International Journal of Physiology, Exercise and Physical Education

Ali Saleh Abd Ali
M.Sc., College of Physical Education and Sports Sciences/ University of Wasit, Iraq

Atheer Hamza Jijan
M.Sc., College of Physical Education and Sports Sciences/ University of Wasit, Iraq

The effectiveness of a training program based on artificial intelligence techniques in developing the coaching competencies of gymnastics trainers

Ali Saleh Abd Ali and Atheer Hamza Jijan

DOI: https://doi.org/10.33545/26647249.2025.v7.i2d.217

Abstract
Technology has increasingly occupied a wide space across various fields of life, with the sports domain being among the most prominent, particularly in the area of athletic training. In light of the rapid advancement of modern technologies, it has become essential for sports coaches to integrate such advanced tools to enhance their coaching skills, thereby positively influencing athletic performance and achievement.

The present study aims to design a training program based on artificial intelligence (AI) techniques and to examine its effect on developing the coaching competencies of gymnastics trainers at Al-Kut Sports Center. The researcher hypothesized the presence of statistically significant differences between the pre-test and post-test results of the study sample in favor of the post-test.

The experimental method was employed using a one-group design (pre-test-post-test), as it was deemed appropriate to the nature of the research problem. The primary sample consisted of six gymnastics coaches representing six clubs in Al-Kut, in addition to two exploratory coaches selected from the youth category. Homogeneity was ensured across the sample in terms of experience and intelligence variables to minimize the influence of extraneous factors.

Consultations were conducted with a group of experts and specialists in gymnastics to determine the appropriate tests for measuring coaching competencies. A pilot study was then carried out to identify potential obstacles prior to implementing the main experiment. The pre-test was administered, followed by the application of the training program over eight weeks, comprising 24 training sessions distributed across Sundays, Tuesdays, and Thursdays, with each session lasting 45 minutes.

After completing the program, the post-test was conducted under conditions identical to those of the pre-test. Data were analyzed using the Statistical Package for the Social Sciences (SPSS). The results indicated significant differences in favor of the post-test, confirming the effectiveness of the AI-based training program in enhancing the coaching competencies of gymnastics trainers.

The researcher concluded that the program contributed to broadening the coaches' perspectives on the applications of artificial intelligence in sports training, while also equipping them with up-to-date knowledge and tools related to planning, analysis, and performance evaluation. The study recommends activating the use of artificial intelligence within training programs for individual-sport coaches, as well as designing similar electronic programs for other sports.

Keywords: Training program, artificial intelligence, coaching competencies, gymnastics

1. Introduction and Research Important
Sports training science has witnessed remarkable development in recent years, with a growing trend toward the integration of modern technologies particularly artificial intelligence (AI) in the design and implementation of training programs. These technologies have become effective tools that contribute to improving the quality of training by accelerating the process of delivering information to athletes and providing a more interactive and realistic training environment. Most contemporary training courses have shown increasing interest in incorporating such digital tools to enhance coaches' abilities in designing more accurate and effective training units, as well as refining their skills in using smart devices and analyzing athletic performance. Artificial intelligence stands out as one of the most promising technologies capable of bringing about a qualitative transformation in training methods, especially in sports that require high precision and diverse performance

Corresponding Author:
Ali Saleh Abd Ali
M.Sc., College of Physical Education and Sports Sciences/ University of Wasit, Iraq

patterns such as gymnastics. Through its ability to analyze motor and biometric data, AI can provide coaches with a comprehensive overview of an athlete's performance, accurately identifying strengths and weaknesses, thereby enabling the construction of individualized training plans tailored to each athlete's abilities and needs. This makes training more flexible and adaptive to performance changes, while also enhancing athletes' efficiency in both the short and long term.

Recent studies suggest that artificial intelligence is no longer a complementary option in the training process, but rather a necessity for keeping pace with advancements and maximizing the physical and technical potential of athletes. Smart devices such as tablets and analytical applications provide effective tools for coaches to make data-driven decisions instead of relying on subjective estimation or traditional methods. This, in turn, facilitates better communication between coaches and athletes and enables more accurate evaluation of progress.

Gymnastics, in particular, is a sport that demands a high level of motor and technical performance, alongside the continuous development of physical fitness and neuromuscular coordination. Therefore, integrating artificial intelligence techniques into gymnastics training may significantly contribute to improving athletes' technical performance by enabling coaches to analyze movements, detect errors, and correct them promptly and accurately.

Accordingly, the significance of this research stems from its attempt to achieve a qualitative shift in the level of coaching competencies among gymnastics trainers, through the design of a training program based on artificial intelligence techniques. The program aims to enhance their abilities in planning and implementing training units according to advanced scientific and technological principles consistent with the requirements of modern training.

