



AN EVALUATIVE MODEL BASED ON ARTIFICIAL NEURAL NETWORKS TO ASSESS MOTOR COORDINATION IN ROTATION PHASE OF YOUNG DISCUS THROWERS

Mahdi Lafta Rahi

University of Kut
IRAQ

Corresponding Author: Mahdi.Rahi@uokut.edu.iq/mahdilافتa@uowasit.edu.iq

Recieved: October 11 , 2024 **Accepted:** December 27, 2024

ABSTRACT

In recent years, there has been a growing interest in using artificial intelligence (AI) techniques to evaluate athletic performance. Artificial neural networks (ANNs) enable the detection of complex movement patterns that are difficult to measure using traditional tests . This research aims to build an evaluative model based on ANNs to assess motor coordination during the rotation phase in young discus throwers and to study its relationship to performance . The researcher employed a descriptive-analytical approach with a sample of 30 young discus throwers. Multilayered neural networks were used to train the model on a set of kinematic variables extracted from video recordings, and the network outputs were compared with expert estimates. The results indicated that the model possessed high scientific coefficients and revealed a strong correlation between the extracted motor coordination scores and numerical achievement ($r = 0.88$). Six standard levels ranging from "weak" to "excellent" were also constructed and can be used in evaluation and selection processes. The study recommends using this model to evaluate young discus throwers and improve training programs.

Keywords; evaluative model, artificial neural networks, motor coordination, discus throwers.



A. INTRODUCTION

Events are considered complex athletics competitions, requiring the athlete to be able to generate high explosive force (Zhao et al., 2023). The discus throw is one such event where force is directed through a series of rapid rotations within the throwing circle, along with a performance technique that requires maintaining balance and coordination between the body parts (Dai et al., 2013), and Studies indicate that effective discus throwing requires successful biomechanical performance to achieve optimal performance, relying on neuromuscular coordination and the ability to control movement (Yuldasheva Kamola Alimjanovna, 2024) so that the movements of the legs, torso, and arms are synchronized to create maximum speed for exit while maintaining body stability. Although coaches focus their training on strength and agility, motor coordination during rotation is often measured separately or qualitatively, leading to a lack of accurate quantitative information that helps in evaluating performance and formulating appropriate training programs. This effectiveness depends on a large number of interconnected and complex kinematic variables, closely related to the specific force and the optimal kinetic path of the disc during the different phases of movement (Jassem and Naji, 2019).

In recent years, the use of artificial intelligence technologies, particularly artificial neural networks, has expanded into several fields, including the analysis of athletic movements . Neural networks are artificial neural networks (ANNs). These are mathematical computer models inspired by the way the human brain processes information and learns complex patterns. They consist of a set of simple computational units (nodes or artificial neurons) interconnected by links with adjustable and learnable weights. These nodes are arranged in multiple, sequential layers: an input layer that receives the raw data, one or more hidden layers that process the data and extract patterns and relationships, and an output layer that delivers the final result or the desired prediction. (GeeksforGeeks, 2025) It is capable of representing nonlinear relationships and dealing with complex time data. Neural networks have been used with clear and tangible success in multiple and varied applications, including analyzing different throwing techniques, classifying athletes according to their levels or specializations, predicting performance and achievement results, and identifying the most influential factors in digital achievement, based on movement characteristics. This

technology offers the possibility of evaluating motor coordination quantitatively, objectively, and almost in real time, which opens new horizons for field sports coaches.

The discus throw involves several overlapping and sequential technical stages, beginning with preparation and proper positioning behind the circle, culminating in the final throw and the optimal angle and speed at which the discus is released, while maintaining balance and not exceeding the circle's boundaries. Harmony between these stages and a smooth, coordinated transition from one to the next without loss of speed or balance are essential for successful execution and achieving the maximum possible distance, as noted by Jalab and Saeed (2019) in their study on the stages of motor development in discus throw instruction (Jalab and Saeed, 2019).

