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Speed Endurance Training Using Artificial Intelligence Techniques (Polar H10) and its Effect on Selected Components of Physical Fitness and Tactical Behavior

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Abstract

The regulation of training loads, particularly for speed endurance, is crucial for optimizing physical fitness in football players. This is achieved by balancing external load components such as intensity, volume, and rest with internal load, as measured by heart rate. Such regulation has a precise impact on the level of specific physical fitness. This study focuses on the regulation of speed endurance training during the specialized preparation period, using artificial intelligence to assess its effects on selected physical fitness components and tactical behaviour in football players. The study utilizes Polar H10 sensors, which function effectively under various environmental conditions and interface with an iPad 8 device to measure heart rate, distance, energy, and power during performance and training. These sensors contribute to making the training process highly regulated and well-documented, providing an objective evaluation of physical load. By inputting player data into a pre-designed difficulty formula, the training load can be determined instantly, without the need to rely on time-consuming manual calculations that may be prone to human error, especially under fatigue or high-pressure conditions. In contrast, these AI-generated metrics are consistently reliable and free from human error. The researchers concluded that developing training programs based on modern technological devices equipped with artificial intelligence is essential, given their capacity to improve physical fitness parameters accurately—particularly speed endurance. The study further examines the influence of these technologies on the targeted physical fitness elements and tactical behaviour of players from Al-Qasim Sports Club in the Iraqi Professional League. and this achieves one of the sustainable development goals of the United Nations in Iraq which is (Quality Education).

Keywords: Artificial intelligence, Football players, Polar h10 sensors, Speed endurance

1. Introduction

In the modern era, artificial intelligence (AI) has become the primary bridge between humans and the challenges they face, owing to the remarkable advancements it has achieved in recent years. AI is now utilized across various industrial sectors, including sports, with a particular emphasis on football. In this field, AI is employed in training processes through sensor-based models that connect players via satellite systems to monitor their movements during both training sessions and competitive matches. This technological integration has made the training process significantly more accurate, competitive, and efficient. Moreover, AI assists coaches in predicting and analyzing athletic performance, as well as assessing player levels and identifying areas for improvement.

Regulating the training load for speed endurance through mechanisms that align the components of external load (intensity, volume, rest) with internal load (expressed through heart rate) can produce precise effects on the level of specific physical fitness in football

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players—particularly when integrated with artificial intelligence technologies.

In light of this, the significance of this study lies in the scientific regulation of training load for speed endurance during the specialized preparation phase, utilizing artificial intelligence to examine its impact on selected elements of specific physical fitness and tactical behaviour in football players. This is achieved through the use of Polar sensors, which function reliably under various environmental conditions and are connected to an iPad device. These sensors allow real-time monitoring of heart rate, distance, average speed, energy expenditure, and power output during training performance.

This approach has contributed to making the training process highly regulated and well-documented, eliminating reliance on subjective self-assessment and instead enabling objective evaluation of physical load. By receiving real-time data from the athlete and inputting it into a pre-established difficulty equation, it becomes possible to determine the intensity level instantaneously—without resorting to manual calculations that involve summing and averaging, which are time-consuming and prone to human error, especially under fatigue or time pressure. In contrast, these automated calculations are consistently accurate and free from such errors.

Through this framework, the researcher aspires to arrive at results that highlight for coaches and sports professionals the critical importance of scientifically regulating training load. The core research problem lies in the fact that speed endurance training units have not been structured according to physiological changes in the functional systems associated with heart rate—despite their direct impact on the targeted physical fitness component. This shortfall is largely attributed to the unavailability of advanced tools and technologies required for precise measurement and load adjustment.

The researcher made use of Polar H10 sensors, taking advantage of their capabilities to monitor the athlete's physical and physiological condition in real time. These sensors are among the latest technological tools used to track training load, helping to determine whether the athlete is within the targeted training intensity, exceeding it, or falling short—particularly during speed endurance training.

