Analysis Of Some Biomechanical Variables To Predict The Accuracy Of Shooting Fixed Balls In Female Football Players

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ARTICLE INFO	ABSTRACT
	The research aims to identify the values of some biomechanical variables and their relationship to the accuracy of shooting from fixed balls outside the penalty area among female soccer players, and to find predictive equations for them. The descriptive approach was used for correlational relationships. The sample included (10) female soccer players from the state of Batna in Algeria. The results showed that the independent mechanical (kinematic and kinetic) variables (kinetic energy, linear momentum of the ball, variables of the speed and angle of launch of the ball, the circumferential speed of the kicker's foot, and the height of the body's center of gravity at the moment of kicking the ball) was suitable for predicting shooting accuracy. The researchers recommend using the research results in the selection and technical training process for this basic skill, in addition to the necessity of adopting predictive studies in the mechanical field in training, similar to other fields. **Keywords:** analysis, biomechanical variables, prediction, accuracy of shooting, Football.

Introduction:

Biomechanics is the foundation for analyzing the kinematics of skilled movements and parts of skill in various sports and competitions to improve performance and achieve the required technical performance. Almadhkhori (2019) stated that "Biomechanics is the science that investigates the mechanical values of sports performance from the aspects of movement, form, and mechanical variables that cause it. Understanding biomechanics is a necessity for training, and it is the first mission of science. Therefore, it is an essential basis for sports training. Training that includes exercises built on mechanical values similar to the stages of performance contributes to the success of motor skills, which is one of the most important indicators of success. And from (Almadhkhori Hikmat and Ratko Pavlovic, Skrypchenko I, Bouchareb Rafahiya, R. Ram Mohan Singh , 2021) it is the first task of science, as it is understanding the movements of athletes; Therefore, it is an indispensable rule in sports training, as exercises that include exercises based on foundations contribute to mechanical values that are similar in nature to the stages of performance, which is one of the important indicators of the success of motor skills.And from (Sugumar CA 2014) Biomechanical Knowledge is a "Must" for Coaching, and all movements of men and animals are determined by the laws of mechanics. It is the first task of science is to understand the movements of athletes; therefore it is an indispensable base for coaching. In the throwing events, the factors influencing the performance are governed by the physical laws of the flight phases of the implement and the biomechanical laws of the movement of the system, putter, and implement' before release ,This was pointed out by (Jabir Bariqah and Kheiria Al-Sukkari ,2010) that "It is necessary to design special exercises according to the movement model used in the competition from several aspects, such as body posture, range of motion, dominant muscle contractions, as well as the dynamic structure and temporal path of forces during performance.And from (Lanka, 2000) pointed out that performing some skills requires determining an appropriate starting angle to achieve the goal"(Baumgartner ,1995) also indicates that "the player's balance, proper motor coordination of body segments, and smooth muscle work at ideal angles have a fundamental role in the success of the mechanics of accurate scoring."

Predictive studies are one of the forms of selection process in sports training, especially for age groups, including female football players. In the preparation period, where factors intermingle into a shape that makes it difficult to find a model, the subject of prediction is one of the basics of the selection process that must rely on pure scientific means to ensure the success of the training process. Prediction is one of the most basic and essential methods of selection. It is a scientifically proven method that is based on measures subject to specific analyses and evaluations. It is a future expectation of what may happen to a change in a phenomenon or behavior, and here lies the importance of research in providing coaches and the scientific community with the most important predictive equations for some biomechanical variables and their relationship to the accuracy of constant scoring. This should be emphasized when developing training programs that are realistic for young female football players. By using these equations, coaches can design training programs that focus on improving the specific biomechanical variables that have the greatest impact on scoring accuracy, thus leading to better overall performance on the field. Furthermore, understanding these relationships can also aid in injury prevention by identifying specific areas of the body that may be more prone to injury based on their biomechanical properties. In conclusion, the integration of biomechanical analysis and predictive modeling can greatly benefit the development of training programs for young female football players and ultimately lead to improved performance and a reduced risk of injury.

