



The Relationship Between Numerical Values of Some Kinematic Variables Contribution Ratios Using Artificial Neural Networks and Young Javelin Throwers' Performance

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Abstract

The present study aims to demonstrate the importance of using artificial intelligence to identify the most important kinematic variables contributing to the achievement of the javelin throwing competition. This study also aims to improve the quality of performance and assist coaches in the success of the training process, given its positive role in achieving the longest throwing distance. The study aims to identify the most important kinematic variables for young javelin throwers and to identify their numerical values using artificial neural networks. The descriptive correlational relationships approach is employed in order to obtain the objectives of the present study. The research population and sample consist of (8) young javelin throwers participating in the Iraqi Central Clubs Championship. Having conducted video recordings during the tournament, analyzed the data using advanced analytical programs, and processed it using artificial neural networks, the researcher concludes that the use of advanced technology, represented by artificial neural networks, contributes to identifying the most important kinematic variables for javelin throwers. Identifying the contribution ratios of these variables helps coaches save time and effort in the training process. Coaches shall use advanced technology in processing the variables under study, and focusing training on the contribution ratios of the specific kinematic variables.

Keywords: Kinematic Variables, Artificial Neural Networks, Achievement.

Introduction

Despite the multiplicity and abundance of sporting activities, the use of modern technological approaches can provide objective information about performance progress (Mali, 2020). Artificial intelligence occupies an important position in various scientific fields, including sports (Omorieg P, 2016). Artificial intelligence techniques are effective tools for analyzing and determining the importance of variables in various sports (Abu Alia, 2025). Combining artificial intelligence techniques with kinematic analysis enables coaches and athletes to gain deeper insights into improving performance, which contributes to improving results and achieving higher levels. This can be used to predict an athlete's current state and is an indicator of progress and development based on several data that coaches must have (Rahi and Sagheer, 2020).

Biomechanics is one of the primary sciences for evaluating sports movements, working to solve problems related to athletes' motor performance with the goal of achieving optimal performance (Sharma, 2024). Given that all movements, without exception, are subject to the laws of mechanics, studying and analyzing the kinematic variables of throwing events is an essential means of detecting subtle errors and correcting them in light of specific considerations of performance specifications (Knudson, 2021), which contributes to improving performance and achievement and developing training strategies. The use of modern technologies has significantly contributed to resolving the challenges facing those interested in developing athletic performance, particularly in track and field events, through kinematic analysis (Lami and Rahi, 2023).

Javelin throwing is a complex form of movement. Throwers seek to generate the greatest possible acceleration at the moment of throwing through vertical circular and non-circular rotational body motion to achieve the maximum possible distance (Pavlovic and Idrizovic, 2020). Processing variables using traditional methods is inaccurate, and determining the effect of wind on the javelin during the throwing process is almost impossible. Therefore, all javelin throwing models are weak.

Artificial neural networks are an effective information processing technique that allows for the objective construction of an input-output model of a problem. These networks have the ability to generalize, i.e., produce reasonable outputs for inputs not encountered during learning. Neural networks efficiently handle fuzzy, flawed, and imprecise data, thus enabling accurate identification of research variables and their effectiveness in performance (Maier et al., 2000).

An extensive review of previous works reveals that local coaches rely on a set of traditional methods to evaluate javelin throwers' performance. While these methods provide corrections for motor paths, they require accuracy and objectivity, especially in identifying the most important kinematic variables that are closely related to the athletic achievement of throwers, which are the foundation of ideal motor performance. To determine the most important quantitative values for the contribution of these indicators, the present study is an attempt to employ neural networks as a modern artificial intelligence technique (Maszczyk et al., 2011).

These techniques have the ability to process inputs (kinematic variables), rotate them, and test them to obtain the true values of the most important ones, ensuring the ideal motor performance path for young javelin throwers (McGinnis et al., 2019). Hence, employing an artificial intelligence technique is important to overcome some of the obstacles facing researchers and specialists and to benefit from them in correcting the motor paths of throwers (Araújo et al., 2021). Determining the true numerical values of the most important kinematic variables affecting performance and their contribution to the final outcome helps coaches predict the performance of javelin throwers. The present study aims to identify the most important kinematic variables specific to javelin throwing and to identify the numerical values of the contribution ratios of the most important performance kinematic variables using artificial neural networks for young javelin throwers.

