment of Shuttlecock Hit) − (0.347 × Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit) − (0.268 × Shoulder Joint Angle at the Moment of Shuttlecock Hit) − (0.951 × Angular Velocity of the Striking Arm) − (0.248 × Angular Velocity of the Trunk) − (0.269 × Shuttlecock Release Speed) − (0.367 × Shuttlecock Release Angle).

Variable 9: (Elbow Angle of the Striking Arm, Trunk Inclination Angle at the Moment of Shuttlecock Hit, Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit, Shoulder Joint Angle at the Moment of Shuttlecock Hit, Angular Velocity of the Striking Arm, Angular Velocity of the Trunk, Shuttlecock Release Speed, Shuttlecock Release Angle, and Height of the Shuttlecock Hitting Point)

The multiple correlation coefficient value was (0.942) and the value of the coefficient of determination was (0.887). The constant value was (20.235), while the F value calculated was (4.891) significant level of significance (0.019), is statistically significant because it is less than (< 0.05). Then the calculated t values were (1.687, 3.442, 2.672, 3.677, 4.121, 3.691, 3.988, 4.292 and 4.519) at significance level (0.003,0.026;0:031;;011;002;,035;.034 [,019;,006] respectively which indicates that our results statistical is significant since it was under (<:.05). This variable was a contribution rate of (88.736%). Accordingly, the predictive equation is:

Long High Serve = 20.235 + (0.615 × Elbow Angle of the Striking Arm) − (0.348 × Trunk Inclination Angle at the Moment of Shuttlecock Hit) − (0.159 × Knee Joint Angle of the Supporting Leg at the Moment of Shuttlecock Hit) − (0.624 × Shoulder Joint Angle at the Moment of Shuttlecock Hit) − (0.528 × Angular Velocity of the Striking Arm) − (0.348 × Angular Velocity of the Trunk) − (0.297 × Shuttlecock Release Speed) − (0.728 × Shuttlecock Release Angle) − (0.688 × Height of the Shuttlecock Hitting Point).

Discussion

As shown in Table (2), stepwise regression led to inclusion and ranking of all biomechanical variables without discarding any. The contribution percentage of all the variables in relation to long high serve skill in badminton was statistically significant. Nine of these predictive equations also yielded significant values, which the researcher says can be relied upon. All biomechanical variables are the major and important role for all of type in enhance skill performance on long high serve, badminton. The findings that were reached in the research are compatible with what has been stated by Habib Ali Dhaher(2004), citing Wajih Mahjoub (1989) when he said: "The angular velocity of the trunk work at the stage of retracting it backward and then hitting the ball where the movement of the trunk works as a stretched bow from which energy resulting from pushing against the earth is stored, to be converted later into kinetic energy transferred to strike it. This process is also supported by mechanical power which is determined according to an equation that requires the time of elevation and the player's mass besides the vertical ground reaction force applied on the center of gravity" (Al-Husseini, 2004, p. 49).

These results are consistent with Talha Hossam El-Din (1993), who pointed out that "angular velocity is an angular motion of each body segment and it has a significant impact on most skills. The trunk is the largest of body segments, and it is the main player in movements of the body while performing a skill or even ordinary movements (Hossam El-Din, 1993 p. 95). These findings are also consistent with the work of Steven M., Monika Serrano, and Mike Elzinga (2008) that "the movement of the body's center of mass, the back, and angular motion of the trunk are among these parts most directly related to dynamic activity associated with forward thrusting motion delivery" (Steven, Monika & Mike, 2008: pp. 114–124).

In addition, he thinks that the arm is considered an integral part to aim in right way of shuttlecock toward opponent's court. As the rotator, the arm is controlled by angular velocity, which directly correlates to power at the impact with shuttlecock. For the same manner, Daniya Riyadh (2004) shows that "Angular velocity is first related to trunk rotational inertia and second muscular torque acting on it. The higher the rotation radius, the smaller the velocity becomes (force + resistance to rotational movement). This mechanical advantage can then be used to create a large linear velocity of the limb farthest from the body (the arm and shoulder during the point of strike) which makes for a high-speed ball when released" (Hamed Al-Najm, 2004, p. 90).

Another argument used by the researcher is that the degree of knee joint angle (the supporting leg) at first contact with a shuttlecock also has great influence in the serve skill. The degree of bending at the knee, which indicates the phase of movement to be taken by the player in order to execute a serve skill will move using flexion and extension movements that can be used as an event preparatory stage for striking. This enables the player to have the appropriate body orientation when hitting the shuttlecock during a long high serve. This clarify what Laith Jabbar (2005) has said that "reason of flexion knee joint in the service strike is to take the greatest speed degree rackets at first and body-moving performance beslissing. One such mechanism is achieved through the flexions in the movement of body joints leading to performance (through the application in knee joints). These flexions are the force action generated by the server due to body pressure over the support point, creating an opposite reaction force in an upward direction" (Al-Mousawi, 2005, p. 40).

The release angle of the shuttlecock, the speed of the shuttlecock and the height at which it is hit all have a significant effect on skill performance of long high serve in badminton according to another researcher. This finding is in agreement with Qasim Hassan et al. (1991) who said that "the distance achievable in throwing events depending on achievement of the release angle and height of the release point" (p. 201). It also agrees with what Habib Ali Dhaher (2004) indicated

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"the trunk angular velocity contributes by (0.903) on the launch of the ball, and this rate increased to when mechanical power added for this is considered where became (0.999)" (Al-Husseini, 2004:49).

