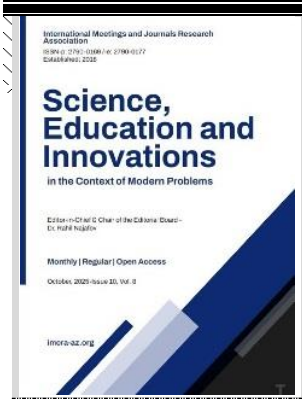

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TITLE OF THE RESEARCH ARTICLE

Analysis of Some Biomechanical Variables of Heading Skill Performance from a Jump and Their Relationship to Accuracy in Football

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Abstract

The study aimed to identify the values of biomechanical variables for the heading skill from a jump among football players, in addition to knowing the relationship between them and the accuracy that characterizes the performance of this skill. We used the descriptive approach with the correlational relationships method due to its suitability to the nature of the study. The research sample included (05) senior category players from the Sidi Ahmed Ben Ali football team, which is active in the first regional division of the Oran Football League for the sports season 2024-2025. In order to determine the values of these variables, we used a test to measure

the accuracy of heading from a jump, where each player performed 05 attempts, and at the same time we conducted video filming while taking the best attempts using a Sony camera at a frequency of 50 frames per second. We also used the Kenovea 8.15 program installed on a Sony computer to extract the values of the biomechanical variables under study, and we relied on the SPSS statistical program to process the data, most importantly the Pearson correlation coefficient. A significant correlation relationship was found between the biomechanical variables under study and the heading accuracy variable from a jump.

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1 .Introduction:

Biomechanics science in the modern era is considered one of the most important sciences that show and clarify the errors and problems that athletes face during performance. Achieving success in various sports activities and events requires correct scientific methods in order to achieve goals and reach the best achievements. The development of sports at the present time has relied on features that control and particularly affect the organization of training (Ammoura, 2019, p. 94). The scientific view of sports activities emphasizes the necessity of having devices and tools to consolidate their performance specifications through detecting errors or developing appropriate training to improve them (Bouchiba, 2019, p. 229). The process of reaching high levels and achieving victory over sports teams depends on many components, including the training process that witnesses continuous development in terms of developing and training skills and diagnosing the requirements and errors that the player falls into (Bouhaj, Baachouch, 2017, p. 142). Football is one of the games that enjoys accuracy and fast performance during play, whether from player movements or the ball, which depends on the number of goals that each team scores in the other team's goal. Therefore, it is necessary to master the heading skill in all its types because it is the essence of the offensive process, as hitting the ball with the head is an important means of scoring goals, whether through distributing balls to the goal area from corner kicks, free kicks, or long balls. This requires high accuracy in delivering the ball to the attacking player in the right place and at the right time (Truffer 2015).

The heading skill is one of the skills that require good elevation to reach the ball, and this is what Ammar and others (2010) pointed to in their study entitled "The effect of a corrective program on some biokinematic variables for hitting the ball with the head from a jump in football." The researchers concluded that there were significant differences in the variables under research; in the stage of maximum flexion of the knee joints, all biokinematic variables were significant and included the hip angle, neck, trunk inclination, knees, and the center of gravity of body mass.

In FIFA statistics during the 2018 World Cup in Russia, it was found that the number of goals scored by header reached 32 goals at a rate of 18.93%, which is an important percentage compared to the 2014 Brazil and 2010 South Africa World Cups, in which 31 goals at a rate of 18.12% and 26 goals at a rate of 17.93% were scored respectively (coupe du monde de la FIFA 20218).

In one of the studies conducted by Kristensen and others (2007), they found that the head moves as a free piece unrestricted by the trunk during hitting the ball with the head from a jump, and that the head affects the ball with the greatest amount of momentum, which increases the speed of the ball after collision.