1.1 Research Problem

Smart devices and digital technologies, such as tablets, have become vital tools in various fields of life, including sports. Despite the availability of such tools, field observations conducted by the researcher with gymnastics coaches at Al-Kut Sports Center revealed a heavy reliance on traditional methods in preparing training units and constructing annual plans, with limited utilization of modern technologies, particularly those based on artificial intelligence.

This lack of integration of digital tools negatively affects the quality of the training process and limits opportunities to improve the physical and motor aspects of gymnasts, whose performance heavily relies on accuracy, balance, motor coordination, and the ability to execute complex skills within short time frames. Moreover, the absence of real-time performance analysis through AI deprives coaches of the opportunity to provide immediate and precise feedback that could help athletes correct errors and improve performance effectively.

Therefore, there is a clear need to design a modern training program based on AI technologies to empower gymnastics coaches in developing personalized training plans tailored to each athlete's abilities, thereby enhancing technical and physical performance efficiency.

Thus, the research problem is defined through the following central question: To what extent can gymnastics coaches benefit from artificial intelligence technologies in designing individualized training programs, and what are the main obstacles that hinder their effective application in the sports training environment?

1.2 Research Objectives
1. To design a training program based on artificial intelligence techniques for the development of the training process.
2. To investigate the effect of the AI-based training program on the development of coaching competencies among gymnastics coaches.

1.3 Research Hypothesis
There are statistically significant differences between the pre-test and post-test results in the level of coaching competencies of gymnastics coaches, in favor of the post-test results.

1.4 Research Fields
1.4.1 Human Field
Gymnastics coaches working in clubs at Al-Kut Sports Center.

1.4.2 Time Field
From April 10, 2025, to July 14, 2025.

1.4.3 Place Field
The gymnastics training hall at Damok Sports Club.

2. Research Methodology and Field Procedures
2.1 Research Method
The researchers adopted the experimental method using a one-group pre-test-post-test design, due to its high suitability for the nature of the research problem and objectives. This design enables a direct measurement of the effect of the training program based on artificial intelligence techniques on the coaching competencies of gymnastics coaches.

2.2 Research Population and Sample
The research population consisted of gymnastics coaches working in clubs within Wasit Governorate, totaling six (6) coaches distributed across six different clubs in Al-Kut center, as shown in Table 1. The population was intentionally selected (intentional sampling), since these coaches represented the entire community of gymnastics trainers in Al-Kut during the study period.

Given the limited number of gymnastics coaches in the governorate, the researchers employed a comprehensive enumeration approach, including all available coaches who were actively engaged in gymnastics training during the specified timeframe.

To ensure homogeneity of the sample and reduce the influence of extraneous variables, the researchers conducted preliminary tests to assess levels of intelligence and coaching experience. This step aimed to verify the relative similarity among participants and to avoid fundamental differences that might bias the experimental results. For this purpose, a standardized intelligence test was used alongside an analysis of the participants' training backgrounds.

Additionally, the researchers developed a custom electronic application for the training content, designed to simulate the environment of smartphone applications. The application was built in collaboration with a software engineer to ensure compatibility with the requirements of the AI-based training program.

Table 1: Research Population

S. No.	Club	No. of Coaches	Training Category	Pilot Sample
1	Al-Kut	1	Advanced	
2	Al-Azzah	1	Advanced	1
3	Damouk	1	Youth	1
4	Al-Nahrain	1	Youth	
5	Al-Jihad	1	Juniors	
6	Al-Shaheed	1	Juniors	
Total		6		2

2.2.1 Sample Homogeneity
The researchers sought to achieve an appropriate level of homogeneity among the sample to minimize the influence of extraneous variables that might lead to inconsistent results and affect the scientific interpretation of findings. Key variables considered were intelligence level and practical coaching experience in gymnastics.

Recognizing the importance of these variables in shaping coaches' abilities and their interaction with the training program, the researchers ensured that all participants began from relatively comparable cognitive and practical levels. Intelligence plays a vital role in the speed of comprehension and understanding of new technological applications, while practical experience may provide certain individuals with advantages over others.

Accordingly, the researchers applied the Multiple Intelligences Scale (adapted from Mohammad Hassan Allawi, 2000, p. 319) [1] to assess intelligence levels, and developed a tailored questionnaire to evaluate practical coaching experience. The questionnaire included a set of items addressing technical and knowledge-related aspects of gymnastics coaching.

To guarantee the accuracy and reliability of this tool, it was reviewed by a panel of experts in gymnastics coaching and academic specialists in testing and measurement. This validation confirmed the tool's appropriateness for assessing coaching experience levels. Table 2 presents the homogeneity results of the sample with respect to these variables.