The research problem:
Given the development of football skills in recent years, it has become increasingly difficult to predict match outcomes due to the convergence of the overall level between teams. It is necessary to take advantage of the possession of the ball to achieve the desired result, especially when the team has a set-piece free-kick outside the penalty area, which often occurs in every match. Here, the technique of executing this main scoring skill comes into play, which requires high concentration and accuracy when executing to achieve a goal that may lead the team to a winning situation. Therefore, there was a need to search for scientific methods through which predictive equations can be found based on biomechanical variables related to player performance when executing this set-piece free-kick and their relationship to scoring accuracy. The research problem is highlighted by answering the following questions:
1- What are the correlational relationships between some biomechanical variables and the accuracy of set-piece free-kick scoring?
2- Is it possible to find predictive equations for scoring according to the biomechanical variables of young female football players?

Research objectives:
1- To identify the values of some biomechanical variables through multidimensional imaging and their relationship to the accuracy of set-piece free-kick scoring among the research sample.
2- To find predictive equations indicating the relationship between some biomechanical variables and the accuracy of set-piece free-kick scoring from outside the penalty area among the research sample.

Research assumptions:
1- There is a significant correlation between the values of some biomechanical variables through multidimensional imaging and their relationship to the accuracy of set-piece free-kick scoring among female football players in the research sample.
2- Predicting the accuracy of set-piece free-kick scoring from outside the penalty area is possible by using predictive equations that relate to some biomechanical variables among the research sample.

Research Methodology, Research Community, and Sample:
The researchers adopted a descriptive approach with a correlational study design to suit the nature of the problem. The research community consisted of female football players from Batna province in Algeria, totaling ten players for the sports season 2022 -2023. To ensure the homogeneity of the sample, the researchers used the coefficient of variation in the research results for growth rates, which include height, player mass, chronological age, and training age. As shown in Table (1), the coefficient of variation for the research sample in the total height variable was (-0.113%), while for body mass it was (0.789%), for chronological age it was (0.429%), and for training age it was (0.798%). Therefore, all the coefficient of variation values were confined to (+1 and -1), indicating the homogeneity of the sample in the mentioned variables above.

Table(1) Shows the homogeneity of the sample

skewness coefficient	standard deviation	median	mean	units	Variables	ت
0.113-	2.647	166.500	166.400	cm	**Total Height**	1
0.786	3.054	55.000	55.800	kg	**body weight**	2
0.429	0.699	18.500	18.600	years	**chronal age**	3

0.798	0.752	2.500	2.700	**years**	**training age**	**4**

A video camera (Casio Exilim) with a frequency of 120 frames per second was used to extract the values of the biomechanical variables under study. The following physical measurements were taken:
- Body mass, measured in kilograms.
- Height, measured in centimeters.