Adi Jasib (2006) pointed out in his study entitled "Study of the characteristics of the force-time curve and some biomechanical variables for the heading skill from a jump" that the research sample members achieving the required values for the height of the hip joint point and in the required time was due to the takeoff and flight angles being appropriate to what was achieved in terms of extension in the foot, knee, and trunk joints, where clear progress appeared in the values of these angles in a way that serves the skillful performance of heading from a jump. The heading process is very important and is sometimes low, which is considered a scoring opportunity. One of the reasons for low accuracy in heading is a change in the biomechanics of performance, often especially if the opposing team players are present in front of the player who is shooting. Adi Jasib (2015) points out that the

player needs many additional movements and the participation of body parts to succeed in the task of interacting with the ball to deliver it to the appropriate place with the required speed and accuracy (Adi, 2015, p. 176). In Karacha's study (2019) which was entitled "Analysis of some kinematic variables and anthropometric measurements for performing the spike serve skill and their relationship to accuracy in volleyball," the researcher concluded that there is a statistically significant correlation between the values of some kinematic variables for the elevation and flight stage and accuracy in performing the spike serve skill in (maximum hip joint height, maximum height of the contact point with the ball, trunk inclination angle at the moment of spiking). Through the researcher's follow-up of the results of the Sidi Mohamed Ben Ali senior football team, he found there is a fluctuation in the level of heading among the team players, which may be attributed to mechanical errors in skill performance, which negatively affects the accuracy of heading from a jump. This led the researcher to pose the following question

Is there a correlational relationship between biomechanical variables and heading accuracy from a jump in football?

Study Hypothesis:

There is a correlational relationship between biomechanical variables and heading accuracy from a jump in football.

Methods and Tools of the Study

1 .Research Methodology:

Alawi (1999) indicated that the approach is the researcher's attempt to control the situation to be studied, excluding the variable or variables that he believes are the cause of a certain change in that situation (Boukertam and others 2019, p. 224). Therefore, the researcher used the descriptive approach with the correlational relationships method, which is consistent with the nature of the researcher's problem.

2 .Research Field:

The research field is represented by the sports complex of the municipality of Sidi Mohamed Ben Ali, Wilaya of Relizane, where the study was conducted in this sports space designated for training and official competitions.

2-1 -Human Field

The human field consists of players from the Chabab Sidi Mohamed Ben Ali team, senior category, belonging to the first regional division of the Oran Football League during the 2024 sports season.

2-2 -Time Field

The study was implemented during the period from March 10, 2024, to June 15, 2024.

3 .Population and Research Sample:

The goals that the researcher sets for his research and the procedures he uses are what determine the nature of the population or sample that we choose (Risan 1988, p. 41). The study population consisted of the players of Chabab Sidi Ahmed Ben Ali, senior category, belonging to the first regional division of the Oran League, numbering 30 players.

The study sample was selected by the purposive (intentional) method for the best five (5) players who represent the highest level of performance and achievement during the tournament (scoring goals with the head). Table No. 01 shows the extent of homogeneity and equivalence of the sample, and the skewness coefficient was limited between ±1, and therefore the sample is considered to be normally distributed.

Table No. (01) Shows the characteristics of the research sample:

Variables	Unit of Measurement	Arithmetic Mean	Standard Deviation	Skewness Coefficient
Height	Meter	1.80	0.025	-0.196

Variables	Unit of Measurement	Arithmetic Mean	Standard Deviation	Skewness Coefficient
Weight	kg	80.60	1.949	-0.081
Age	Year	23.90	1.431	0.332
Training Age	Year	13.90	0.741	0.552

4 .Biomechanical Research Variables

1. Maximum flexion of the knee joint of the pushing leg
2. Takeoff angle
3. Hip joint height at the moment of hitting the ball
4. Trunk angle at the moment of hitting the ball
5. Head angle at the moment of hitting the ball
6. Ball launch angle after hitting

5 .Research Tools:

Represents the technical performance test for the heading skill from a jump

5-1 Performance Method:

The tested player is asked to run from the first marker toward the second marker, which is 3 meters away from it, where he jumps with one foot at the (6 meters) line opposite the second marker. At the moment of jumping, the player tries to hit the ball with his head and direct it toward the square defined in the lower right side of the goal, which measures (1.21 m × 1.21 m).

The ball is thrown by the throwing player who stands 6 meters away from the second marker and parallel to it, so that the player's movement is timed with the moment the ball is launched.

Each player is allowed five consecutive attempts to record the required performance.