It manifests importance search in aspects following: Importance scientific supports this Search Literature Sports In a model My calendar Used Networks Nervousness To estimate compatibility Kinetic He is area accident relatively in sciences Sports. Importance Applied provides model Proposal tool measurement objectivity Fast maybe using it in programs training to rectify level compatibility kinetic players, and placed plans training individual building on results. as maybe its use in operations selection to determine talents promising. Importance training: helps to set variables biomechanical basic in phase rotation coaches on concentration their programs on development that variables, the matter that reflected positively on performance technician.

On despite from importance compatibility kinetic it indicates the reviewer field to scarcity presence tests regulated measure this variable in picture mimic nature the performance in throw the disc, where focus most tests traditional on power or balance in a way separate. (Jalab et al., 2019) as he faces coaches difficulty in evaluation level players accurately, given absence tools measurement scientific objectivity, which affects negatively on operations selection and guidance training y, therefore maybe drafting problem search in questions the following: Is it possible to build model My calendar existing on Networks Nervousness artificial To measure compatibility Kinetic in phase rotation For archers disc Young people ? What nature relationship between compatibility Kinetic And the achievement digital I have Archers disc Young people? Do maybe situation levels Standard For degrees compatibility Kinetic Contributes in Operations Calendar And selection?

It aims to what comes building model calendar existing on networks nervousness artificial to measure compatibility kinetic in phase rotation for archers disc young people. Extraction most important variables biomechanical related at the stage rotation and inserting it in model network nervousness. Study relationship between grades compatibility kinetic resulting on the model and the achievement digital for athletes. building levels standard (stairs evaluation) for degrees compatibility kinetic maybe accreditation on it in operations calendar and selection.

Based on problem search and its goals, situation researcher assumptions the following to test it the assumption the first there are relationship correlation moral between grades compatibility kinetic that predicts in it model the network nervousness and degrees compatibility that he evaluates it experts. the assumption the second: there are relationship correlation positive moral between degree compatibility kinetic and the achievement digital in throw disc. the assumption third : they differ grades compatibility kinetic between archers according to for levels standardization, and it is possible classification sample to levels specific building on their results.

B. METHOD

It depend search curriculum descriptive analytical for its suitability nature the study that it aims to analysis movements and extraction variables specifically related to the coordination of movement and performance for the discus throw. the research community is defined as shooter players. disc youth registered in the central union Iraqi games forces the researcher selected the research sample purposively, and it consisted of discus throwers participating in Iraqi championship for the 2024-2025 season. size sample (30) throwing, and they possess expertise training no reduce on three years.

Photography and analysis kinetic were used three cameras digital high speed (120 frames/second) install it around circle throwing according to corners known to capture phase rotation complete . analysis shots using program analysis movement to extract variables the following per throw: (time) rotation, speed the corner for the trunk, corner bend your knees, corner foot front, path center weight on level horizontal, and angle separation the disk). it was completed. filtering data using butter worth quadruple candidate ranks to reduce noise.

Calendar experts: it was completed numbers form calendar compatibility kinetic it included several terms like: (synchronization) a movement legs, poise the trunk, transmission the weight smoothly, path feet , and angle disposal, grants all item from 0 to 20 degrees, so that he is total the grades are 100 % . experts the six calendar all throw on sharpness, and it was account middle grades to be standard reference for compatibility kinetic. tools help to completed use platforms measurement power ground to measure power to reply the verb vertical during rotation with the aim analysis balance, as used balls medical weighing 5 kg for training preliminary.

Statistical procedures for the sample: it was completed to divide sample to two groups group training model the network nervousness 20 rami and a group test model 10 shooters and participant six experts in training games forces calendar performance and granted grades compatibility kinetic out of (100) degrees to form the standard golden that you will compare with him outputs the network.

Building model network Nervousness

Use model network nervousness multiple multilayer perceptron (mlp) estimation compatibility kinetic based on variables the biomechanical properties of discus throwing efficiency and designed the network in form following: inputs network: five variables biomechanical main she : time rotation (second), middle the speed the corner for the trunk (rad / second), corner knee when beginning rotation (degree), distance a movement center weight (meter), and angle separation disc (grade). done normalization values between 0 and 1.