Research Methodology

The present study employs the descriptive approach, using survey and correlation techniques, for its suitability for the nature of the present study.

The Research Population and Sample: The research consists of (8) javelin throwers in the Iraqi national team, who compete in the youth javelin throwing event. They also represent the main research sample. The researcher used methods, devices, and tools through which data could be collected to obtain the objectives and come up with the results.

Study Procedures

Identifying the Kinematic Variables of Javelin Throwers The researcher reviewed numerous Arab and foreign sources, dissertations, and theses to select the appropriate kinematic variables for the effectiveness of javelin throwing, which fit the nature of the present study. To ensure the identification of the most important kinematic indicators, the researcher prepared a survey form that was distributed to (9) experts and specialists. The forms were collected, the data were transcribed, and data validity was extracted using the Chi-square test at a significance level of (0.05) and a degree of freedom of (1), noting that the tabular Chi-square value is (3.841). All the proposed variables were verified and accepted as shown in Table (1).

Table (1) The calculated Chi² test values for the kinematic variables in question

Kinematic variables	Measurement Unit	Approvers	%	Disagree	%	Chi ² Test Value		Sig.
						Calculated	tabular	
Javelin speed	Meter Second	9	100	0	0	9	3.84	Sig.
Javelin Release Height	Seven centimeters.	9	100	0	0	9	3.84	Sig.
Pitch Arm Anchor Linear Speed	Meter Second	8	88.89	1	11.12	5.46	3.84	Sig.
Last Step Time	Second	8	88.89	1	11.12	5.46	3.84	Sig.
Last step...	Meter	8	88.89	1	11.12	5.46	3.84	Sig.
Javelin starting angle	Degree	9	100	0	0	9	3.84	Sig.
The inclination angle of the object at the moment of leaning when placing the throw	Degree	9	100	0	0	9	3.84	Sig.

Trunk inclination angle Start of throwing position	Degree	8	88.89	1	11.12	5.46	3.84	Sig.
Knee angle of fixing leg	Degree	9	100	0	0	9	3.84	Sig.
The corner of the two legs at the moment of the last step	Degree	8	88.89	1	11.12	5.46	3.84	Sig.
Performance	Meter	9	100	0	0	9	3.84	Sig.

The tabular Chi-square value is (3.84), at a degree of freedom of (1), and a significance level of (0.05).

Data Processing Using Artificial Neural Networks

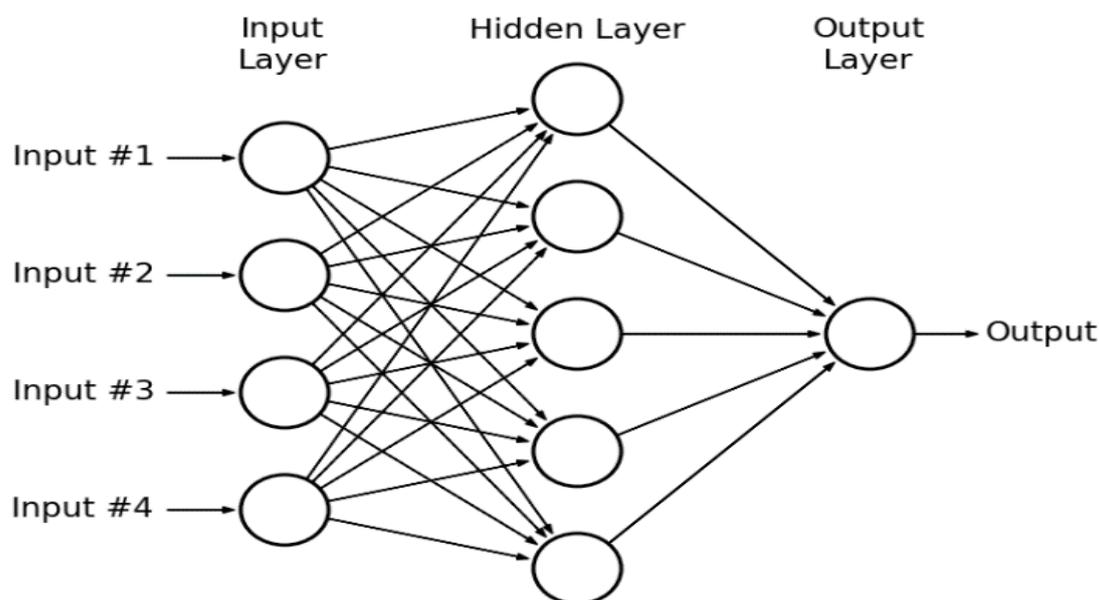
Artificial neural networks (ANNs) are among the most important methods of artificial intelligence. They are defined as an artificial representation of the human brain, attempting to simulate the learning process (Gallo, 2011). They are computational techniques designed to mimic the way the human brain performs a specific task. This is achieved through massive, parallel, distributed processing, composed of simple processing units. These units are computational elements called neurons or nodes, which have a neural property in that they store practical knowledge and experiential information and make it available to the user by adjusting weights (Tronto et al., 2008).