5-2 -Evaluation Method:

The performance evaluation is based on the accuracy of directing the ball toward the target square, according to the following:

- If the ball enters inside the designated square: 3 points are counted.
- If the ball touches the square frame: two points are counted.
- If the ball enters any other part of the goal: one point is counted.
- If the ball goes outside the goal: the attempt is not counted.

5-3 -Scientific Foundations of the Test:

Test Reliability:

Marwan Abdel Majid (2016, p. 205) indicates that the reliability of the test means maintaining its results if it is repeated on the same sample under similar conditions.

To verify the reliability of the current test, it was re-applied to an exploratory sample consisting of five players.

The results showed that the test reliability coefficient (heading accuracy from a jump) reached 0.726, which is considered sufficient to achieve reliability for this type of skill test. Table No. (02) shows the value of the Pearson correlation coefficient between the results of the two performances.

Test Validity:

Test validity means that it actually measures what it was designed to measure (Boudaoud Atallah 2009, p. 105).

The researcher extracted the self-validity of the test from the reliability coefficient by calculating the square root of the reliability coefficient (Ben Naaja, 2018, p. 177).

Self-validity coefficient = √reliability coefficient = 0.85

Table No. (02) Shows the scientific coefficients of the test

	First Application		Second Application				
Skill	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**r (Calculated)**	**Reliability Coefficient**	**Validity Coefficient**
Accuracy	2.20	0.577	2.04	0.675	**0.726	0.726	0.85

6 .Video Filming Procedures:

A video camera was used placed at a distance of 8.15 meters from the skill performance point inside the field, and at a height of 1.7 meters from the ground surface to the camera lens.

The camera was placed on the player's right side at a perpendicular angle to him, with the aim of recording the complete performance and accurately identifying the movement variables during skill execution.

The researcher relied on a scale measurement of (1 meter) to accurately adjust kinetic measurements during the biomechanical analysis process.

Computer Analysis:

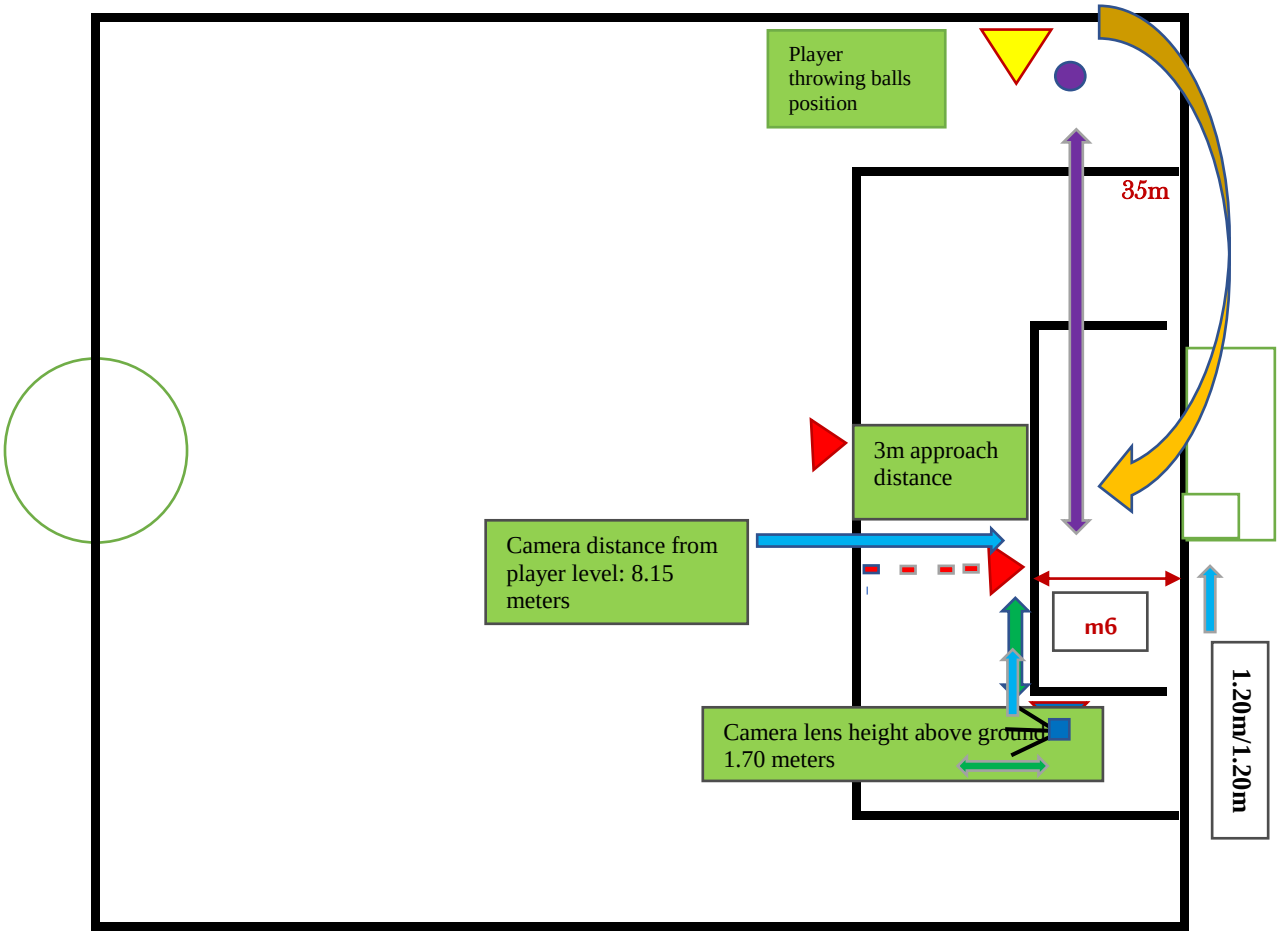
The filmed video was transferred from the Sony camera memory to an SD memory card using a Sony computer, in order to facilitate the analysis steps. After that, the files were transferred to the Kinovea program version 8.15 installed on the computer, which is a specialized program for analyzing sports movements and extracting kinetic indicators related to technical performance.