Layers: It consists network from layer Inputs, two layers Hidden (first one: 12 neurons) second one is 8 neurons and layer outputs one Weight continuous Represent degree compatibility Kinetic (Yang Z, Yang Z. 2014)

Training: Completed training the model using algorithm decline gradual random (adam) rate learn 0.001 and the number is 50 eras . we used function loss average the quadratic (mse) between outputs the network and degrees experts , it was completed to divide data sample up to 70% for training and 30% to check (verification) intersecting) and it stopped practical training when settle curve loss. (wazan , 2022) A test model: after an end training, it was completed a test the model on group test components out of 10 archers, it was

completed account transactions honesty and steadfastness objectivity as its explanation will follow.

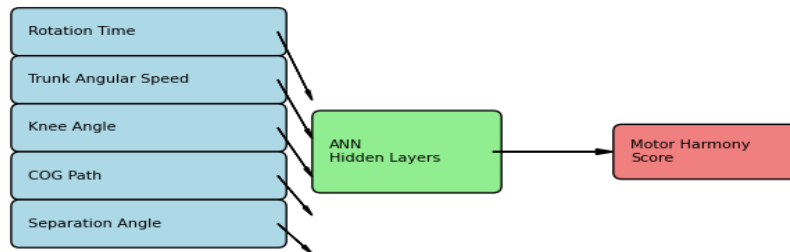


Figure 1. It is clear The structure conceptual For the model Nervous Proposal

Where to intervene five variables Biomechanical in layer Inputs Dates via two layers Hidden To generate degree compatibility Kinetic in layer Outputs .

Scientific principles and treatments Statistics

Honesty : It was completed Use coefficient correlation Pearson between outputs The network and degrees Experts in group Test To measure sincerity Concomitance as It was completed Approval Honesty Self Because relationship strong between Variables Biomechanical And the achievement.

Stability : has been achieved re measurement Performance for five Archers after week from Measurement the first, And it was calculated coefficient Steadfastness Using coefficient Pearson between The two measurements showed a high-value correlation coefficient .

Objectivity : It was completed account coefficient Link between grades Experts themselves To make sure from objectivity Calendar, then comparison that with outputs The network was working, and the results were positive .

Relationship with Achievement : Done study relationship between grades compatibility Kinetic resulting on The network and distance Throwing The investigator Using coefficient correlation Pearson Analysis decline Simple .

Levels Standardization: Used The method centipede to divide grades compatibility Kinetic to six Levels : weak (less out of 50) Don average (50–59) middle (60–69) good (70–79) good very (80–89) , excellent (90 And higher.

C. RESULTS AND DISCUSSION

Results

It is clear shape next curve accuracy training and verification for model the network nervousness across 50 eras . it becomes clear that accuracy training it rose quickly during first ten ages, then it settled around 0.92 , in when it settled accuracy verification around 0.89, which it indicates on compresence excess to learn clear and suitability the model for the data.

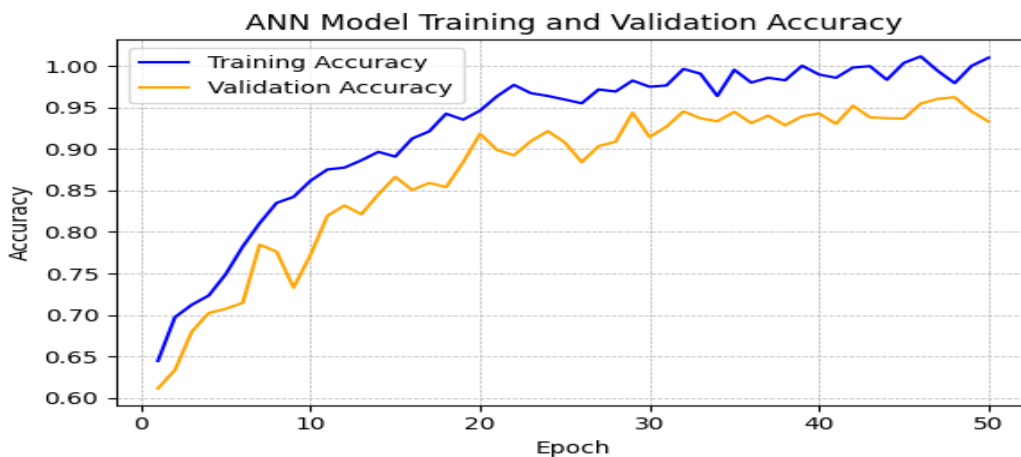


Figure 2. Illustrates Curve Accuracy Training And Verification For The Model The Nervous One