The accuracy of fixed shooting was measured using the Hikmat Abdul Karim and Abbas Sa'adoon 2021 test by the penalty kick taker. The purpose of the test was to measure the accuracy of fixed shooting by the penalty taker in the presence of a wall.
Tools used in the test included a measuring tape, five colored string squares to determine four top squares inside the goal measuring 50 cm x 50 cm, and a rectangular shape measuring 1 x 1.44 cm at the bottom of the squares. Footballs were used along with a wall consisting of five inflatable player figures.
The test was performed as follows: The experimenter stands on the starting line, which is 3-2 meters away from the center of the designated shooting area, and the edge of the area is one meter away from the penalty box. When the experimenter hears the whistle, the player shoots to the left side of the goal when the shooting area is on the right side, and shoots to the right side of the goal when the shooting area is on the left side. Shooting alternates on the goal to hit the larger squares with greater accuracy, as shown in the figure below.
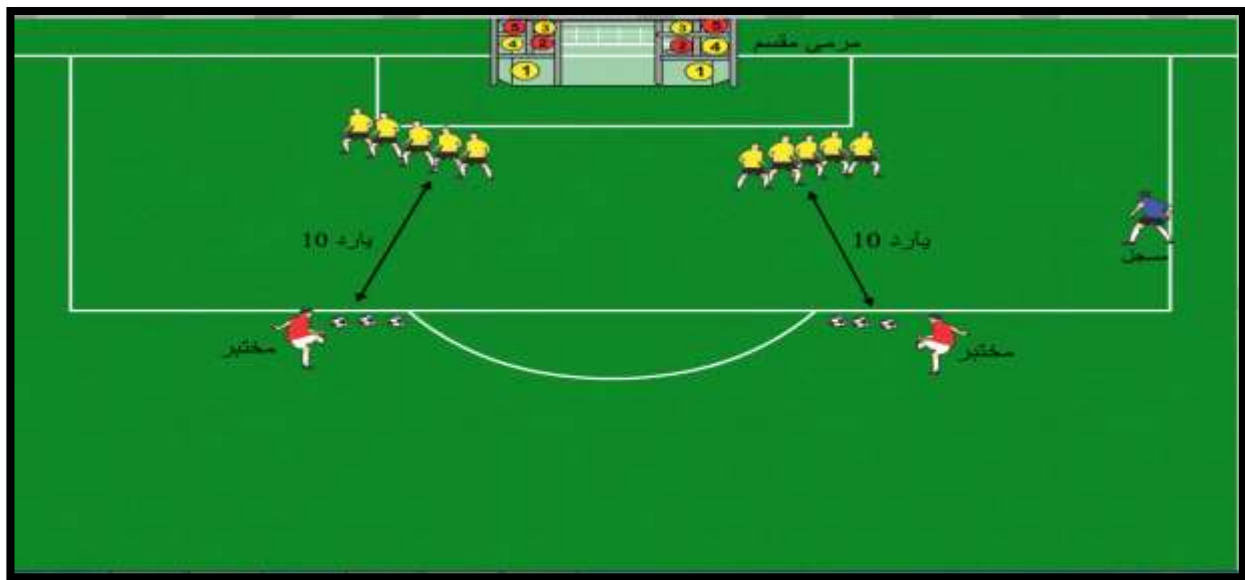

Figure (1)

This segment describes the test conducted by Dr. Hikmat Abdul Karim and Abbas Saadoon to measure the accuracy of constant penalty shooting from the penalty arc.

Test specifications:
● Assign a score to each square based on the ball's distance and difficulty for the goalkeeper.
● Determine the scoring areas from the penalty arc with a distance of 1m on each side.
● Set a threshold for the required shooting speed.
● Shoot from the right side of the arc to the left side of the goalkeeper.
● Shoot from the left side of the arc to the right side of the goalkeeper.
● Each player has six attempts on each side.
● The best three attempts are calculated for each player on each side.

Scoring:
The evaluation scores for shooting attempts are calculated as follows:
● 5 points if the ball enters the square above the target from both sides.
● 4 points if the ball enters the square below the above-mentioned square.
● 3 points if the ball enters the adjacent square.
● 2 points if the ball enters the square below the adjacent square.
● 1 point if the ball enters the goal below the squares mentioned above.
● 0 points if the ball is outside the designated areas in the goal.

The main experiment was conducted on April 17, 2022 AD, corresponding to Sunday, at exactly ten in the morning. The Casio camera was placed vertically from the side at a frequency of (120) images/second, which is very suitable for extracting the values of the selected variables. The focal height of the camera was (1 m) above the ground and vertically (9.36 m) away from the field of movement. This is in order to cover the player's performance during shooting, and this machine was used to obtain the values of the biomechanical variables (under study), which are a mixture of some kinematic variables and some kinetic variables affecting this skill, noting that all variables were taken from one angle in this study for the purpose of taking Arithmetic mean values under the same shooting conditions.