7 .Statistical Methods Used:

Regarding statistical processing, Abu Allam (2011) pointed out that using an inappropriate statistical method may lead to inaccuracy in testing research hypotheses, and that choosing the correct statistical method depends on a number of factors such as: the method of forming groups and their number, the number of independent variables, the type of data processed, and the nature of the study.

In this study, data were analyzed using the Statistical Package (SPSS) version 24, with the aim of extracting the arithmetic mean, standard deviation, Pearson correlation coefficient, and skewness coefficient.

Figure No. (01) shows the player's position and the camera location during the performance recording process.



III. Results:

Table No. (03) shows the results of the arithmetic means and standard deviations and the relationship between the values of some biomechanical variables for the heading skill from a jump in football with accuracy

Biomechanical Variables	Unit of Measurement	Arithmetic Mean	Standard Deviation	Heading Accuracy		Calculated (r) Value
				M	E	
Knee joint angle at maximum flexion moment of push	Degree	132.72	7.038	2.40	0.707	-0.797**
Takeoff angle	Degree	78.72	7.86			0.568**
Hip joint height at moment of collision with ball	Meter	1.311	0.070			0.490*
Trunk angle at moment of hitting ball with head	Degree	54.96	7.881			-0.475*
Head angle at moment of hitting ball	Degree	31.64	5.83			-0.813**

Biomechanical Variables	Unit of Measurement	Arithmetic Mean	Standard Deviation	Heading Accuracy		Calculated (r) Value
Ball launch angle at moment of hitting with head	Degree	-13.24	7.038			-0.588*

IV. Discussion:

Through Table No. (3), we notice the existence of a correlation relationship between the arithmetic means of some biomechanical variables and the heading accuracy variable. For the purpose of testing the hypothesis that states the existence of a relationship between the values of some biomechanical variables for the heading skill in football and shooting accuracy, the results showed the following:

The arithmetic mean of the knee joint angle variable at maximum flexion at the moment of push for the research sample reached (132.72 degrees), with a standard deviation of (7.038). As for the mean of the heading accuracy variable, it reached (2.40 m/s), with a standard deviation of.(0.707)

As for the correlation coefficient between the two variables, it was estimated at (-0.797), which is greater than the tabular value at the adopted significance level, indicating the existence of a significant inverse correlation relationship between the knee joint angle and heading accuracy.