The figure above shows that accuracy verification it settled when values high don presence spacing big on accuracy training, what it indicates to that the model no he suffers from excess allocation.

Comparison outputs model calendar Experts

After training the model it was completed account coefficient correlation pearson between grades compatibility kinetic that predict in it the model and degrees experts in group test for (10) archers. It reached coefficient link 0.87 ($p < 0.01$) which it indicates on sincerity high for the model. reached middle the difference absolute between the score is 3.5 points. he is difference small relatively. It showed results steadfastness that coefficient link between the two measurements the first the second for the same shooters it reached 0.90, which it indicates to stability high . also reached coefficient link between grades experts their own 0.93, what enhances objectivity the calendar.

Relationship between compatibility Kinetic And achievement

It shows shape following is that there relationship line positive between grades compatibility kinetic expected by the network nervousness and performance digital distance throwing in group the test. where it increases achievement by increasing degree compatibility kinetic and reached coefficient the correlation is 0.88. this reflects that that compatibility kinetic it is variable whatever explains part large from contrast in the achievement so reached coefficient determination is 78% , and this what confirms attic studies that linked between abilities kinetic and achievement in throw disc.

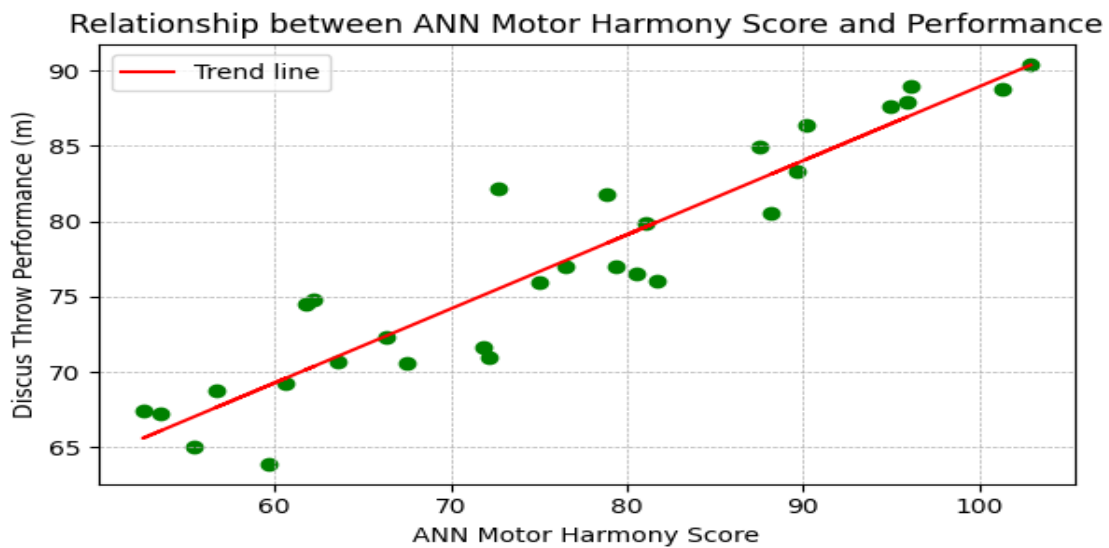


Figure 3. illustrates the relationship between degree compatibility Kinetic Expected by The network Nervousness axis The sines and distance Throwing axis The Sads appear Line red line trend Output on decline Linear, And it indicates points to Data Actual . It tends Line to Height with more Grade, what It indicates on relationship correlation Positive Strong .