Artificial neural networks (ANNs) are an information processing model inspired by the way biological nervous systems, such as the brain, process information. Artificial neural networks consist of multiple layers of simple processing elements called neurons. A neuron performs two functions, including collecting inputs and generating outputs (Dongare et al., 2012). Neural networks handle fuzzy, flawed, and inaccurate data in an appropriate manner. Therefore, an alternative model can be designed for the desired variable and may offer advantages over existing models.

To process the data for the present study, the Lasso Regression method, a common technique used in statistical modeling and machine learning was employed to estimate relationships between variables and make predictions. LASSO stands for Least Absolute Shrinkage and Selection Operator. It is an introduction to neural networks. It is an important method for obtaining a kinematic model for javelin throwers. Lasso Regression is a common type of regularized linear regression used to reduce data toward center points determined by equations that fit each variable (Sayyid Ali, 2020). It also regularizes linear models. Machine learning techniques, such as artificial neural networks (ANNs) have been used and proven effective in many fields. They are an important method for classifying potential outcomes and an effective tool that helps provide insights to coaches and competitors to achieve integrated performance (Musso et al., 2013). Using modern techniques to detect correlations between the variables under study can lead to logical results, facilitating the learning

process and ensuring high objectivity in assessing performance (Lami and Rahi, 2023).

After identifying the shape of the variables, dividing the sample into groups, and then preparing the layers and completing all network construction requirements, including training, learning, and testing, in addition to the activation functions, the final form is as shown below:



Main experiment and kinematic analysis of throwing attempts the researcher conducted

Main experiment on the research sample. Video recording was conducted during the championship held by the Iraqi Central Athletics Federation in accordance with the International Athletics Laws. This helped the competitors commit to performing to the highest standard, competing for advanced positions, and achieving the highest possible achievements.

In order to control the kinematic variables that affect the javelin throw and obtain reliable data, the researcher relied on modern Japanese Casio cameras with a high frequency speed in the kinematic analysis of the variables of javelin throwers. The speed was set at a frequency of 240 frames per second. To record the study variables, two cameras were placed on both sides of the throwing path and diagonally on the thrower's movement field, 7 meters away from the middle of the throwing path for each of them and at a height of (1.25) meters. The third camera was placed in front of the thrower's path inside the throwing sector and perpendicular to the middle of the throwing path and at the same distance and height. Through video recording, the kinematic data of the throwers were obtained during the performance of the prescribed throws in order to analyze them using analysis programs to come up with calculating the quantitative amount of the research variables using the approved mechanical laws as shown in the following table.

Table (2) Research variables and data for calculating quantitative values of variables

No.	Research variables	Quantitative Parameters
1	Javelin speed	It is the ratio between the starting distance, which represents the starting path (center of gravity) of the javelin from the legacy of the archer's hand until after the abandonment at the time of this departure
2	Javelin Release Height	It is the vertical distance between the height of the break point of the arm contact with the spear and the horizontal plane
3	Pitch Arm Anchor Linear Speed	It is the ratio between the distance traveled by the throwing wrist from the moment of placing the throw to the last point of leaving the spear at the time of this distance
4	Last Step Time	It is the time between the moment of landing of the right foot (anchoring) until the landing and contact of the left foot with the ground(fixation)
5	Last step...	It is the distance between the right foot (abutment foot) and the left foot (fixation foot)
6	Javelin starting angle	It is the angle between the straight line between the grip of the spear before and after the moment of departure and the horizontal line
7	The angle of inclination of the object at the moment of leaning when placing the throw	It is the angle between the vertical line (gravity line) passing through the fulcrum point (right foot) and the line connecting the center of gravity of the body and the fulcrum point at the moment of final push
8	Trunk inclination angle Start of throwing position	It is the angle between the line perpendicular to the ground and the inclination of the bowman's trunk when throwing
9	Knee angle of fixing leg	It is the angle between the thigh and the leg from behind when The shooter took the throwing position
10	The corner of the two legs at the moment of the last step	It is measured directly by computer and represents the angle between the two lines of the thighs that meet the hip
11	Performance	It measures the total distance of the spear from the end line of the approach road to its point of contact with the ground

