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SPECIAL ISSUE ARTICLE

The Effect of Training Exercises Using an Innovative Device on Developing Skill Performance Among Female Foil Fencers

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Abstract

The researchers turned to modern technology and artificial intelligence by integrating equipment into the training process. This integration aimed to optimize time and reduce boredom and physical strain in both the instructional and training processes of fencing, through the development of exercises utilizing a device designed to regulate the distance between the feet during advance and retreat movements, with the goal of reaching higher levels of skill performance. This led to the following research question: Does training with the aid of an innovative device positively influence the development of skill performance? The researchers employed the experimental method due to its suitability for the research problem. The research sample consisted of 14 female foil fencers from the College of Physical Education and Sport Sciences for Women at the University of Baghdad during the 2023–2024 athletic season. The participants were divided into two groups: a control group and an experimental group. A skill performance test in foil fencing was administered using a fixed dummy (partner) holding a weapon. The test was documented using video recordings for both pre- and post-tests, and the performance was evaluated using a standardized fencing assessment form scored on a scale from 1 to 10, with the mean score calculated for each participant. Training sessions for the experimental group included the use of the innovative device. The researchers applied appropriate statistical methods to analyze the test results and concluded that the exercises implemented by both research groups contributed to improving skill performance. However, the experimental group, which used the innovative device, outperformed the control group. Accordingly. And this achieves one of the sustainable development goals of the United Nations in Iraq which is (Quality Education).

Keywords: Exercises, Innovative device, Skill performance, Foil fencing

1. Introduction

Exercises play a vital role in preparing athletes both physically and skillfully across various sports disciplines, in accordance with the nature of the sport and the targeted group. They represent a fundamental component of the training session, and for the training unit to be productive and objectively driven, these exercises must be impactful, effective, and aligned with specific conditions and standards that ensure the achievement of training objectives—particularly when performed using modern tools and technologies in sports training. In today's world, rapid technological advancement is evident across all fields, and the sports domain is no exception. Technological progress has contributed significantly to the modernization of training tools and diverse methods aimed at improving athletic performance and achieving training goals in a shorter time and with less effort. This has led to swift developments in training methods and strategies in recent years, particularly through the integration of artificial intelligence

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technologies. As a result, coaches now continuously seek the latest innovations in the field of sports training to enhance their athletes' performance, achieve positive outcomes, and reach elite competitive levels.

Fencing is one of the sports that requires thorough preparation and continuous training to achieve optimal results. Training must be carried out in a scientifically planned and methodical manner to help the athlete reach their goals by refining and improving the execution of technical skills, mastering defensive positions, and performing offensive movements.

According to Hazem (2017), skill performance is the ultimate outcome of training, achieved through the athlete's ability to apply all technical skills in order to reach accuracy, efficiency, and correct execution during play.

Maleh (2008) also emphasized that one of the most important factors contributing to the success of an offensive move is the accurate selection of timing and the appropriate distance, while ensuring precision in execution.

Furthermore, Maleh and Hashem (2023) asserted that the application and implementation of exercises in training sessions have recently come to rely on various training tools based on modern technology and techniques, as they provide motivation and clarity during training, making it easier for both the coach and the athlete to define and achieve the intended goals. The use of devices and tools in learning, training, or assessment helps coaches demonstrate the required skill or exercise and evaluate the capabilities of fencing athletes.

The significance of the current study lies in developing exercises using an innovative device, which is expected to positively affect skill performance.

1.1. Research problem

As the researchers themselves are fencing athletes, and through reviewing the available literature and references related to fencing, it became evident that the sport encompasses numerous skills that require a significant amount of time to master. To address this challenge, the researchers turned to modern technology and artificial intelligence, integrating a training device into the training process to optimize time and reduce both fatigue and monotony—whether in instructional or training contexts. This led to the development of a device designed to help regulate the distance between the feet during advancing and retreating movements, aiming to improve technical performance and help athletes reach higher levels of skill execution.

Accordingly, the researchers formulated the following question:

- *Does training using the newly developed device have a positive effect on the development of skill performance?*

1.2. Research objectives

1. To design exercises using the innovative device for female foil fencers.
2. To identify the differences between the pre- and post-tests in skill performance within the experimental and control groups of female foil fencers.
3. To identify the differences between the experimental and control groups in the post-tests regarding skill performance among female foil fencers.