Levels Standardization For compatibility Kinetic

Using distribution centennial for degrees compatibility kinetic for the whole sample (30 archers), it was completed to divide grades to six levels. as in shape the next distribution athletes via levels . most shooters they positioned themselves in level "good" and "good" very" while back number a little in level "weak" "excellent" maybe use this is amazing levels standard for selection talents or to set points weakness and power i have athletes . as shown in the following table:

Table 1. Shows Levels, Number Of Athletes Under Each Level, And Percentages

Level	Athletes number	Percentages
Weak	1	3.3%
Middle low	3	10.0%
Middle	6	20.0%
Middle high	10	33.3%
Good	6	20.0%
Good very	4	13.3%
Excellent	0	0.0 %

Shows Table number athletes and the ratio centennial in all level from levels compatibility Kinetic and It is observed that about third Sample He was in Level (middle high) , while did not Investigates any athlete level (excellent) because of small The sample.

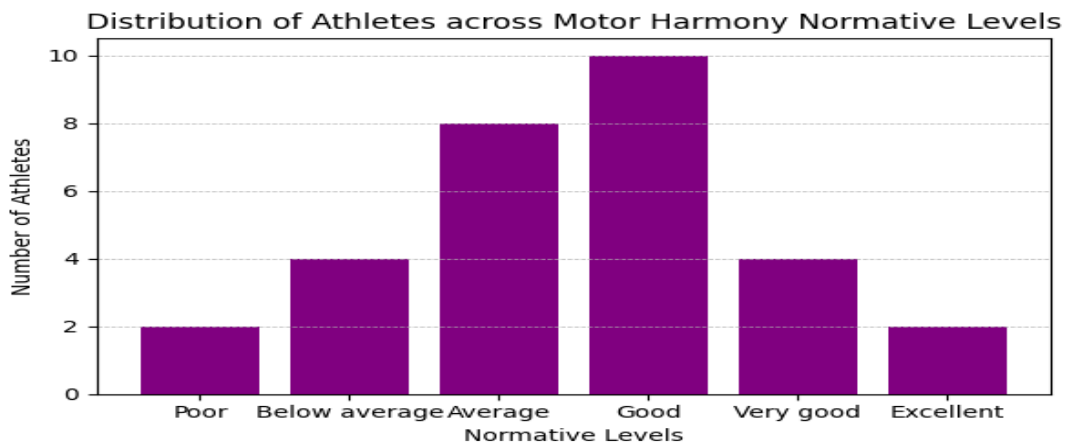


Figure 4. Distribution illustrates grades compatibility Kinetic via Levels Standardization . Represents axis horizontal levels Performance (from weak to excellent), And represents axis vertical number athletes

Table 2. Mean, Standard Deviation, Minimum, And Maximum Values For Biomechanical Variables Are Shown

Variable	Mean	Standard deviation	Min.	Max.
Time rotation (sec.)	1.844	0.110	1.545	2.027
Speed trunk corner (degree/ second)	197.105	9.142	180.192	219.508
Corner knee (degree)	44.331	4.825	36.369	54.479
Path center Weight(m.)	0.526	0.051	0.433	0.597
Corner separation (degree)	25.193	1.858	22.017	29.766

We notice from table above statistics descriptive for variables biomechanical the five used in training, in what in that averages and deviations standardization and borders the world and the highest for the sample (n = 30), it appears this is amazing statistics that time rotation reached middle calculations its value is 1.844 seconds, while he was middle speed trunk the corner approximately 197 degrees in second.

Analysis link between biomechanical and compatibility kinetic and achievement

To delve deeper in to understand Relations between Variables Biomechanical and level compatibility Kinetic And the achievement Digital, It was completed account Transactions correlation Pearson between all variable and degree compatibility And also between Variables and performance Digital.

Table 3. Shows Correlation Coefficients Of Biomechanical Variables With Digital Performance And Degree Of Motor Coordination.