Biomechanical variables (under study) and their measurement method:
The researchers relied on the most important biomechanical variables affecting the performance of the fixed scoring skill from the side of the penalty arc, which are (kinetic energy, linear momentum, ball launch angle, ball launch speed, circumferential speed of the foot kicking the ball at the moment of kicking the ball, height of the body's center of gravity at the moment of kicking the ball). All these values were extracted through the Kenova program.
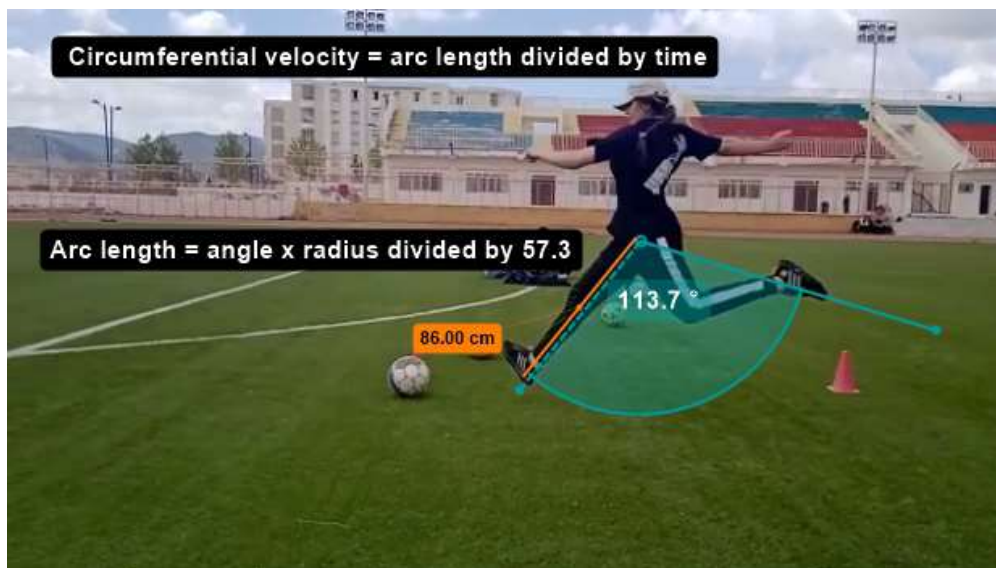

Figure (2)

1- The kinetic energy of the ball after its launch is the product of half of its mass multiplied by the square of its launch speed.
2- The launch angle of the ball is the angle between the line connecting the center of mass of the ball before its flight and its position in the first to fifth frames (depending on the camera speed) of its flight with the horizontal line passing through the center of mass of the ball before its launch.
3- The launch speed of the ball is the resulting speed measured by calculating the horizontal displacement from the moment the ball is kicked in the two closest images in time to the phase.

Launch speed of the ball =
$$\frac{horizontal\ displacement\ from\ the\ moment\ the\ ball\ is\ kicked\ in\ the\ two\ closest\ images}{phase\ time}$$

3- The circumferential speed of the kicking foot of the ball at the moment of kicking is the angular speed of the kicking foot of the ball divided by the sector of the circle (57.3) multiplied by the length of the leg (half the radius).
Circumferential Speed:
$$\frac{(kicking\ speed\ for\ the\ foot\ of\ the\ player's\ angular\ speed)}{sector} \times half\ of\ the\ radius\ (length\ of\ the\ leg)$$

4- Hip joint height at the moment of kicking the ball is the vertical distance between the hip point (center of mass of the body) and the pivot point measured vertically in centimeters in the first contact image of the kicking foot of the ball with the ball. The raw data for linear distances, dimensions, heights, and angles were extracted using the X-Kinovea software, which is one of the applications of motion analysis software.

Results presentation, analysis, and discussion:

In order to obtain predictive values for the accuracy of shooting by young female soccer players from the penalty arc, based on some biomechanical variables, researchers used the simple regression equation through which it is possible to predict "prediction is one of the most important purposes of regression analysis, meaning estimating (or predicting) the value of one variable if the value of another variable is known" (Muhammad Jassim & Abdul-Majeed-2021).