The reason for this result is attributed to the fact that the explosive power of the pushing leg contributes to raising the player's body to the highest possible level, through bending the knee. Therefore, the flexion must be appropriate and not be large, which would lead to delaying the takeoff and increasing the time period. This is consistent with the study (Karacha, 2019, p. 127) where he concluded that when the knee joint angle is appropriate, it allows the opportunity to push the force to the maximum possible, and thus reach a good and appropriate elevation in order to hit the ball in the best position and at the best timing that helps to hit and direct the ball to the goal with high accuracy and with ideal and integrated performance stages. This stage is characterized by common mechanical characteristics, which is converting the direction of horizontal momentum to semi-vertical through using the maximum possible force components on the ground, which qualifies him to prepare for takeoff and achieve the maximum possible appropriate vertical force values (Adi, 2015, p. 181). The more the player exerts greater force and benefits from the preparatory stage and applies the pushing process to obtain from it a good elevation and reaction, as all of this contributes to performing a good movement to hit the ball with the head and thus achieve the goal of the movement (Ammar Ali and others 2010).

It appears from Table No. (03) that the arithmetic mean of the takeoff angle variable for the research sample reached (78.72) with a standard deviation of (7.86). As for the heading accuracy variable, the arithmetic mean reached (2.40) m/s with a standard deviation of (0.707). As for the correlation coefficient, it was estimated at (0.568), which is greater than the tabular value, indicating the existence of a significant correlation relationship between the two variables. The researcher attributes the reason for this to the fact that the player works to increase the takeoff angle so that the body covers a greater vertical distance to reach the highest possible height, which helps give freedom of movement to the trunk and thus increase its peripheral speed, which leads to the transfer of movement from the trunk to the head and thus the increase in the speed of hitting the ball and the transfer of force from the head to the ball, resulting in good accuracy. This is consistent with the study (Al-Dulaimi and Ghanem, 2009, p. 10) where the takeoff angle plays an effective role in this skill in determining the correct path for the body's center of gravity for after takeoff, i.e., in the flight stage, and this requires optimal investment in the direction of the required path to be achieved through effective extension in the knee joint of the pushing leg before the moment of leaving the ground (Adi, 2015, p. 184).

Through Table No. (03), it is clear that the arithmetic mean of the maximum hip joint height variable at the moment of hitting the ball with the head for the research sample reached (1.311 m), with a standard deviation of (0.070). As for the arithmetic mean of the heading accuracy variable, it reached (2.40 m/s), with a standard deviation of.(0.707)

As for the simple correlation coefficient between the two variables, it was estimated at (0.490*), which is greater than the tabular value at the adopted significance level, indicating the existence of a significant positive correlation relationship between the maximum hip joint height variable and the heading accuracy variable.

The reason for this relationship is attributed to the fact that the research sample members were able to perform the appropriate and suitable height to achieve the goal of this skill, which is to reach the best possible body height during shooting, which helped achieve the highest degrees of accuracy. This is due to the fact that extension in some body joints contributed to raising the hip joint point to the optimal level, which resulted from the force exerted during the takeoff stage that works to achieve complete extension in the pushing leg joints.

Also, directing the path of the body's center of gravity flight properly and exploiting the result of vertical thrust and transferring mechanical energy from the lower part to the upper part of the body in a coordinated manner, all these factors helped achieve this proficient and accurate performance in heading, which is confirmed by the study (Ammar and others, 2010, p. 467).

It is also clear from Table No. (03) that the arithmetic means of the trunk and head angle variables after hitting the ball for the research sample were respectively (54.96), (31.64) with standard deviations of (7.881), (5.83). As for the heading accuracy variable, its arithmetic mean reached (2.40) m/s with a standard deviation of (0.707). As for the correlation coefficient, it was estimated respectively at (-0.475), (-0.813), both of which are greater than the tabular value, indicating the existence of a significant inverse correlation relationship between the heading accuracy variable and the trunk and head angle variables at the moment of hitting the ball with the head.

The reason for the relationship between the variables is attributed to the nature of the motor performance of the heading process, as its rapid execution requires rotating the trunk around the longitudinal axis of the body, and this rotation contributes to increasing the amount of momentum transferred to the head, which leads to increasing the hitting force and thus increasing the ball speed after collision.