The sensors transmit real-time data on various physiological and physical parameters, including heart rate, distance, and speed. These measurements are then incorporated into a pre-prepared training load equation using an Excel-based difficulty model, enabling the calculation of the instantaneous training load imposed on the athlete. Training is conducted in accordance with energy production systems—specifically the lactic acid system—by employing artificial intelligence technologies to regulate work and rest intervals during training, as aligned with the intended objectives and heart rate targets (Al-Janabi and Taha, 2023). This approach is consistent with the broader application of modern technologies in training, which enable the efficient use of effort, time, and financial resources, ultimately contributing to the achievement of optimal performance levels. Accordingly, the training process becomes more precise in assigning training loads to the players of Al-Qasim Sports Club, which competes in the professional football league. This study aimed to investigate the effect of speed endurance training—guided by artificial intelligence technologies—on selected components of specific physical fitness and tactical behaviour among Al-Qasim Football Club players in the professional league.

The researchers hypothesized that speed endurance exercises implemented through artificial intelligence techniques would have a significant impact on improving specific physical fitness elements and tactical behaviour in professional football players of Al-Qasim Club.

2. Methodology and procedures

2.1. Research method

The nature of the problem being studied, along with the objectives established by the researcher, led to the selection of the most suitable methodology, which was determined by the specific conditions of the study. Al-Dalawi and Mardan (2021) emphasized that the experimental method, involving two equivalent groups experimental and control with a pre-test and post-test design, is well-suited to the nature of the research and is expected to yield accurate results.

Research population and sample

The research population consisted of players from the Iraqi Professional League for the 2024-2025 football season. The sample was selected from the players of Al-Qasim Sports Club, comprising a total of 24 players. These players were divided into two groups: a control group and an experimental group, with 10 players in each group. The players were chosen using random stratified sampling. Goalkeepers (3 players) and one injured player were excluded from the sample.

Tools, equipment, and resources used in the research

1. Questionnaire
2. Tests and Measurements

3. Polar H10 Device, GPS (10 units), and Difficulty Equation Program (Excel)
4. Drone Camera
5. Height and Mass Measuring Device
6. Stopwatches (4 units) and Fox Whistles (2 units)
7. Measuring Strips (50 units) and Large and Small Markers (30 units)
8. Football Balls (20 units)

Homogeneity of the research sample

The researchers ensured the homogeneity of the sample members to control for variables such as age, weight, height, and training age, in order to attribute any differences between the two groups to the experimental factor, which was then statistically processed using appropriate methods (Saleh and Hammad, 1985).

Equivalence and the research sample members

The researchers ensured homogeneity among the sample members to control for individual differences in variables such as age, weight, height, and training age. This step was essential to attribute any differences between the two groups solely to the experimental factor, with appropriate statistical procedures applied to validate this control.

As for the equivalence between the experimental and control groups, the researchers conducted tests for equivalence across both the study variables and the dependent variables. This approach aligns with Huwaidi (2021), who emphasized that equivalence is necessary to ensure the validity of group comparisons. Similarly, Matar (2019) noted that "equivalence refers to the statistical determination of whether the difference between the means of two or more groups is non-significant, indicating that their average scores do not differ to a statistically meaningful extent. When this condition is met, the groups are considered equivalent" (p. 5).

Field research procedures

- Identification of Physical Variables and Their Tests
- Identification of Tactical Behavior and Its Tests

Identification of physical variables

In order to identify the most important physical variables for football players that serve the objectives of the research, a review of the content analysis of scientific sources was conducted. Based on the researchers' experience as fitness trainers in the Iraqi Professional League, it was agreed to train the specific endurance elements (speed endurance). The physical fitness elements to be measured were identified, as they are considered to be the independent variables that may influence them.

Physical tests

1. **Test of Visual Response Speed in Three Directions** (Al-Rubaie and Al-Mawla, 2016)
   The name of the test: Test of Visual Response Speed in Three Directions, as shown in Appendix (1-1)
   Recording: The total time between the appearance of the red light and its extinction is recorded for three varied attempts.
2. **Zigzag Running in the Shape of an "8" (**Hassan, 1998).
   Objective of the Test: To measure agility, as shown in Appendix (1-2).
   Recording: The shortest time recorded by the player from the start line to the finish line is recorded.
3. **Speed Endurance Test (40m × 5) Multistage (**Al-Rubaie and Al-Mawla, 2016). As shown in Appendix (1-3)
   Recording: The shortest time for the subject is recorded based on the specified distance.
4. **Maximum Speed Test, 30m from a Standing Position (**Al-Rubaie and Al-Mawla, 2016) As shown in Appendix (1-4).
   Recording: The shortest time for the subject is recorded based on the specified distance.
5. **Explosive Strength Tests**
   Test Name: Explosive Power of the Legs. Appendix (1-5)
   Identification of Tactical Behavior Variables and Their Tests

The researchers identified the variables through testing, which involved assessing the players' knowledge of tactical behavior during game performance.