Variable	Coefficient Link with degree compatibility	Coefficient Link with Performance digital
Time rotation (sec.)	0.10	0.12
Speed trunk corner (degree / second)	0.57	0.45
corner knee (degree)	-0.04	0.08
path center weight (m.)	0.52	0.45
corner Separation (degree)	-0.12	-0.07
Degree of compatibility Kinetic	1.00	0.93
Performance digital (m.)	0.93	1.00

We can see from table that transactions link between variables biomechanical and degree compatibility kinetic and performance digital where it indicates numbers to power relationship between variables, for example it is related speed trunk the corner and path center weight positively with degree compatibility and performance, while it is related corner separation negatively with them.

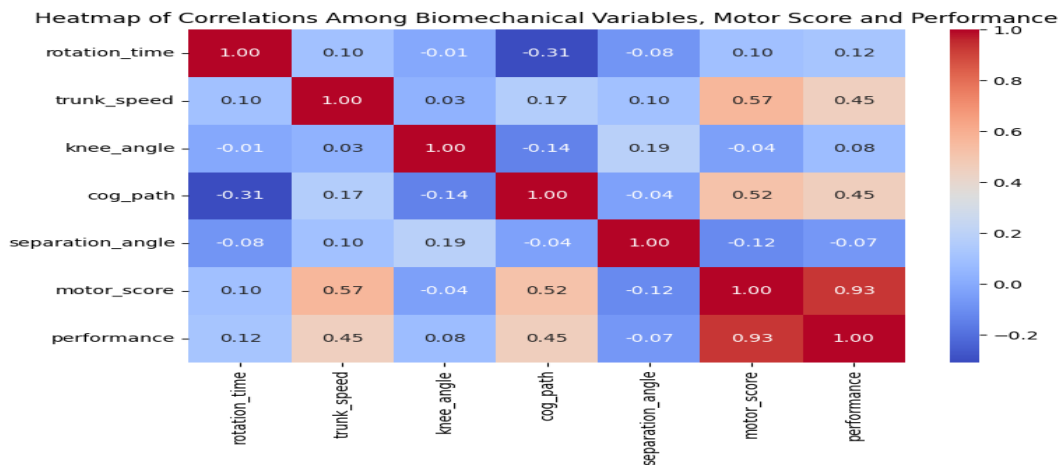


Figure 6. Diagram shows thermal for transactions link between variables biomechanical and degree compatibility kinetic and performance digital.

We can see in the figure above that each color he crosses on value coefficient link (blue) for connections negative, and red for connections positive. and it is noted clearly correlation speed trunk the corner and path center weight degree compatibility and performance.

Discussion

Results showed that model proposal enjoy with the ability high on appreciation compatibility kinetic as it is clear from coefficient link the high (0.87) between its outputs and calendar the experts. approaching this is amazing result which rose in research precedent around use networks nervousness in analysis technologies throwing, so registered studies pearl shollhorn and their colleagues accuracy similar when use maps self the organization to analyze throw disc. (bartlett, 2006) as show yan woo that networks multiple layers reduce mistake prediction angle and speed exit disc comparison by decline traditional (yan & wu, 2000) conforms that with what reported with him article bertle on that networks nervousness you can simplification data complex and discovery patterns no maybe her observation from during analysis classical. (Bartlett, 2006)

It indicates curve accuracy training and verification to that the model to learn quickly and it reached phase stability after about 15 era, and did not show signs excess allocation . he returns that to use group data enough normalization variables and determining structure suitable for the network . it is observed that addition more from layers or neurons did not it leads to to improve big in accuracy during experiments primary, which it indicates on that structure simple relatively may be enough to represent relationship between variables biomechanical and degree compatibility . it becomes clear. from results analysis that this is amazing variables capable on explanation rate large from contrast in grades compatibility kinetic.

As it showed results the study presence relationship correlation strong between grades compatibility kinetic and the achievement digital (distance throwing) where reached coefficient correlation 0.88. conforms this with studies that confirmed that performance in competitions throwing he depends on abilities physical and skill together, and that to improve compatibility and balance he increases from effectiveness power producer and as that 78% of contrast in achievement maybe its interpretation in degrees compatibility kinetic it is rate superiority what i recorded it tests traditional measure power or balance

they alone in studies precedent widdel that on that the model proposal reflects in a way good integration between variables different in performance.