Table 2: Sample Homogeneity

Variables	Unit of Measurement	Mean	Median	SD	Skewness
Intelligence	Score	68.322	68.308	4.014	-0.003
Experience	Score	42.35	42.32	2.540	0.011

2.3 Instruments, Devices, and Tools Used
2.3.1 Information Collection Tools
The researchers relied on an extensive review of recent scientific sources related to the research topic, including specialized books and peer-reviewed journals in sports training and AI applications. They also utilized updated information from online resources, in addition to employing structured scientific observation during the implementation of the training program to document the interactions between coaches and the smart tools used.

2.3.2 Devices and Tools
1. A gymnastics training hall equipped with all supporting facilities.
2. Six (6) Samsung tablets dedicated to the training program.
3. A data show projector for demonstrating and explaining program mechanisms.
4. A digital stopwatch for timing performance and assessments.
5. A hall with internet access to support smart applications and interactive sessions.

2.4 Field Procedures
2.4.1 Identification of Research Variables
The selection of core research variables was based on a comprehensive review of sports training literature, alongside consultations with gymnastics experts. Given the innovative nature of the AI-based training program, emphasis was placed on coaching competencies directly related to planning and organizing the training process. Thus, the research variables targeted included:
- Training Unit Planning
- Design of Training Curricula

These represent the essence of modern coaching practice and reflect a coach's ability to construct comprehensive training content.

2.4.2 Identification of Research Tests
A series of scientific interviews were conducted with gymnastics coaches, academics, and measurement specialists to determine appropriate tools for assessing the targeted coaching competencies. The researchers adopted a practical training skills test, delivered through a specially designed electronic application developed with the assistance of a software expert.

The application included multiple-choice questions covering topics such as training unit design, annual training plan development, and principles of workload and recovery distribution. It also incorporated interactive scenarios that evaluated the coaches' ability to address varied training situations.

2.4.2.1 Training Skills Test
The researchers adopted Anderson's Model of Learning Evaluation (2023) as a framework for assessing coaching competencies. This model emphasizes linking training outcomes to the strategic objectives of the institution and consists of three main phases:
1. Aligning training program goals with institutional strategic priorities.
2. Employing diverse evaluation methods to measure program impact.
3. Selecting evaluation approaches suitable for the nature of training and participant needs.

2.4.3 Pilot Study
A preliminary pilot study was conducted in collaboration with the research team on a sample outside the research population, consisting of two youth gymnastics coaches (see Table 1). The pilot aimed to identify any administrative or technical issues that might arise during the main trial and to ensure the reliability of the tests and smart tools used.

2.4.4 Pre-Test
The pre-test was conducted on April 20, 2025 (Sunday) at 4:00 PM in the closed hall of Al-Kut Gymnastics Club. All organizational aspects were carefully considered, including projector setup, seating arrangement, and provision of the required tablets, to create an optimal testing environment.

2.4.5 Main Experiment

The main experiment commenced on April 23, 2025 (Wednesday) after preparing the tablets and installing the training program. It began with an introductory session in which the researchers provided detailed explanations on the program's mechanisms, usage instructions, and content, which included modules on training unit design, workload management, rest periods, and distribution of training intensity in line with the nature of gymnastics.

The program targeted the development of coaches' competencies in training unit planning, emphasizing the three core sections:

1. The preparatory part
2. The main part
3. The concluding part

It also addressed multiple themes related to the design of training curricula and annual programs, as well as strategies tailored to gymnastics. Special emphasis was placed on enhancing coaches' awareness of essential training skills and the integration of modern technologies particularly artificial intelligence in advancing the training process.

The program included 24 training sessions delivered over 8 weeks, with three sessions per week (Sunday, Tuesday, Thursday), each lasting 45 minutes.

In the final two weeks (weeks 7-8), each participating coach was tasked with creating a complete training unit using the provided tablet and smart application. The coaches then presented their training units via the projector (Data Show) to their peers, fostering an interactive environment that encouraged performance analysis, feedback exchange, and collective problem-solving. This collaborative learning approach enhanced professional growth and raised overall coaching competencies.

3. Results, Analysis, and Discussion

3.1 Presentation, Analysis, and Discussion of the Findings

After implementing the training program and collecting the pre- and post-test data from the research sample, the researchers organized and processed the statistical data in order to conduct the necessary analyses and verify the hypotheses. Statistical methods appropriate to the nature of the data were applied to ensure objectivity in interpreting the results.