Required Equipment

An evaluation form reviewed by a panel of experts (for performance assessment), a football field, remotely operated video cameras (drones), and a stopwatch.

Test Duration:
45 minutes

1. Knowledge of Performance Evaluation for Gameplay

The performance of the game will be evaluated using the performance evaluation system developed by

(Judith & Lida, 2006) which is designed to suit both team and individual open games. It includes 7 sections on the player's tactical movements during the game. The system also includes an observation form for game analysis, aimed at providing an accurate picture of gameplay performance. The game situations are categorized into two main cases:

Appropriate performance level

Inappropriate performance level

The performance is recorded with statistics in the observation form by the experts. A scale can be used for repeated testing and distinguished by five levels as follows:

- Very Good Performance (5 points) - Appropriate
- Good Performance (4 points) - Appropriate
- Average Performance (3 points) - Appropriate
- Poor Performance (2 points) - Inappropriate
- Very Poor Performance (1 point) – Inappropriate

2. Tactical Performance Regulation Section:
– Components of Tactical Performance Regulation:

1. **Proper Movement** (Adjusting to the demands of gameplay)
2. **Decision-Making**
3. **Skill Execution**
4. **Support**
5. **Cover**

3. Method for Calculating Tactical Performance Evaluation Scores:

First:

A. Evaluation of each tactical performance component individually:
$= \frac{\text{Number of appropriate repetitions}}{\text{Number of inappropriate repetitions}}$ and this is done for each player and for the rest of the items accordingly
B. The number of repetitions is then converted into scores. As previously indicated, the outcome will be a single numerical value.

Second:

A. Calculating the overall performance evaluation level for each player and all items: $= \frac{\text{Result of the first item + result of the second item + result of the third item + } \ldots}{\text{Total number of items used}}$
B. After obtaining the result for each player, we calculate the mean (average) for both the experimental group and the control group.
C. Then, we compare the first experimental group with the second experimental group in terms of means and standard deviations to determine which group shows better results.

2.2. Pilot study

The researchers conducted this exploratory experiment on Thursday, August 29, 2024, at 5:00 PM, at the Local Administration Stadium in Babylon Province, which is affiliated with the Ministry of Youth and Sports. The purpose of this study was to identify the appropriate timing for implementing the main experiment by determining the duration of each test and exercise. It also aimed to explore how the exercises should be applied, identify any errors or obstacles that may arise, and assess the readiness and capability of the supporting team.

Additionally, the study sought to evaluate the suitability of rest intervals between repetitions and exercises, as well as to determine the appropriate number of repetitions for the various exercises by measuring the peak heart rate during each activity using the (Polar H10 GPS) device. The difficulty level was calculated using Excel, and the study also ensured the safety and functionality of the equipment used to determine exercise intensity at 100%.

3. Main experiment

The researchers conducted this experiment on Saturday, August 31, 2024, at 5:00 PM, at the Local Administration Stadium in Babylon Province, which is affiliated with the Ministry of Youth and Sports. The following was implemented:

3.1. Pre-test

1. The physical tests were conducted over the course of two days, as follows:

3.2. The first day

A. Visual Reaction Speed (Three-Direction Test)
B. Agility (Zigzag Running Between Cones)

3.3. The second day

A. Vertical Power using the Sargent Jump Test (for the dominant leg, non-dominant leg, and both legs)
B. Speed (30 meters) from a standing start
C. Speed Endurance (5 × 40 meters)

2. Conducting the tactical behavior test by dividing the research sample into two groups, as previously mentioned: an experimental group of 10 players and