Statistical Methods

- (SPSS) was used.
- Arithmetic Mean
- Standard deviation
- Simple correlation (Pearson)
- Coefficient of skewness
- (T-Test) for independent samples
- Chi-square test

Results

Table (3) Description of Bio-Kinematic Variables, Performance, and (t) Values to Indicate Levels

Variables	Unit of measure	mean	Deviati on:	Media n	Maxim um	Minimu m	Skewnes s
Javelin speed	m/s	26.2	2.2	26.0	30.0	23.0	0.3
Javelin tee height	Seven centimeters	194	8.0	196.5	210.0	180	-0.1
Linear speed of the hand wrist of the throwing arm	m/s	2.1	0.2	2.1	2.5	1.7	0.2
Last Step Time	Second	0.1	0.0	0.1	0.2	0.1	10
Last Step Length	Meter	200.0	9.5	199	218	185	0.1
Javelin starting angle	Degree	34.0	3.5	33.0	42.0	30.0	0.6
The angle of inclination of the object at the moment of leaning at the final th	Degree	33.1	2.1	33.0	38	29.0	0.2
Trunk inclination angle Start of throwing position	Degree	116.3	2.5	116.5	121	111	-0.2
Knee angle of fixing leg	Degree	125.5	3.6	125.5	133	120	0.2
The corner of the two	Degree	69.2	3.0	69	77	64.0	0.3

legs in the last step							
Performance	Meter	59.1]	11.4	58	66.4	26.2	-0.6

Table (3) shows that the standard deviation values are small relative to their arithmetic mean. It is also noted that the values of the skewness coefficient are within (± 1), confirming the appropriateness of the sample size and its validity as a representative sample of the original population. The candidate tests are characterized by moderation and homogeneity, and can be relied upon to draw reliable and trustworthy results.