Results of the predictive value of the accuracy of shooting by young female soccer players based on some biomechanical variables:

Table(2) The descriptive statistics show the accuracy of the fixed scoring and some biomechanical variables:

variation coefficient	standard error	standard deviation	median	Mean	units	variables
- 0.772	0.43	1.35	22.000	21.600	**degree**	Fixed shooting accuracy
0.270	0.55	1.75	71.100	71.180	**joules**	Kinetic energy
0.339	0.095	0.30	7.0950	7.169	kg·m/s	Linear momentum of the ball
-1.138	0.152	0.482	15.000	14.890	**degree**	Launch angle
1.059	0.423	1.337	27.000	27.300	**m/s**	Launch velocity
-0.434	0.213	0.675	23.000	23.300	**m/s**	Circumferential velocity of the kicking foot of the ball
0.349	0.702	2.221	62.650	62.680	**cm**	Center of gravity height at the moment of kicking the ball

Table (3) Shows the multiple correlation coefficients, contribution percentages, and standard errors of estimation between fixed shooting accuracy and some biomechanical variables.

standard error	contribution percentage	multiple correlation coefficient	Model
0.294	0.984	0.992	1

Based on our observation of Table (2), it is clear that the multiple correlation coefficient value is 0.992 with a contribution percentage of 0.984 and a standard error rate of 0.294. In order to identify the regression coefficient of some independent variables (biomechanical) contributing to predicting the fixed shooting accuracy as a dependent variable, the researchers used an analysis of variance test. Table (3) shows this.

Table(4) Shows the analysis of variance for the multiple regression to examine the quality of fit of the multiple linear regression model for fixed shooting accuracy and some biomechanical variables.

error rate	F	mean square	degree of freedom	sum of squares	Model	
0.009	30.920	2.690	6	16.140	**regression**	**digital level**
		0.087	3	0.260	**Remainder**	
			9	16.400	**Sum**	

According to table (3), it is clear that the independent variables are suitable for predicting the fixed shooting accuracy of female soccer players with a significant value of (F) of 30.920 and a standard error of 0.009. In order to obtain the multiple regression equation, the researchers used the (T) test, and table (4) shows that.

Table(5) Shows the values of the intercept and slope (effect) between the fixed shooting accuracy and some biomechanical variables, along with their standard errors, level of true significance, and significance of differences.

Significance	Sig	T	Unstandardized Coefficients	Model

			standard error	B		
significant	0.499	-0.768	11.470	- 8.805	**(Constant)**	**1**
insignificant	0.192	- 1.678	0.353	- 0.592	**Kinetic Energy**	
insignificant	0.919	- 0.111	3.277	- 0.362	Linear momentum of the ball	
significant	0.025	4.175	0.593	2.477	**Launch angle**	
insignificant	0.819	0.250	0.351	0.087	**Launch speed**	**shooting accuracy**
insignificant	0.706	0.415	0.634	0.263	Circumferential speed of the kicking foot for the ball	
insignificant	0.136	2.023	0.235	0.475	Center of gravity height at the moment of kicking the ball.	

From table (4), it is evident that the variable "launch angle" is the first contributing independent variable, "kinetic energy" is the second contributing independent variable, "height of the center of gravity of the body at the moment of kicking the ball" is the third contributing independent variable, "linear momentum of the ball" is the fourth contributing independent variable, "peripheral speed of the kicking foot of the ball" is the fifth contributing independent variable, and "launch speed" is the sixth contributing independent variable. Therefore, the predictive regression equation for constant scoring accuracy based on the influential (biomechanical) estimates can be derived using the multiple regression equation as follows:

Predicted value of scoring accuracy = 8.805 - (0.592 × mean kinetic energy) - (0.362 × mean linear momentum) - (2.477 × mean launch angle) + (0.087 × mean launch speed) + (0.263 × mean peripheral speed) + (0.475 × mean height of the center of gravity).