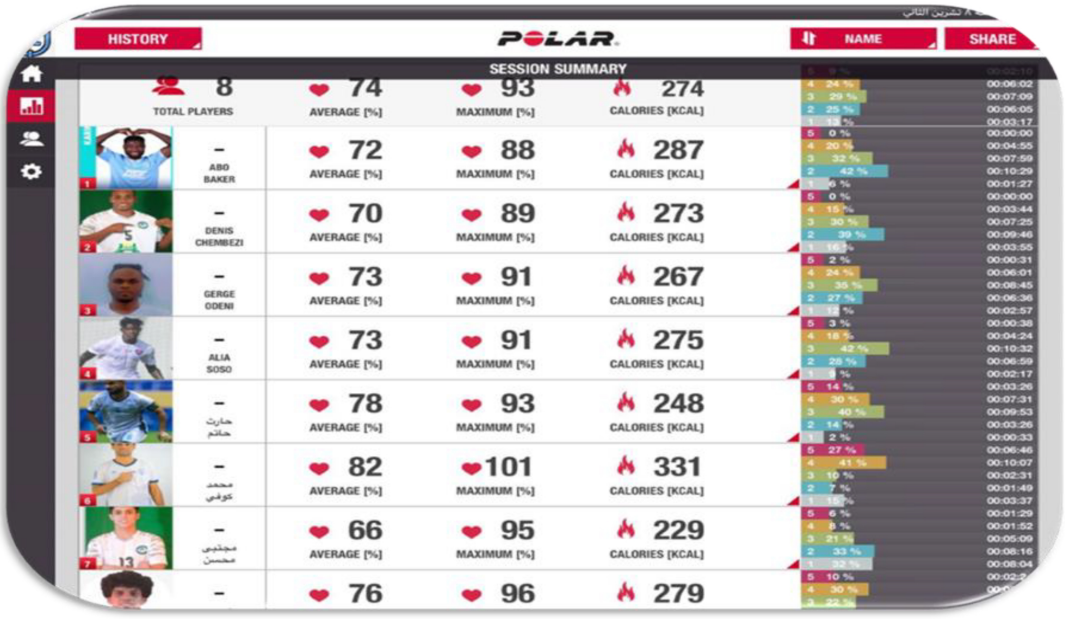

Fig. 1. It shows the interface of the (Polar H10 Team) program.

a control group of 10 players. Each group represents a team, and the tactical behavior of each team is evaluated.

The exercises prepared by the researchers

The researcher developed exercises based on scientific sources and expert opinions, aimed at improving speed endurance during the specific preparation period. The program consisted of 2 training sessions per week for a duration of 6 weeks, from September 1, 2024, to October 15, 2024. The training days were as follows: Monday and Wednesday for speed endurance.

The researchers used the following methods: (High-intensity interval training and repeated efforts) (Al-Dalawi, 2011).

The researchers calibrated the workload using artificial intelligence and modern technologies, as shown in the images below. The highest heart rate was determined using the Polar H10 device during the maximum test for the trained physical attribute (speed endurance), as shown in (Fig. 1). After determining the maximum intensity, the intensity for each exercise was set based on the maximum intensity of the trained physical element, as illustrated in Fig. 2, which shows the maximum intensity for the exercises and the highest heart rate. Appendix 2 shows some of the speed endurance exercises.

Post-test

After the completion of the training period, the researchers, with the assistance of the support staff, conducted the post-test at 5:00 PM on Thursday, October 22, 2024, at the Local Administration Stadium in Babylon Governorate, affiliated with the Ministry of Youth and Sports. The tests were conducted at the same time and in the same sequence as the pre-test, as follows:

Statistical Methods: The researchers used the SPSS statistical software.

4. Displaying, analyzing, and discussing the results

4.1. Displaying, analyzing, and discussing the difference between the pre-test and post-test in the specific physical fitness elements and tactical behavior of the control group

The results presented in the Table 1 clearly indicate statistically significant differences between the pre-test and post-test scores in several variables, as evidenced by the significance levels observed in the speed endurance test, right leg power, left leg power, agility, maximum speed, and tactical behaviour. All of these differences were in favour of the post-test, indicating noticeable improvements.