1.3. Research hypothesis

1. The innovative device has a positive effect on the development of skill performance among female foil fencers.

1.4. Scope of the research

1. **Human Scope**: Female fencers from the College of Physical Education and Sport Sciences for Women at the University of Baghdad for the 2023–2024 athletic season, totaling 14 athletes.
2. **Time Scope**: From October 7, 2023, to August 18, 2024.
3. **Spatial Scope**: Fencing Hall, College of Physical Education and Sport Sciences for Women, University of Baghdad.

1.5. Definition of terms

1.5.1. Innovative device – operational definition

An innovative device is defined as the design and development of a new concept that has not been previously explored, established on scientific principles under the guidance of engineers and relevant specialists. It has been evaluated and approved by the Central Organization for Standardization and Quality Control.

2. Research methodology and field procedures

2.1. Research method

One of the most critical factors for the success of scientific research is **determining the methodology best suited to solving the research problem**. As Maleh and Benjamin (2021) noted, selecting a method that

is appropriate for the research problem is among the most important steps toward ensuring the success of the scientific process, as the methodology must align with the nature of the problem and the objectives to be achieved.

Accordingly, the researchers adopted the **experimental approach** due to its relevance and suitability to the nature of the research problem.

2.2. Research population and sample

One of the essential foundations of scientific research is the precise identification of the research population. Accordingly, the research population was defined as female foil fencers from the College of Physical Education and Sport Sciences for Women at the University of Baghdad for the 2023–2024 sports season, totalling fourteen (14) athletes. These participants were divided into two groups: an experimental group and a control group. The entire population (100%) was selected as the research sample.

The normal distribution of the research population was assessed using the skewness coefficient across the variables of chronological age, training age, height, and body mass. The results indicated that the population distribution was normal and homogeneous, as one of the characteristics of homogeneity is that the skewness coefficient should fall within the range of (+1) to (−1).

2.3. Instruments, tools, and equipment used in the research

- Arabic sources and references
- Skill performance evaluation form
- Fencing court
- Foil weapons (14)
- Notebook and pens for recording data and observations
- Wooden training targets (2)
- Transparent adhesive tape (1 roll)
- Colored permanent marker
- Lenovo laptop (1)
- Video recording camera (1)

2.4. Field procedures

2.4.1. Skill performance tests in foil fencing

The skill performance test in foil fencing was conducted in front of a fixed target or an opponent, using the athlete's weapon-holding arm. The pre- and post-tests were video-recorded and evaluated based on a standardized scoring form established in fencing. Scores ranged from 1 to 10, and the average score was calculated. The evaluation method, as adopted in the study by Al-Haddad et al. (2022), relies on analyzing movement patterns by recording the skill performance and presenting the footage to three expert judges for assessment.

2.4.2. The skill performance tests included the following

First Test:

The athlete stands in the "on guard" position while holding the foil. Upon hearing the command "Start," she takes one step forward, then retreats one step, advances one more step, and performs a direct thrust at the dummy. She then retreats two consecutive steps, advances two consecutive steps, and delivers another direct thrust at the dummy.

- **Scoring:**
  Performance is evaluated on a 10-point scale using the standardized fencing assessment form, and the final score is calculated as the arithmetic mean of the three judges' ratings.

Second Test:

The athlete stands in the "on guard" position while holding the foil. Upon hearing the command "Start," she takes one step forward, executes a simple parry on the dummy, and follows it with a thrust to score a touch. She then retreats one step, advances another step, and performs an attack involving a change of direction.

- **Scoring:**
  Performance is evaluated on a 10-point scale, and the final score is determined by the arithmetic mean of the judges' ratings.

Third Test:

The fencer begins in the "on guard" position while holding the foil. Upon hearing the command "Start," she takes one step forward and performs a circular thrust attack to score a touch. She then retreats one step, advances one step, and delivers a cutting attack from bottom to top.

- **Scoring:**
  The performance is evaluated on a 10-point scale using the standardized assessment form, and the final score is based on the arithmetic mean of the judges' ratings.