Discussion:

The passage discusses the variables that can predict the accuracy of penalty kicks in young female soccer players. The researchers found that the independent variable, which is the kinetic energy of the ball after being kicked, is a good predictor of the dependent variable, which is the accuracy of the penalty kick. They attribute this to the players' good skill performance in executing direct free kicks, as this requires power to deliver the ball to the goal while maintaining its speed and accuracy.

The researchers believe that the importance of this variable lies in generating the necessary power to deliver the ball to the goal, and good performance requires the player to execute the kick quickly. This speed is due to the kicking leg's backward swing, followed by extension towards the ball, which increases the speed and kinetic energy of the ball. The law of kinetic energy depends on the body's mass (the ball) multiplied by the square of the body's speed, with the ball's mass remaining constant, generating the appropriate force to kick the ball accurately.

The passage also highlights another variable that can predict the accuracy of penalty kicks, which is the angular momentum of the kicking leg when it touches the ball. The researchers attribute this to the fact that the movement of kicking the ball is a series of rotational movements of body parts during the kick, with the goal of producing the necessary kinetic energy of the body parts and, therefore, the ball. The passage also mentions that the accuracy of the kick largely depends on the area of contact between the foot and the ball, as increasing this area leads to greater accuracy.

From the results, it is also apparent that the variable "ball launch angle" contributes to predicting the accuracy of scoring from the penalty arc. Researchers attribute this to the fact that the ball launch angle determines the accuracy, direction, and trajectory of the ball. Therefore, it requires the ability to perceive the distance and direction of the player's movement when approaching in order to maintain the launch angle accurately, providing high accuracy and away from the wall and within reach of the goalkeeper. The ball launch angle is one of the mechanical factors affecting the achievement of distance and the horizontal range of the ball's trajectory during the flight arc, giving it importance in scoring accuracy as mentioned by (Talha Husam, 1993). If the nature of the skill requires the necessity of the thrown body (tool) reaching the target quickly to reach its target quickly, as in passing or rapid shooting, researchers see that the launch angle has a significant relationship with the ball kicking technique by touching the player's foot to the ball during execution. This agrees with the principle of (Mackenzie), where the player's foot touching the ball determines the angle in which the ball will exit towards the goal, as well as the strength of the kicker's leg towards the target area (hitting the target), which gives the player the ability to control and act correctly during kicking the ball in the specified position to launch it in the correct direction. The ball launch angle plays an active and direct role in drawing the trajectory of the flight arc which is represented in achieving the goal (mechanically) during the accuracy scoring skill, in terms of the correct application of the directed force through the ball kicking process. Therefore,

this angle is directly related to the ankle angle of the kicking leg, in addition to the magnitude and direction of the driving force of the leg. If this force is directed towards the center of the ball, a linear motion occurs. However, if it is directed outside the center of the ball, a rotational and linear motion occur together. Thus, it is clear that the value of this angle affects the accuracy of the kick, as it is one of the mechanical factors affecting the horizontal range that the ball's trajectory line covers.

It becomes clear to us that the independent variable (the speed of the ball's launch) is suitable for predicting the measure of accuracy (the accuracy of shooting from the penalty area) for young female football players. The researchers attribute this to the fact that the speed of the ball's launch depends on other mechanical variables that have an active role in achieving efficiency and a good rate for this speed. The research sample utilized kinematic variables with high compatibility and fluidity, which made the values of the speed of the ball's launch high. This is in line with what Talha Hussam al-Din pointed out, "the interplay of both accuracy and speed elements is necessary to ensure the achievement of the goal. Therefore, it is necessary to utilize the movements of body parts, with all their positions, movement rates, rhythm, and synchronization, so that these movements achieve the best results." It is worth noting that the speed element is of great importance, as a suitable amount of speed must be available to deliver the ball quickly to the most challenging areas for the goalkeeper. This requires a suitable amount of strength that enables the player to control the kicking leg and determine the path without any errors in the joints of the kicking leg. This leads to a stable performance, in addition to the availability of the strength element, which is the important factor in this according to Newton's second law, where acceleration is directly proportional to the force produced by the movement, and its direction is in the direction of the movement. This means that to direct the ball accurately towards the goal, a good amount of force must be available. (Hikmat Amadhkhori, 2019)