Intercorrelation Matrix Between Bio-Kinematic Variables and Performance

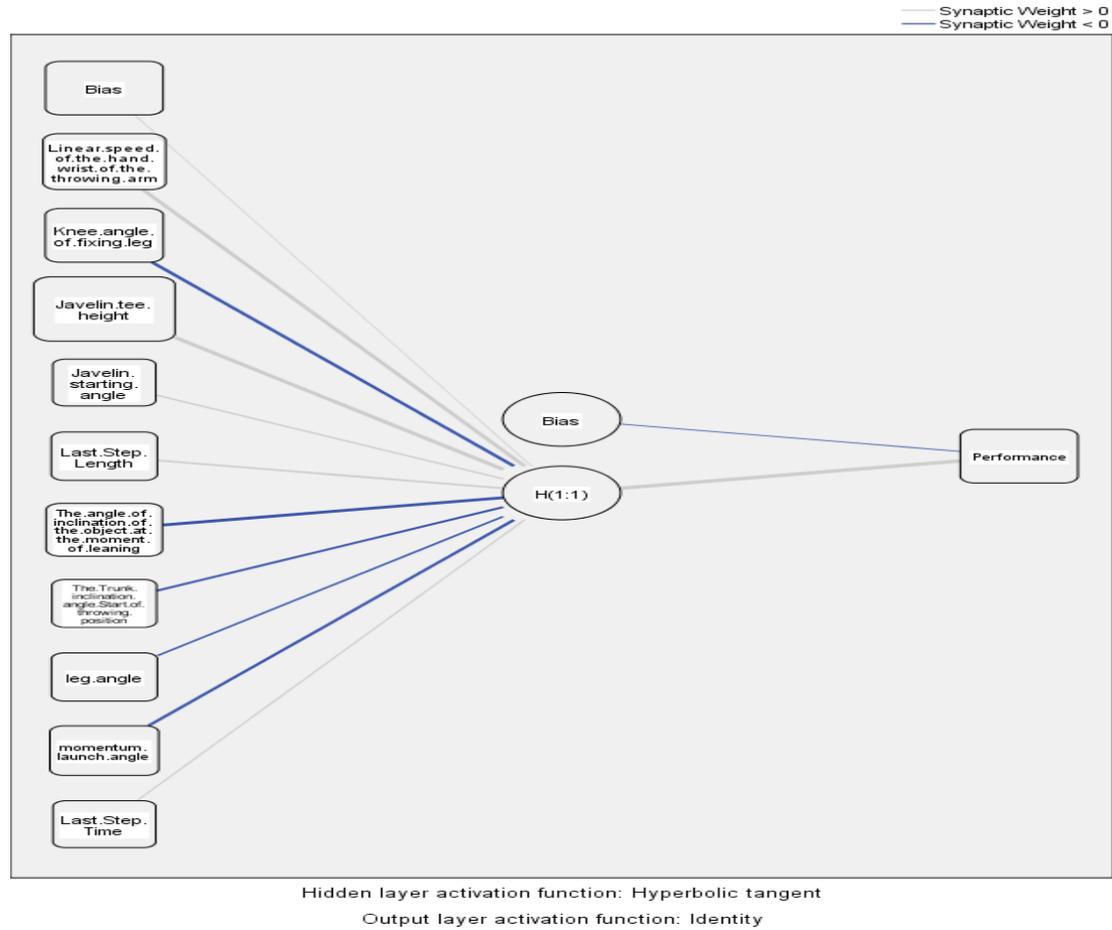
Variables	Javelin release speed	Javelin tee height	Linear speed of hand wrist of throwing arm	Last Step Time	Last Step Length	Javelin starting angle	Angle of inclination of object at moment of leaning at final	Trunk inclination angle Start of throwing position	Knee angle of fixing leg	Corner of two legs in last step	Performance
Javelin release speed	1.000										
Javelin tee height	-.116	1.000									
Linear speed of hand wrist of throwing arm	0.686	141	1.000								
Last Step Time	.388	-192	426.	1.000							
Last Step Length	0.098	-0.166	-0.050	0.109	1.000						
Javelin starting angle	.789	072	.524*	327.	.105	1.000					
Angle of inclination of object at moment of leaning at final	0.056	144	0.146	0.166	.086	-0.020	1.000				
Trunk inclination angle Start of throwing position	—0.021	0.085	-0.061	203	.031	.089	(0.057)	1.000			
Knee angle of fixing leg	- 260.	.215	174	0.183	-.356	220.	0.151	121	1.000		
Corner of two legs in last step	.013	-0.010	0.232	-160	-.364	069	0.161	-0.102	.096	1.000	
Achievement	0.424	.399	0.333	115	.154	0.199	0.155	-0.128	355	0.138	1.000

This matrix includes a description of the correlations between the study variables. It indicates that all the relationships between the results of the numerical achievement level of young throwers in the javelin throwing effectiveness and some kinematic variables were statistically significant through testing the hypotheses of the

correlation coefficient, meaning that all the kinematic variables of the thrower have significant contributions to the achievement level.

Architecture of Artificial Neural Networks

Figure (1) The geometric structure of artificial neural networks



Presentation and Discussion of Values of Weights Between Layers and Contribution Ratio

Table (4) Values of weights between all layers

Independent Variables		Hidden layer	internal
		Trunk H.1: 1	Achievement
Inputs.	(Bias)	.977	
	Javelin release speed	666	

	Javelin height	633	
	Linear speed of the hand wrist of the throwing arm	1 (187)	
	Last Step Time	1.355	
	Last Step Length	920	
	Javelin starting angle	.329	
	The angle of inclination of the object at the moment of leaning	.988	
	Trunk inclination angle Start of throwing position	.456	
	Knee angle of fixing leg	080	
	The corner of the two legs in the last step	-.105	
Hidden layer	(Bias)		0.082
	Trunk H.1: 1		732

Figure (1) and Table (4) illustrate the geometric structure of artificial neural networks, the weight values between layers, and the contribution ratio. The number of the (10) independent variables is shown, along with the bias coefficient. It is also noted that there is one hidden layer and one dependent variable, (achievement). Each line represents a weight point, the value of the coefficient that connects the relationship between all cells. Its value is limited to (± 1), and the value sometimes increases above one to indicate high weights. The weight of each variable is equivalent to its relative importance and contribution ratio to the subsequent variable.