3.1.1 Presentation and Analysis of Differences Between Pre- and Post-Test Results in Training Competencies of the Experimental Group

The statistical analysis revealed significant differences between the pre- and post-test results in the level of training competencies of the experimental group, in favor of the post-test. This indicates the effectiveness of the AI-based training program in enhancing the ability of gymnastics coaches to design training plans and curricula.

The results further demonstrated that the digital content employed featuring smart applications and interactive approaches enabled coaches to achieve noticeable improvement in training efficiency. This was accomplished by strengthening their capacity to design comprehensive training units and adapt them to the athletes' needs.

Table 3: Arithmetic means, standard deviations, t-values, error ratio, and significance of differences in training competency (pre- vs. post-test) for the experimental group

Variable	Unit	Pre-Test Mean ± SD	Post-Test Mean ± SD	df	SE	t-value	Sig.	Significance
Training Competency	Score	54.70 ± 3.020	68.80 ± 1.135	14.1	2.02	6.403	0.000	Significant

3.1.2 Discussion of Findings

The significant differences reported in Table (3) in favor of the post-test highlight the positive impact of the AI-driven training program. This improvement can be attributed to the program's effectiveness in providing gymnastics coaches with advanced knowledge and contemporary concepts regarding unit planning and curriculum design areas that were not adequately represented in their previous experience.

The program functioned as an "expert system," offering access to technological tools and knowledge resources that supported evidence-based decision-making. Additionally, the interactive learning environment facilitated by the program enriched coaches' knowledge base and improved their ability to handle varied training scenarios efficiently.

These findings are consistent with prior literature emphasizing that smart technologies enhance learning by presenting information in a more realistic and applicable format (Wissam Salah *et al*., 2020, p. 233) [2]. Similarly, AI-driven applications allowed coaches to conceptualize, analyze, and resolve real-world training problems, thereby fostering higher-order thinking skills and improving practical application.

The results also demonstrated that the AI-based environment played a critical role in developing cognitive flexibility among the sample coaches. This flexibility is essential for modern coaching practice as it enables professionals to reorganize prior knowledge, generate alternative solutions, and apply learned concepts to novel contexts (Rhodes & Rozell, 2017) [4].

In sum, the program promoted deeper conceptual understanding, strengthened decision-making skills, and enhanced coaches' ability to integrate planning, analysis, and evaluation into their practice. This reflects the importance of technology-based interventions in elevating professional training standards in gymnastics

4. Conclusion and Recommendations

4.1 Conclusion

1. The AI-driven training program proved effective in enhancing gymnastics coaches' understanding of modern technological concepts and their relevance to the training process.
2. The program provided specialized knowledge supporting the design of gymnastics training curricula, particularly in unit planning and load distribution.
3. The integration of tablets as a training aid facilitated practical tasks for gymnastics coaches, helping them overcome several challenges encountered in applied training environments.

4.2 Recommendations

1. Emphasize the integration of artificial intelligence techniques in gymnastics training programs to improve coaching efficiency and foster professional development.
2. Encourage the use of smart devices and applications to monitor and evaluate both technical and physical performance in gymnastics.
3. Generalize the application of AI-based training programs across other sports disciplines, while accounting for their specific characteristics, in order to expand the benefits of technology-driven coaching.

References

1. Alawi MH, Radwan MN. Measurement in physical education and sport psychology. Cairo: Dar Al-Fikr Al-Arabi; 2000.
2. Salah WAH, *et al*. Learning and teaching in the age of information technology. 1st ed. Babel, Iraq: Dar Al-Sadiq Cultural Foundation; 2020.
3. Samir S, Abdullah M. Technological empowerment according to the level of cognitive flexibility (adaptive/spontaneous) in developing digital learning skills and professional adaptability of faculty members. J Fac Spec Educ Univ Mina. 2020;6(28):[page numbers not provided].
4. Rhodes AE, Rozell TG. Cognitive flexibility and undergraduate physiology students: increasing advanced knowledge acquisition within an ill-structured domain. Adv Physiol Educ. 2017;41(3):375-382.
5. Eisenberger J, *et al*. Self-Efficacy: Raising the Bar for All Students. 2nd ed. New York: Routledge; 2014.
6. Moran R, Keeley P. Teaching for Conceptual Understanding in Science. Virginia: NSTA Press; 2015.

Appendixes

Appendix 1: Questionnaire Form

Skill	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My ability to use automated video analysis to identify performance errors	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○
Accuracy of my interpretation of quantitative data (joint angles, movement sequences)	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○

Appendix 2: Training Program, Training Skills, Program Access

Prepared by: M.Sc. Ali Saleh Abdul Alim M.Sc. Athir Hamza Jejan

Use of Tablets for Explaining Basic Skills

1. Training Planning
2. Training Curriculum
3. Training Circuits
4. Use of Tablets