3. Design and development of the innovative electronic device

3.1. Core concept of the innovative electronic device

The core idea behind designing and developing the innovative electronic device is to measure the distance

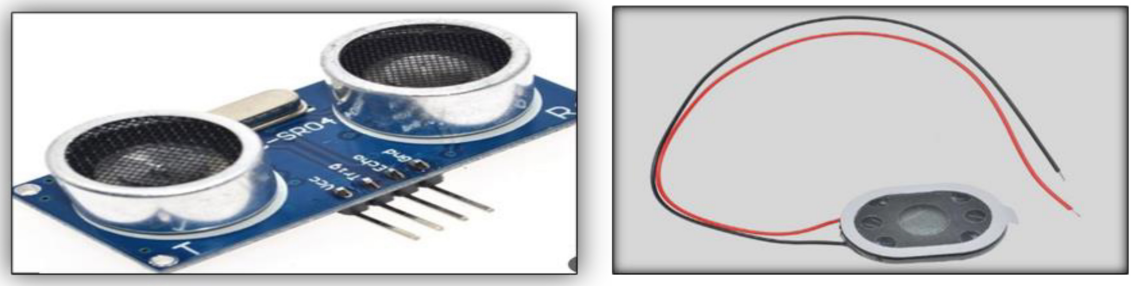

Fig. 1. Shows an image of the distance-measuring sensor (HC-SR04 Ultrasonic Sensor).

between the feet during performance and to identify weaknesses resulting from improper spacing. This allows for targeted training to correct these issues. The device provides essential information and real-time feedback to the athlete regarding the optimal foot spacing required for peak performance during advancing and retreating movements. Additionally, it supports the coach's ability to correct errors related to spacing, thereby reducing mistakes caused by improper foot distance during performance.

3.2. *Device manufacturing stages*

After identifying the primary purpose of designing and manufacturing the device for the sport of fencing, a qualitative analysis of footwork performance across various fencing competitions was taken into consideration. This process involved reviewing relevant resources through the global information network (Internet) and consulting with specialists in biomechanics, artificial intelligence, information engineering, and communication technologies. Expert advice was obtained regarding the feasibility of designing and manufacturing the device locally. Following multiple trials conducted over a continuous period of more than six months—during the preparatory year (the guidance and seminar phase)—and in collaboration with a specialist engineer in microcontroller systems, the device was successfully developed. The operational mechanism of this device differs from other tools used to measure foot spacing during performance. Most existing tools rely on video motion analysis, which, in some research, fails to deliver precise measurements of foot distance. This limitation represents a significant drawback, especially considering that accurate foot spacing is a critical training indicator. The innovative device, therefore, provides precise results for measuring the distance between the feet, with a margin of error as low as 0.03. The sensor utilized in the device features high measurement accuracy in accordance with its technical specifications. See Fig. 1.

Fig. 1 shows the distance-measuring sensor, which is a device that measures distance using ultrasonic wave reflection technology (HC-SR04 Ultrasonic Sensor).

3.3. *Main components and specifications of the innovative electronic device*

The device consists of two primary parts:

Part One: Data Recording Unit, which includes the following components:

- A plastic casing measuring 15 cm in width, 10 cm in length, and 6 cm in height.
- A distance-measuring sensor (Ultrasonic): This sensor operates using ultrasonic wave reflection technology. It emits an ultrasonic sound signal (commonly known as a *ping*) and waits for the returning echo after the signal reflects off a surface.
- By applying the known speed of sound in the given medium, the device can calculate the distance traveled by the ultrasonic wave to the barrier and back. By measuring the time interval between emission and reception of the sound wave, the device can determine the distance with high accuracy. This allows users to precisely identify positions and interact effectively with their surroundings.

The specifications of the sensor are presented in Table 1.

Table 1. Presents the specifications of the sensor.

Electric Parameter	
Working Voltage	DC 5V
Working Current	15 mA
Working Frequency	40 Hz
Max Range	4 m
Min Range	2 cm
Measuring Angle	15 degree
Trigger Input Signal	10uS TTL pulse
Echo output Signal	Input TTL lever signal and the range in proportion
Dimension	$45 * 20 * 15$ mm

The Table 1 presents the fundamental technical specifications of the sensor used in the design, which serve as the basis for determining the devices efficiency and the accuracy of its measurements.

- A loudspeaker with a power output of 1 watt and an impedance of 8 ohms (Loudspeaker 1 W 8 Ω, small trumpet type, 14 × 20 mm).
- Connection cables measuring 1.5 meters in length.
- One power switch.
- Two LED indicators to show device operation status.
- Two buttons: one for starting and stopping the device's operation, and another to enable its function when connected to a laptop.
- A 16 MB memory module for storing device data.
- A 9-volt lithium battery to power the device.