Importance of Variables in Artificial Neural Networks

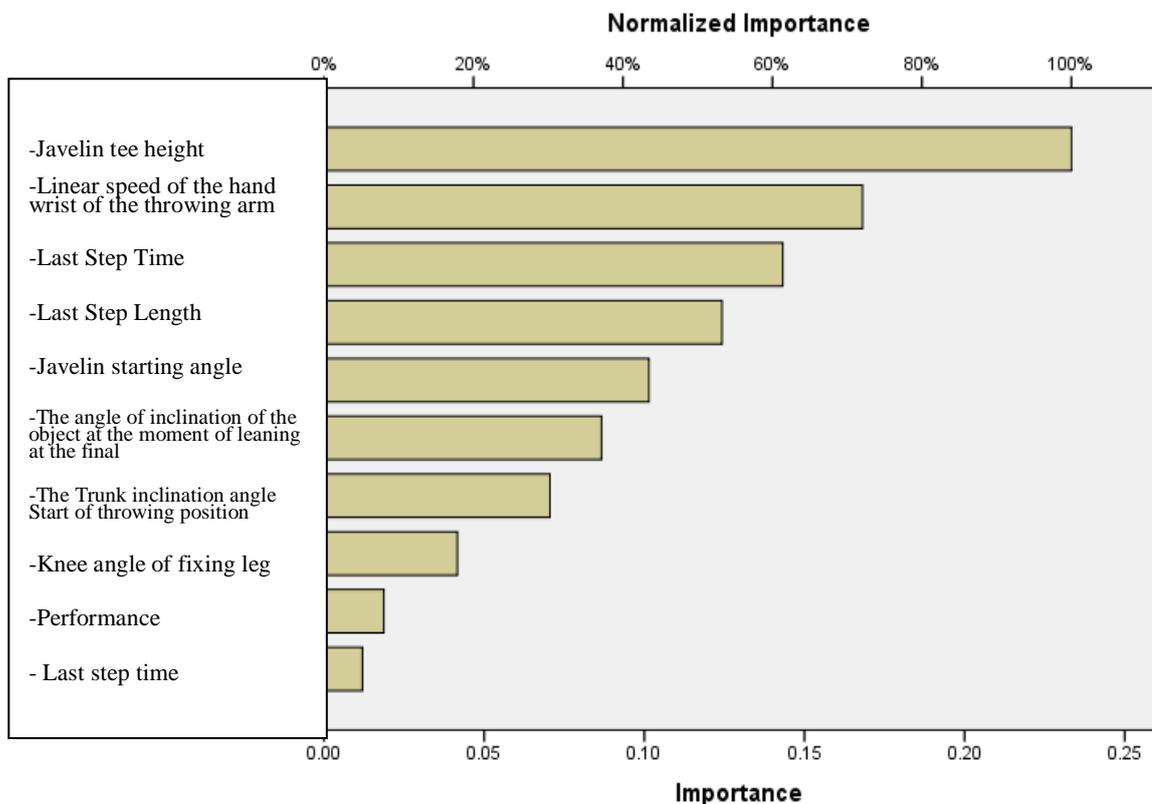
Table (5) Importance and percentage of independent variables

No.	Variables	Importance	Percentage of Importance
1	Javelin release speed	.087	371
2	Javelin height	.233	1.000
3	Linear speed of the hand wrist of the throwing arm	0.168	.721

4	Last Step Time	0.143	0.614
5	Last Step Length	0.124	0.532
6	Javelin starting angle	.042	0.179
7	The angle of inclination of the object at the moment of leaning	0.101	0.435
8	Trunk inclination angle Start of throwing position	0.071	.302
9	Knee angle of fixing leg	.012	.052
10	The corner of the two legs in the last step	.019	.233

Table (5) shows the importance of each of the variables used in the artificial neural network in terms of their impact on the dependent variable. These values are equivalent to beta values in the regression coefficients. It is possible to build a predictive equation in which all the mentioned variables are included according to their ratios as illustrated in the following figure:

Figure (2) The importance of independent variables



Discussion

Results of the present study indicate that all kinematic variables specific to javelin throwers have significant correlations with performance, and each has a specific

contribution, with some having a high contribution. This indicates that the high degree of contribution of kinematic variables to the level of performance of throwers reflects the integrated picture of performance (Rahi and Sagheer, 2020b). No single variable can be considered in isolation, as the final picture of performance is influenced by a set of active variables, which facilitates prediction of the distance traveled by the throwing tool.