However, for bilateral leg power and visual reaction speed, the differences between the pre-test and post-test in the control group were statistically non-significant. A significant improvement at the 0.05 level was observed only in the speed endurance variable for the control group, with the post-test outperforming the pre-test. This improvement can be attributed to the coach-designed training program, which emphasized endurance training aligned with

Fig. 2. It shows the five intensity levels of the (Polar H10).

Table 1. Shows arithmetic means, standard deviations, and T-value for the paired samples, indicating the difference for the control group between the pre-test and post-test.

			Pre-test		Post-test				
No.	Test Name	Measurement Unit	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Significance Level	Calculated(t) value	Difference
1	Speed endurance	Second	33.5	1.86	32.13	1.81	0.00	9.59	Significant
2	General ability	cm	75.4	4.94	76.6	3.90	0.73	0.35	Random
3	Right-side ability	cm	90.8	1.25	94.7	5.24	0.03	2.66	Significant
4	Left-side ability	cm	84.9	3.86	86.4	1.74	0.00	5.58	Significant
5	Response speed	Second	3.30	0.08	3.25	0.21	0.65	4.10	Random
6	Agility	Second	4.62	0.15	4.33	0.24	0.00	5.08	Significant
7	Maximum speed	Second	4.18	0.25	4.10	0.20	0.01	3.05	Significant
8	Tactical behavior	degree	67.3	2.15	72.1	1.64	0.01	3.28	Significant

the specific demands of the game. This finding is supported by Al-Dalawi (2011), who noted that the most effective way to enhance performance is by conducting training that closely simulates the conditions of actual competition, thereby increasing training specificity.

Furthermore, as Al-Madamgha (2008) pointed out, many skills in football depend on complex physical capacities, particularly the integration of speed and endurance or the combination of power and endurance. These combined capacities require special attention from coaches, who must consider the principle of progression from simple to complex during training sessions.

With regard to power development, whether for the dominant or non-dominant leg, it remains crucial for football players in executing basic skills as well as sport-specific physical demands—such as striking the ball or jumping for headers. This aligns with the assertion made by Al-Lami (2010), who emphasized that when developing sport-specific physical fitness components, the range of motion should correspond to the anatomical structure of the relevant joints in the specialized sport, thereby contributing significantly to the enhancement of technical performance.

Finally, the tactical behaviour of the control group also showed notable improvement, as evidenced by the statistically significant differences between pre-test and post-test scores. This progress can be attributed to enhancements in specific physical fitness elements and speed endurance among the football players.

Table 2. Shows the means arithmetic mean, standard deviations, and T-value for the paired samples, and indicates the difference for the experimental group between the pre-test and post-test.

No.	Test Name	Measurement Unit	Pre-test		Post-test		Significance Level	Calculated t-value	Difference
			Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
1	Speed endurance	Second	33.325	1.41	30.19	1.41	0.00	16.29	Significant
2	General ability	cm	73.4	4.28	81.2	4.28	0.00	13.59	Significant
3	Right-side ability	cm	92.9	6.18	99.6	6.18	0.00	8.00	Significant
4	Left-side ability	cm	85.1	15.67	87.4	15.67	0.00	6.26	Significant
5	Response speed	Second	3.33	0.11	3.089	0.11	0.00	7.70	Significant
6	Agility	Second	4.61	0.19	4.04	0.19	0.00	10.16	Significant
7	Maximum speed	Second	4.22	0.05	4.05	0.05	0.00	9.83	Significant
8	Tactical behavior	degree	68	1.67	74	1.67	0.00	4.18	Significant

4.2. Presentation, analysis, and discussion of the differences between pre-tests and post-tests in the specific physical fitness elements and tactical behavior of the experimental group

It is evident from the Table 2 that there are significant differences between the pre-test and post-test by observing the significance levels for speed endurance, leg power (both legs), response speed, agility, maximum speed, and tactical behavior for the paired samples of the experimental group, in favor of the post-test. This indicates that the specific endurance (speed endurance) of the experimental group participants improved, as the training program designed by the researchers contributed to enhancing their physical fitness through the exercises and the structured program applied to the sample. The continuous improvement observed confirms the development of the physical variables in the experimental group in the post-test (Hamad, 1994a).