Part Two: This component connects to the computer to receive data and includes the following materials:

- Arduino Microcontroller: Equipped with a USB port and a power button, it can be easily integrated into various projects that require a compact microcontroller with high capabilities.

Table 2 presents the technical specifications.

Table 2. Presents the capabilities and technical specifications of the microcontroller.

Capabilities	Specifications
Microcontroller	ATmega32U4
Operating Voltage	5 V
Input Voltage	(recommended): 7–12 V
Input Voltage (limit):	6–20 V
Digital I/O	Pins: 20
PWM Channels:	7
Analog Input Channels:	12
DC Current per I/O Pin:	20 mA
DC Current for 3.3V Pin:	50 mA
Flash Memory: by bootloader	32 KB (ATmega32U4) of which 4 KB used
SRAM	2.5 KB (ATmega32U4)
EEPROM	1 KB (ATmega32U4)
Clock Speed:	16 MHz
LED-BUILTIN:	13
Length	48 mm
Width	18 mm
Weigh	13

Fig. 2 illustrates an image of the Arduino Micro, which features a USB port and a power button.

3.4. SD card memory module

The SD card module is particularly useful for projects that require data logging. With the use of a specialized software library, the Arduino can create a file on the SD card to write and store data. There are various models of this module available from different manufacturers; while they may vary in design, they all operate using the same communication protocol. This unit is compatible with microSD cards, and in this case, it is used to record data on a memory card with a capacity of 12 megabytes.

Fig. 4 illustrates the calibration process and verification of accurate measurement by placing an object in front of the distance sensor. The measured distance is displayed on the screen and then compared with a manual measurement using a ruler to confirm the sensors accuracy.

3.4.1. Specifications and features of the newly developed electronic device

- The weight of the first component is 110 grams (excluding batteries), with an additional 25 grams for the batteries.
- The weight of the second component, which is attached to the athlete's foot, is 33 grams.
- Device dimensions: width – 10 cm; length – 8 cm; height – 4 cm.
- Operating voltage: 9 volts.
- The device operates on a 9-volt power supply for approximately six continuous hours.
- The device is operated by pressing the power button, followed by pressing the start measurement button. Upon completing the activity, the user presses the stop recording button, then powers off the device and removes the memory module. Alternatively, data can be transferred directly to a computer by transmitting it from the sending unit to the receiving unit, where it is stored as an Excel file for statistical analysis. Thus, two data storage methods were adopted: the first through RAM memory, and the second by transmitting the data electronically to a computer and saving it in Excel format, as previously described, for statistical processing.
- One of the most distinctive features of the device is its ability to measure distance during skill performance while emitting a specific, limited-frequency sound to indicate the target distance during training.
- The device is user-friendly for coaches, having demonstrated both accuracy and efficiency in measuring and estimating the distance between the athlete's feet. When the spacing exceeds the predetermined limit, an immediate alert tone is emitted. Conversely, if the distance falls below the required threshold, a different tone with an alternate frequency is produced to inform the athlete that the spacing is insufficient particularly in the context of fencing.
- It is cost-effective.

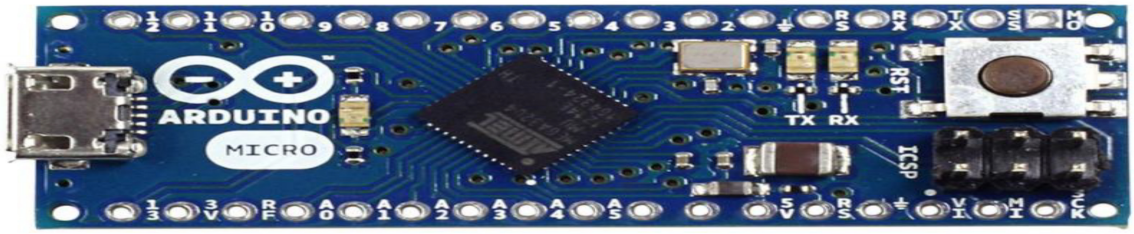

Fig. 2. Illustrates the Arduino Micro.