Moreover, the findings are in accordance with that mentioned by Zeina Arkan (2018), who mentioned "The magnitude force is time-dependent during support moments; thus, it is essential to produce a considerable amount of instantaneous force within the least possible period if they significantly contribute to accelerating after ground contact. "The higher the force exerted over minimal time and at high speed, the more the efficiency of neuromuscular responsiveness reflected in producing recommended movement speed" (Hameed, 2018, p. 71).

On the angle of inclination from the trunk at the moment it strikes the shuttlecock, according to this researcher, it must be almost straight, without large deviations since without achieving a straight service it does not strike correctly. It corresponds to the extension of the imaginary line of the trunk concerning the soil. The performer should not lean too far as they are performing in both directions — balance is key. This ensures that the trunk angle does not deviate too much from either a vertical or horizontal axis, which would lower striking accuracy of the shuttlecock. This corresponds to what was confirmed by Mohammed Diaa (2006), on the authority of Abdul Ali Naseef and others (1990),"the technique of this angle must be in a straight line without lateral inclination, because if you adopt more leaning, it leads to loss of balance during the performance of movement. The player should not lean too much forward, backward or sideways instead stay in the middle area between two feet" (Al-Khazaei, 2006, p. 57).

Conclusions:

Thru presenting and discussing the results, the researcher arrived at (9) predictive equations with significant values that can be relied upon in the relationship between biomechanical variables and the skill performance of the high long serve in badminton, as follows:

Model (1): High long serve = 9.123 + (0.542 × Angle of the hitting arm elbow).

Model (2): The high long serve = 13.567 + (0.280 × angle of the hitting arm elbow) – (0.599 × angle of the torso tilt at the moment of hitting the shuttlecock).

Model (3): The high long serve = 13.439 + (0.849 × angle of the hitting arm elbow) – (0.131 × angle of the torso tilt at the moment of hitting the shuttlecock) – (0.738 × angle of the knee joint supporting at the moment of hitting the shuttlecock).

Model (4): The high long serve = 14.526 + (0.722 × angle of the striking arm elbow) – (0.022 × angle of the trunk tilt at the moment of hitting the shuttlecock) – (0.609 × angle of the knee joint at the moment of hitting the shuttlecock) – (0.517 × angle of the shoulder joint at the moment of hitting the shuttlecock).

Model (5): The long high serve = 15.223 + (0.571 × angle of the hitting arm elbow) – (0.691 × angle of the torso tilt at the moment of hitting the shuttlecock) – (0.278 × angle of the knee joint at the moment of hitting the shuttlecock) – (0.612 × angle of the shoulder joint at the moment of hitting the shuttlecock) – (0.715 × angular velocity of the hitting arm).

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Model (6): The high long serve = 16.471 + (0.522 × angle of the hitting arm elbow) – (0.492 × angle of the torso tilt at the moment of hitting the shuttlecock) – (0.712 × angle of the knee joint at the moment of hitting the shuttlecock) – (0.364 × angle of the shoulder joint at the moment of hitting the shuttlecock) – (0.331 × angular velocity of the hitting arm) – (0.348 × angular velocity of the torso).
Model (7): High long serve = 17.261 + (0.678 × Angle of the elbow of the striking arm) – (0.348 × Angle of the trunk tilt at the moment of hitting the shuttlecock) – (0.164 × Angle of the knee joint at the moment of hitting the shuttlecock) – (0.912 × Angle of the shoulder joint at the moment of hitting the shuttlecock) – (0.677 × Angular velocity of the striking arm) – (0.542 × Angular velocity of the trunk) – (0.564 × Velocity of the shuttlecock launch).
Model (8): High long serve = 18.205 + (0.461 × Angle of the hitting arm elbow) – (0.816 × Angle of the trunk tilt at the moment of hitting the shuttle) – (0.347 × Angle of the knee joint at the moment of hitting the shuttle) – (0.268 × Angle of the shoulder joint at the moment of hitting the shuttle) – (0.951 × Angular velocity of the hitting arm) – (0.248 × Angular velocity of the trunk) – (0.269 × Velocity of the shuttle release) – (0.367 × Angle of the shuttle release).
Model (9): High Long Serve = 20.235 + (0.615 × Angle of the Hitting Arm Elbow) – (0.348 × Angle of the Trunk Tilt at the Moment of Hitting the Shuttlecock) – (0.159 × Angle of the Knee Joint at the Moment of Hitting the Shuttlecock) – (0.624 × Angle of the Shoulder Joint at the Moment of Hitting the Shuttlecock) – (0.528 × Angular Velocity of the Hitting Arm) – (0.348 × Angular Velocity of the Trunk) – (0.297 × Speed of the Shuttlecock Launch) – (0.728 × Angle of the Shuttlecock Launch) – (0.688 × Height of the Shuttlecock Hit Point).

Recommendations

1. The necessity of relying on the biomechanical variables of badminton players. The necessity of relying on the biomechanical variables of badminton players.
2. The necessity of conducting further studies related to other skills in badminton that were not addressed in the current study, in light of the biomechanical variables. The necessity of conducting further studies related to other badminton skills that were not addressed in the current study, with reference to biomechanical variables.
3. The necessity of conducting similar studies on the study variables and at different levels for both genders. The necessity of conducting similar studies on the study variables and at different levels for both genders.

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