It is evident to us that the independent variable (the circumferential velocity of the kicking foot at the moment of contact with the ball) is suitable for predicting the measurement (the constant shooting accuracy from the penalty arc) for young female soccer players. The researchers attribute this to the fact that the research sample greatly benefited from the mechanical principles during the performance of the shooting skill, which helped them achieve the goal of this skill to the fullest extent. In this part of the skill, the player is required to move the body parts that revolve around the axis of rotation as far as possible, that is, to extend the kicking leg fully and without bending at its joints, in order to fully benefit from the effect of the principle of elongating the half radius of rotation, so that the circumferential velocity of the kicking foot increases, which helps to increase the kicking speed. Therefore, it can be said that the kicking movement of the leg should be very fast, as it determines the speed of the ball. This is what Adi Jasib Hassan agrees, citing Asami and Nolte, that there is a high correlation between the speed of the ball and the speed of the foot, and the latter is an important factor in the mechanics of the interaction between the ball and the kicking foot.

The researchers believe that the values of the angular velocity of the leg have affected the value of the circumferential velocity of the kicking foot, and thus an increase in the angular velocity is accompanied by an increase in the circumferential velocity, as "the higher the angular velocity, that is, the better its value, the better the circumferential velocity, that is, its value increases."

It is clear to us that the independent variable (hip height at the moment of kicking the ball) is suitable for predicting the measure (accuracy of shooting towards the penalty arc) for young female football players. The researchers attribute this to the moment when the supporting foot is fixed and the kicking foot is positioned behind the body with the hip and knee joints in an extreme flexion position. Additionally, the trunk rotates backward and to the side. Furthermore, the angle of the hip joint is related to the degree of flexion of the knee joint of the kicking leg at the moment of kicking the ball. The less the flexion of the knee joint of the kicking leg, the greater the dimensions of the thigh of the kicking leg are from the trunk, making the angle of the hip joint more important. This, in turn, increases the angular speed of the kicking leg and thus increases its peripheral speed. This is confirmed by (Rissan Khreibet and Najah Mahdi Shalash, 1992), who state that the kicking foot, during its swing back, reaches the maximum possible muscle tension while being flexed at the knee joint. This maximum muscle tension in the thigh and knee flexion has mechanical benefits to serve the motor task.

The researchers believe that the required angular technique puts the body in a position that allows the player to swing her kicking leg over a wide range of motion before touching the ball. This swing causes the hip to move from right to left and vice versa, thus causing the player to lower her center of gravity by flexing the knee joint of the supporting leg, resulting in contact between the kicking foot and the ball.

Conclusions:

1. The independent variable (kinetic energy of the ball) is suitable for predicting the measure of accuracy of fixed shooting from the penalty arc for young female soccer players.
2. The independent variable (linear momentum of the ball) is suitable for predicting the measure of accuracy of fixed shooting from the penalty arc for young female soccer players.
3. The independent variable (angle of ball launch) is suitable for predicting the measure of accuracy of fixed shooting from the penalty arc for young female soccer players.
4. The independent variable (speed of ball launch) is suitable for predicting the measure of accuracy of fixed shooting from the penalty arc for young female soccer players.

5. The independent variable (height of hip at the moment of ball launch) is suitable for predicting the measure of accuracy of fixed shooting from the penalty arc for young female soccer players.

Recommendations:

1. It is necessary to pay attention to the variables that achieved high contribution percentages by focusing on them during training.
2. It is necessary to take the results of the research into account to benefit from them in the selection process in sports training, especially for age groups.
3. Adopt predictive studies in the mechanical field, following the example of other fields.
4. Coaches and those working in the field of training should be informed of the research results obtained from this sample so that they can develop appropriate training programs accordingly.

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