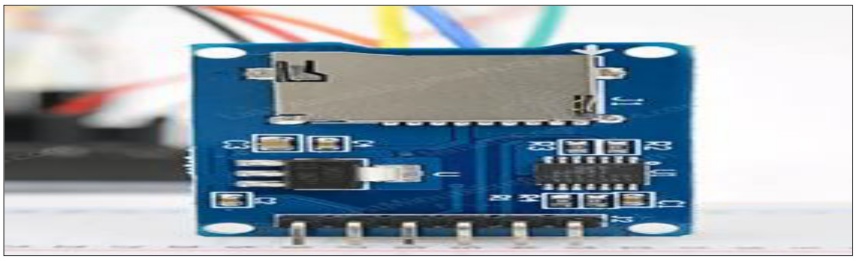

Fig. 3. Displays an image of the SD card memory module innovative device.

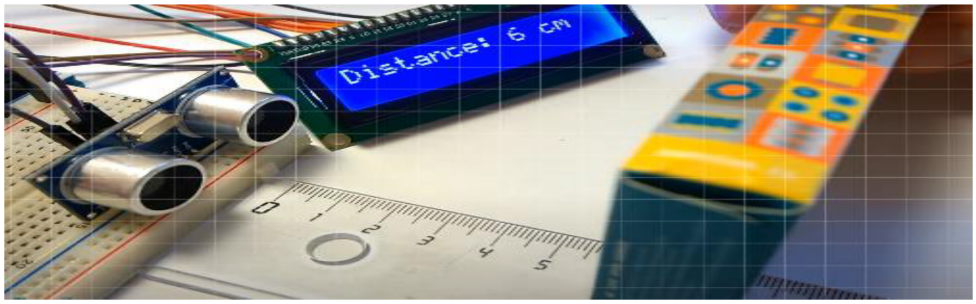

Fig. 4. Illustrates the calibration process and verification of the accurate measurement value.

- The materials required for the fabrication and assembly of the device are readily available in local markets.
- The device clearly highlights variations in footwork distances during advance and retreat movements. This allows coaches to design specialized drills aimed at improving spacing based on specific performance criteria.

3.5. Pilot study

According to Abdel Hadi (2001, p. 89), "the pilot study is a scaled-down version of the full research, conducted by the researchers to identify the potential strengths and weaknesses that may accompany the testing procedures or the main experimental steps.

The first pilot study was carried out on the research population, consisting of both the experimental and control groups (14 female athletes), due to the limited availability of female participants in the sport of fencing.

This initial pilot test was conducted on Thursday, October 12, 2023, at 10:00 a.m., and was repeated on Wednesday, October 18, 2023, in order to identify the challenges that the researchers might face during the main experiment. The primary objective of this first pilot study was to:

- Identifying potential obstacles that may arise during the administration of the tests.
- Training the supporting research team on how to conduct the tests and record the results accurately.
- Ensuring that the test instructions are clearly understood by the participants.
- Assessing the reliability and safety of the training program.
- Determining the time required to assemble and disassemble the device for each athlete, as well as the time needed to extract each athlete's results.
- Evaluating the suitability of the exercises when using the device.
- Identifying the appropriate and necessary duration for conducting the tests.
- Establishing the scientific foundations of the tests.

To determine the scientific foundations of the tests used in this research, the researchers examined key measurement properties: validity, reliability, and objectivity, as detailed below:

3.6. Device operation procedure

The process begins by formatting the memory card, which is then inserted into its designated slot in the device. Distance sensors are attached to the heel of the athlete's front foot. The athlete then assumes the (En garde) position in fencing, and the initial distance between her feet is recorded before beginning the skill performance. This initial measurement is transferred to the computer and serves as a calibration reference to ensure precise data collection and accurate individual distance assignment for each athlete. Following calibration, the athlete performs forward and backward footwork movements, with the speed tailored to the coach's requirements. During execution, if the distance between the athlete's feet exceeds the acceptable range, the device emits a specific sound to indicate that the spacing is too wide. Conversely, if the distance is less than required, a different sound with a distinct frequency is triggered to alert the athlete that the spacing is too narrow. If the distance remains within the optimal range, no sound is emitted. Once the skill movements are completed, the data recording is stopped by pressing the appropriate button. The device is then powered off, and the memory card is removed and inserted into a computer for statistical processing. The collected data for each forward and backward movement is exported into Excel spreadsheets for further analysis, as illustrated in Fig. 5.

3.7. Data recording

- Readings are collected via the memory card for each forward or backward movement performed during offensive and defensive skill execution.
- The distance between the feet is recorded to the nearest centimetre, along with the number of errors committed during performance.