The obtained throwing distance is the result of a complex interaction between many different variables, in addition to the unknown wind factor. The kinematic variables of javelin throwing have a significant impact on performance, most notably the height of the throwing point, javelin release speed, final stride length, and knee position (Pavlovic, 2020). The higher the javelin release point, the longer the javelin flight time, which increases the horizontal displacement of the javelin according to the laws of projectiles (Abu Bshara and Abdulfattah, 2021). As indicated above, the linear speed of the throwing arm plays a major role in performance. The greater the speed of the throwing arm, the greater the force acting on the throw, thus achieving a greater throw distance (Ali et al., 2021). Most of the outstanding javelin throwers in the present study demonstrate near-full extension at the left knee angle, which resulted in their increased vertical javelin release speed (Tauchi et al., 2009). Furthermore, the important angles and body positions during the throwing stance are the basis for the success of the thrower's body movement in the javelin throwing.

In conclusion, identifying numerical values for the kinematic variables important to the performance of throwers in athletics throwing events enables coaches to focus on the most important variables required for the success of ideal performance, and thus achieving the desired distance. The researcher believes that achieving success in the javelin throw in athletics is influenced by a set of important kinematic variables that contribute to determining the correct path for performance. Consistent with the ideal, scientific standard, these variables are the basis for achieving the longest possible distance and, consequently, the highest achievement.

Conclusions and Recommendations

The researcher concludes that the use of advanced technology, represented by artificial neural networks, contributes to identifying the most important kinematic variables for javelin throwers. Identifying the contribution ratios of these variables helps coaches reduce time and effort in the training process. It also plays an effective role in raising the level of performance. Artificial neural networks shall be used by coaches and players in processing the variables under study. Training shall focus on the contribution ratios of the identified kinematic variables.

References

Abu Alia, M. K. (2025). The Possibility of Applying Artificial Intelligence in Faculties and Departments of Physical Education in Palestinian Universities, *Journal of Physical Education Studies and Research*, 519–532: <https://doi.org/10.55998/jsrse.v35i1.1004>.

Abu Bshara, J. and Abdulfattah, O. (2021). The Optimum Release Height for Javelin Throwers in Proportion to Their Lengths, *International Journal of Innovation, Creativity and Change*, 15(6), 653–757.

Ali, M. Yousef, F. and Rahi, M. (2021). The Effect of Plyometric Training on Improving Values of Some Biokinetics Variables of High-Jump Shooting Skill with the Accuracy in Handball. *Indian Journal of Forensic Medicine and Toxicology*, 16(1), 743–750. <https://doi.org/10.37506/ijfmt.v16i1.17580>

Ali, S. (2020). Determinants of Private Investment in Algeria for the Period (1990-2017), *Journal of Economics, Management and Business Sciences*, 12(3), 209–222.

Araújo, D. Couceiro, M. Seifert, L. Sarmento, H. and Davids, K. (2021). *Artificial Intelligence in Sport Performance Analysis*, (1st Edition), Routledge: <https://doi.org/10.4324/9781003163589>.

Dongare, A. D. Kharde, R. R. and Kachare, A. (2012). Introduction to Artificial Neural Network, *International Journal of Engineering and Innovative Technology (IJEIT)*, 2(1), 189–194.

Gallo, C. (2011). Artificial Neural Networks, Convolutional Neural Networks in Visual Computing, 1–426.

Knudson, D. (2021). Linear and Angular Kinematics, In D. Knudson, *Fundamentals of Biomechanics* (pp. 79–100). Springer International Publishing. https://doi.org/10.1007/978-3-030-51838-7_5.

Lami, M. and Rahi, m. (2023). Quantitative Values of Correlations in Terms of the Two Kinetic and Kinematic Analyzes for the Stages of Approaching and Getting up and Their Relationship to the Performance Level of the Students' Long Jump and High Jump Activities, *Asociación Canaria de Psicología Del Deporte*, 18(2), 204–209.