And it is levels standardization that it was completed preparing it tool practical to classify athletes and determining points power and weakness. level is "good" . very" "excellent" they represent performance ideal that it should that seeks to him athletes, while it indicates level "weak" to need the player for programs training intensive to improve compatibility. it is also possible use this is amazing levels in practical selection for national teams nationalism or to set goals training individual. likewise, maybe to update that levels periodically when availability data additional from categories age different to ensure its suitability for reality field-based.

D. CONCLUSION

In light of findings of the current research, the following conclusions can be drawn multi-layered artificial neural network model has demonstrated a high and reliable ability to estimate motor coordination in the rotation phase of young discus throwers. Statistical analysis revealed a strong and statistically significant correlation between the motor coordination scores predicted by the neural model and the numerical achievement (throwing distance) among young discus throwers. Standardized levels provide a practical and easy-to-use tool that helps coaches and assessors classify athletes accurately and objectively, identify each athlete's strengths and weaknesses, and guide them towards individualized training programs appropriate to their levels.

Based on previous results and conclusions, researcher recommends the following the researcher recommends using the proposed model based on artificial neural networks in sports training centers, clubs, and athletics teams to evaluate the level of motor coordination among shooting athletes. integrating compatibility training into training programs coaches and specialists in discus throw training are focusing more and more systematically on neuromuscular coordination and dynamic balance training, in addition to muscular strength training. using and applying the most advanced and complex deep learning techniques such as neural networks. conducting in-depth and comprehensive comparative studies between different artificial intelligence models (neural networks, decision trees, support machines, deep learning) and traditional biomechanical analysis models and classical physical tests.

E. ACKNOWLEDGMENT

The author extends sincere appreciation to all those who contributed to the success of this research.

F. AUTHOR CONTRIBUTION STATEMENT

Mahdi Lafta Rahi Abd is fully responsible for the content of the article.

G. REFERENCE

- Bartlett, R. (2006). Artificial intelligence in sports biomechanics: New dawn or false hope? *Journal of Sports Science and Medicine*, 5, 474–479.
- Dai, B., Leigh, S., Li, H., Mercer, V. S., & Yu, B. (2013). The relationships between technique variability and performance in discus throwing. *Journal of Sports Sciences*, 31(2), 219–228. <https://doi.org/10.1080/02640414.2012.729078>
- GeeksforGeeks. (2025). *Artificial neural networks and their applications*. <https://www.geeksforgeeks.org/artificial-neural-networks-and-its-applications/>
- Jallab, H., & Saeed, S. M. (2019). Stages of motor development in teaching discus throwing at the beginner level. *Journal of Physical Education*, 20(2), 196–200.
- Jassim, S., & Ahmed, N. (2019). Special strength training to develop the action of the muscles involved in the throwing position and final throw phases of the discus and its effect on discus throwing performance in young people. *Journal of Physical Education*, 31(3), 206–213.
- Milad, W. (2022). *Deep learning from the basics to building a deep neural network in Python* (A. Ta'ima, Trans.). [Original work published 2022].
- Yan, X., & Wu, Y. (2000). Multi-layer neural network analysis of shot-put techniques. *Proceedings of the International Symposium on Biomechanics in Sports*.
- Yang, Z., & Yang, Z. (2014). *Comprehensive biomedical physics* (Vol. 1). Elsevier. ISBN 978-0-444-53633-4
- Yuldasheva, K. A. (2024). *Biomechanical analysis of discus throwing in female athletes: A*

comprehensive review. Zenodo. <https://doi.org/10.5281/zenodo.14031302>

Zhao, K., Siener, M., Zhao, Y., & Hohmann, A. (2023). Physical fitness and motor competence performance characteristics of elite Chinese youth athletes from four track and field throwing disciplines: A cross-sectional study. *Frontiers in Physiology*. <https://doi.org/10.1101/2023.07.20.549861>