The researchers attribute this development in the physical variables in the post-test for the experimental groups to two main reasons. The first reason is the improvement in the quality of speed endurance, which resulted from the nature of the exercises used during the training process—exercises that were based on scientific principles in terms of intensity, number of repetitions, and rest intervals. This is supported by Al-Janabi and Taha (2023), who stated that using advanced techniques helps in identifying the immediate effects of training on athletes during the training process, especially regarding the component of speed endurance, which functions under the anaerobic lactic system. This system requires precise monitoring of pulse variables and adherence to its physiological demands. The use of such techniques (e.g., Polar H10) clearly demonstrated the effect of training on the post-test result, which aligns with the principles of sports training science.

Khuraibet (1988) confirmed in his study that programmed training based on scientifically correct methods and the principle of gradual increase has a positive effect on trainees. In addition, specific endurance training leads to significant athletic development, as it creates suitable conditions for the assimilation of technique according to the type of sport practiced.

The second reason, as noted by Al-Basati (1998), is that the observed improvement in physical performance can be attributed to the exercises employed during training, which contributed to enhancing the players' physical and technical abilities. He explains that "a set of exercises or targeted physical efforts lead to adaptations or functional changes in the body's internal systems in order to achieve a high level of athletic performance" (p. 3).

This is also confirmed by Saleh and Hammad (1985), who stated that "using sport-specific training based on the practiced activity (training specificity) leads to improvements in skill-related aspects. Accordingly, the physical attributes of a football player largely determine the efficiency of both technical and tactical performance during a match" (p. 178).

4.3. Presentation, analysis, and discussion of the difference between the post-tests in physical abilities for the experimental and control groups

Table 3 show the results of the research sample in the variable under study for the pre-test and post-test of the experimental group.

Table 3. It shows the arithmetic means, standard deviations, and the value of (T) for the independent samples, and presents the difference between the experimental and control groups in the pre-test and post-test.

No.	Test Name	Measurement Unit	Pre-test		Post-test		Significance Level	Calculated(t) value	Difference
			Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
1	Speed endurance	Second	32.13	1.81	30.19	1.41	0.02	2.57	Significant
2	General ability	cm	76.6	3.90	81.2	4.28	0.00	9.91	Significant
3	Right-side ability	cm	94.7	5.24	99.6	6.18	0.00	6.56	Significant
4	Left-side ability	cm	86.4	1.74	87.4	15.67	0.00	4.50	Significant
5	Response speed	Second	3.25	0.21	3.08	0.11	0.04	2.22	Significant
6	Agility	Second	4.33	0.24	4.04	0.19	0.04	2.29	Significant
7	Maximum speed	Second	4.10	0.20	4.05	0.05	0.04	2.26	Significant
8	Tactical behavior	degree	72.1	1.64	74	1.67	0.00	8.01	Significant

The arithmetic means showed statistically significant improvements in the tests of speed endurance, bilateral leg power, right leg power, left leg power, reaction speed, agility, maximum speed, and tactical behavior at a significance level of less than (0.05). This indicates that there are statistically significant differences between the pre-test and post-test results for the experimental group, in favor of the post-test. The researchers attribute this improvement to the effectiveness of the training program, as emphasized by Hamad (1994), who noted that tactical preparation of football players is extremely important and must receive equal attention from the coach, as well as its fair share in training.

As confirmed by Hanafi (1980) "The coach must work on developing the player physically, technically, tactically, and psychologically in a way that aligns with the requirements of the modern player" (p. 12)

The researchers observed in Table 3 that the experimental group outperformed the control group in tactical behavior. This significant improvement is attributed to the type of exercises used, which included various specific endurance drills combined with the execution of rapid tactical skills. These exercises aimed to achieve quick progression and a direct connection between skill execution and speed of performance (Issam, 1999). Nearly every drill incorporated tactical and technical elements, performed under conditions that simulated real game situations. The researcher designed these exercises to closely resemble actual gameplay. The repeated application of such drills in the training sessions contributed to improving the players' execution time, as continued practice required them to perform in the shortest possible time during the game to achieve the intended objective, scoring against the opponent. As stated, repeating complex drills that combine specific physical and technical elements within a tactical sequence, particularly those that closely resemble real game situations, can reduce the player's reaction time and enhance their ability to respond quickly in tactical scenarios. The researchers believe that the nature of the exercises, which mimicked real match situations, significantly contributed to players' spatial awareness, enabling them to position themselves in key areas more effectively, thus facing the goal faster and more efficiently. This had a positive impact on the development of tactical behavior.