Lami, M. and Rahi, L. (2023). Quantitative Values of Correlations in Terms of the Two Kinetic and Kinematic Analyzes for the Stages of Approaching and Getting up and Their Relationship to the Performance Level of the Students' Long Jump and High Jump Activities, *Revista Iberoamericana de Psicología Del Ejercicio y El Deporte*, 18(2), 204–209.

Maier, K. D. Wank, V. Bartonietz, K. and Blickhan, R. (2000). Neural Network Based on Javelin Flight Models: Prediction of Flight Distances and Optimal Release Parameters, *Sports Engineering*, 3(1), 57–63. <https://doi.org/10.1046/j.1460-2687.2000.00034.x>.

Mali, N. (2020). Modern Technology and Sports Performance: An Overview, *International Journal of Physiology, Nutrition and Physical Education*, 5(1), 212–216.

Maszczyk, A. Zając, A. and Ryguła, I. (2011). A Neural Network Model Approach to Athlete Selection, *Sports Engineering*, 13(2), 83–93. <https://doi.org/10.1007/s12283-010-0055-y>.

McGinnis, E. W. Anderau, S. P. Hruschak, J. Gurchiek, R. D. Lopez-Duran, N. L. Fitzgerald, K. Rosenblum, K. L. Muzik, M. and McGinnis, R. S. (2019). Giving

Voice to Vulnerable Children: Machine Learning Analysis of Speech Detects Anxiety and Depression in Early Childhood. *IEEE Journal of Biomedical and Health Informatics*, 23(6), 2294–2301. <https://doi.org/10.1109/JBHI.2019.2913590>

Musso, M. F. Kyndt, E. Cascallar, E. C. and Dochy, F. (2013). Predicting General Academic Performance and Identifying the Differential Contribution of Participating Variables Using Artificial Neural Networks, *Frontline Learning Research*, 1(1), 42–71. <https://doi.org/10.14786/flr.v1i1.13>

Omoriegie P, O. P. (2016). *The Impact of Technology on Sport Performance*, accra, Ghana. Accra, Ghana, 896–905.

Pavlovic, R. (2020). Biomechanical Analysis in Athletics: The Influence of Kinematic Parameters on The Results of Javelin Throw of Elite Athletes, *The Swedish Journal of Scientific Research*, 7(3), 1–11.

Pavlovic, R. and Idrizovic, K. (2020). The Differences of Kinematic Parameters Javelin throw between Male and Female Finalists World Championship (Berlin, 2009-Daegu, 2011). *American Journal of Sports Science and Medicine*, 8(1), 8–15. <https://doi.org/10.12691/ajssm-8-1-2>

Rahi, M. L. and Sagheer, A. H. (2020a). The Predictive Value of High Jump Achievement in Terms of Some Physical Abilities and Biomechanical Variables for Young Youth, *Journal of Human Sport and Exercise - 2020 - Summer Conferences of Sports Science*. *Journal of Human Sport and Exercise - 2020 - Summer Conferences of Sports Science*. <https://doi.org/10.14198/jhse.2020.15.Proc4.06>

Rahi, M. L. and Sagheer, A. H. (2020b). The Predictive Value of High Jump Achievement in Terms of Some Physical Abilities and Biomechanical Variables for Young Youth, *Journal of Human Sport and Exercise - 2020 - Summer Conferences of Sports Science*. *Journal of Human Sport and Exercise - 2020 - Summer Conferences of Sports Science*. <https://doi.org/10.14198/jhse.2020.15.Proc4.06>.

Sharma, D. (2024). Review of Application of Gesture and Poses for Reducing Injury in Sports. *International Journal of Convergence in Healthcare*, 4(1), 31–35.

Tauchi, K. Murakami, M. Endo, T. Takesako, H. and Gomi, K. (2009). Biomechanical Analysis of Elite Javelin Throwing Technique at the 2007 IAAF World Championships in Athletics. *Bulletin of Studies in Athletics of JAAF*, 5, 143–149.

Tronto, I. Silva, J. & Anna, N. (2008). An Investigation of Artificial Neural Networks Based Prediction System in Software Project Management, *Journal of Systems and Software*, 81(3), 356–367.