This interpretation is consistent with what the study (Adi, 2006, p. 101) concluded, which indicated that the player must increase the trunk and head inclination backward before hitting to increase the inclination angle, then work to reduce this angle at the moment of ball contact, which leads to reducing the performance time and increasing the angular velocity of both the trunk and head, and thus increasing their peripheral speed.

The trunk at this stage also obtains a doubled amount of motion that is partially transferred to the head, which helps change the direction of the ball with high speed and accuracy. This depends largely on the peripheral speed of the head, as the amount of speed that the head loses during shooting is transferred to the ball, which was also confirmed by (Adi, 2015, p. 16).

Through Table No. (3), it is clear that the arithmetic mean of the ball launch angle variable after hitting for the research sample reached (-13.24) with a standard deviation of (5.85). As for the heading accuracy variable, its arithmetic mean reached (2.40) m/s with a standard deviation of (0.707). As for the correlation coefficient between the two variables, it reached (-0.588), which is greater than the tabular value, indicating the existence of a significant inverse correlation relationship between the ball launch angle and heading accuracy after hitting the ball.

The researcher attributes this to the result of similarity in the position of the players during the execution of heading from the jumping position, as the player is asked to direct the hit toward the upper surface of the ball, which makes it launch downward after impact. This direction leads to a negative launch angle considered appropriate to achieve accuracy in heading.

This interpretation is consistent with what the study of Adi (2006, p. 103) concluded, which indicated that hitting from top to bottom contributes to improving shooting accuracy as a result of better control over the ball's path and angular velocity.

V. Conclusion:

In light of the study results and within the limits of the research sample, and after statistical analysis, the researcher concluded that the studied biomechanical variables contributed to achieving an ideal performance level for heading accuracy, whereby the heading accuracy variable had an inverse correlation relationship with the knee angle during the push for the purpose of lowering the body's center of gravity and giving a good push to the body upward. There also appeared a significant correlation relationship between heading accuracy and the takeoff angle variable, and this is due to the amounts of force exerted during the takeoff stage that work to achieve extension in

the pushing leg joints. A significant correlation relationship was found between the heading accuracy variable and the maximum hip joint height variable at the moment of hitting the ball with the head, and this is through optimal exploitation of the results of vertical thrust. A significant inverse correlation relationship was found between the heading accuracy variable and the trunk and head angle variables at the moment of hitting the ball with the head, where the player needs a rapid trunk movement by bending it backward, which gives him a wide motor extension, and this is through exploiting the motor transfer from the trunk to the head and then to the ball so that it heads toward the required place with high power, speed, and accuracy. There was a significant inverse correlation relationship between the heading accuracy variable and the ball flight angle variable after hitting, and this is due to the method of performing the hitting test with the head at the moment of collision with the ball and directing it downward toward the small goal.

We concluded that the biomechanical variables (knee joint angle at its maximum flexion at the moment of push, takeoff angle, flight angle, hip joint height at the moment of collision with the ball, trunk and head angle, and ball launch angle at the moment of hitting with the head) have a correlational relationship with heading accuracy from a jump, and therefore great importance must be given to these biomechanical variables during training because of their role in controlling and directing the ball with high accuracy.

Modern technology tools such as cameras of good quality and high speed should also be relied upon when conducting future studies similar to this topic.

Methodology

A descriptive–correlational research design was adopted to examine biomechanical factors influencing heading accuracy. Five senior male football players executed five jump-heading attempts each toward a defined accuracy target. A Sony digital camera (50 frames per second) recorded movements from a standardized angle and distance. Kinovea 8.15 software was utilized for kinematic analysis, measuring joint angles, body segment alignment, jump elevation, and head-ball contact timing. Data were processed using SPSS v.26, employing mean, standard deviation, and Pearson correlation coefficients to determine relationships between biomechanical variables and accuracy outcomes.

Ethical Considerations

Participants provided informed consent and were briefed on study aims and procedures. Privacy, safety, and data confidentiality were ensured. No invasive protocols were used. The research complied with the Declaration of Helsinki (2013) and institutional ethical policies at Hassiba Benbouali University of Chlef.

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Conflict of Interest

The authors declare no conflict of interest.

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