As emphasized by Hamada (1998) "It is essential to achieve an optimal balance between the level of physical traits necessary for specialized sports (football), which allows for the best and most accurate execution of skill, tactical, and mental performance. Without high levels of the physical traits specific to the game and the type of skill performance, it would be difficult to achieve the goals of developing physical, skill, tactical, and mental performance. He adds that to achieve the goals of developing physical, skill, and tactical performance, it is necessary to execute good, fast, and repetitive performance, using performance difficulty to simulate conditions similar to real game situations the match (p. 211–212).

This training includes physical, skillful, and tactical aspects, and has worked on the development of speed endurance and performance speed. Radcliffe and Farentinos (1999) confirm that proper regulation of training loads at various levels, related to the type of

specialized game football is crucial for both the coach and the player when preparing training programs and when using different training methods and modern techniques to control the load on the player's functional systems. This contributes to influencing them as needed while monitoring each player carefully.

Hussein (1983) confirmed that "the training process is a developmental process aimed at improving and developing physical abilities in order to achieve the best performance" (p16)

Al-Janabi and Taha (2023) mentions that "'the closer the training conditions are to the competition conditions (the match), the more beneficial the training is for the player and it helps achieve the goal of reaching match performance levels. This is what actually helped in developing the variables under study." (p. 200)

5. Conclusions

1. Speed endurance training using artificial intelligence techniques has developed the specific fitness elements for the football players of Al-Qasim Sports Club in the Professional League."
2. Speed endurance training, using artificial intelligence techniques, has developed the tactical behavior specific to the football players of Al-Qasim Sports Club in the Professional League.
3. The experimental group outperformed the control group in the specific fitness components and tactical behavior in the post-tests of the football players of Al-Qasim Sports Club in the Professional League (Hamada, 1994b).

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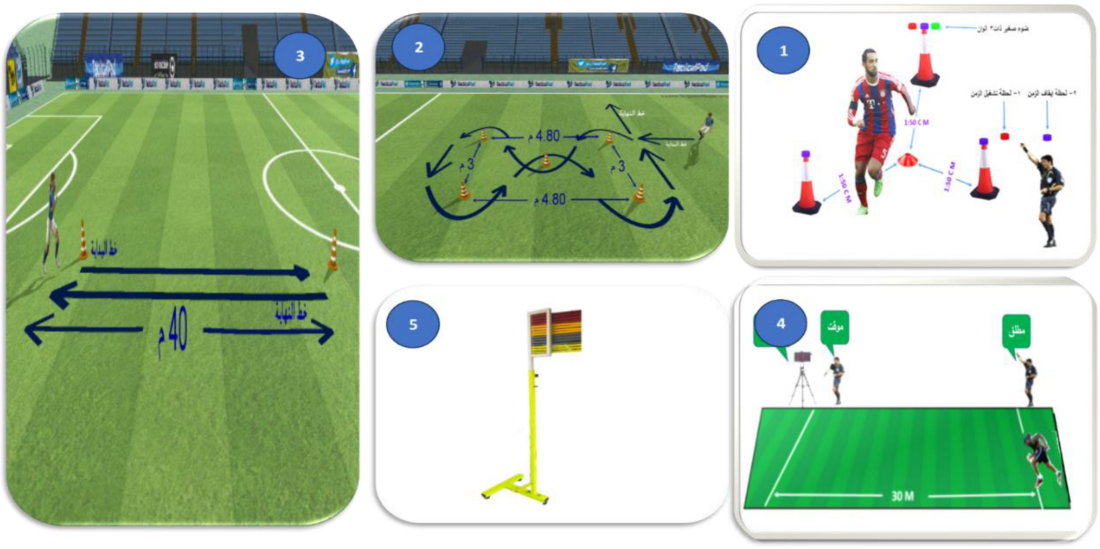
A. Appendix 1

Shows the test forms



B. Appendix 2

Presents examples of speed endurance exercises