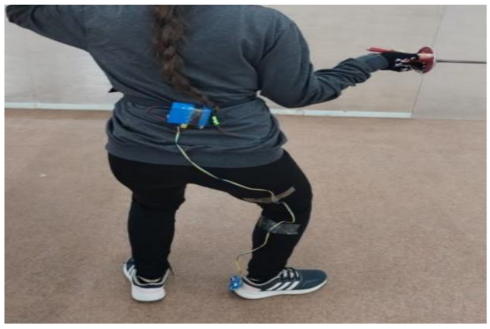

Fig. 5. Illustrates the method of connecting the device during performance.

Fig. 5 illustrates the method of attaching the device during performance. The first component is fastened around the waist, while the sensor unit is secured to the shoe in a manner that ensures accurate distance measurement.

4. Main experiment procedures

4.1. Pre-tests

The researchers supervised the administration of the pre-tests for both the experimental and control groups on Sunday, October 22, 2023, at 10:00 a.m., in the fencing hall of the College of Physical Education and Sport Sciences for Women, University of Baghdad. The pre-tests were conducted following a standardized warm-up routine for all participants in both groups. All spatial and temporal conditions were controlled and documented to ensure consistency with the conditions under which the post-tests would later be administered. Subsequently, the research sample was randomly assigned—using a lottery method based on even and odd numbers—into two groups: an experimental group and a control group, with seven athletes in each. Following the grouping, equivalence between the experimental and control groups was established based on the pre-test results. An independent samples *t*-test was used to examine differences between the two groups. The calculated *t* values indicated a significance level greater than 0.05, suggesting that no statistically significant differences existed between the two groups in the pre-test results. This confirms that both groups started from an equivalent baseline. The results are presented in Table 3.

Moreover, the homogeneity of the sample was verified through Levene's test values, as indicated by the results generated from the statistical software for the pre-tests. The findings revealed that the Levene's test values had significance levels greater than 0.05, indicating that the research sample was normally distributed under the Gaussian curve.

4.2. Device-based exercises

The researchers adopted the coach's training program for both groups; however, the experimental group performed their exercises using the device. Initially, the coach provided verbal guidance based on the auditory signals emitted by the device—indicating whether the distance between the athlete's feet was too short or too wide. Eventually, the athletes became able to independently recognize the sounds in order to adjust and maintain the correct spacing between their feet. The device was employed during

Table 3. Presents the statistical characteristics of the two research groups in the pre-tests for the purpose of establishing equivalence.

Tests	Arithmetic Mean		Standard Deviation (points)	Levene's F Value	Levene's Sig	Calculated t-Value	T-test Sig	Sig. of Differences
First Skill Performance Test	Experimental	6.71	0.75 5	0.485	.4990	0.306	0.765	Not statistically significant
	Control	6.56	0.97 6					
Second Skill Performance Test	Experimental	6.28	0.75 6	0.046	.8340	0.693	0.502	Not statistically significant
	Control	6.55	0.78 5					
Third Skill Performance Test	Experimental	6	0.8 16	1.739	.2120	0.812	0.433	Not statistically significant
	Control	5.54	1.13 3					

Statistically significant at a significance level of ≤ 0.05.

Table 4. Presents the statistical characteristics used to identify the differences between the pre-test and post-test results for the experimental group.

Tests	Arithmetic Mean (points)		Standard Deviation	Mean Difference	Degrees of Freedom	Calculated T-value	Significance Level	Sig. of Differences
First Skill Performance Test	Pre-test	6.71	0.755	2.285	1.253	4.82	0.003	Significant
	Post-test	9	0.816					
Second Skill Performance Test	Pre-test	6.28	0.756	2.571	1.272	5.34	0.002	Significant
	Post-test	9.28	0.487					
Third Skill Performance Test	Pre-test	6	0.816	2.714	0.951	7.55	0.001	Significant
	Post-test	8.71	0.755					

Statistically significant at a significance level of ≤ 0.05.

the main part of the training session, specifically in the skill development phase, as outlined in Appendix 1 and 2. The exercises involved technical movements such as advancing, retreating, lunging, and both offensive and defensive skills. These were performed over a period of 25 minutes within the main training section.

The implementation of the training program began on Monday, October 23, 2023, and continued until Wednesday, December 27, 2023, with two sessions per week held every Monday and Wednesday, totalling twenty training sessions. Each session lasted between 60 and 90 minutes, including both the warm-up and cool-down phases. The warm-up and final phases of each training session were conducted jointly for both the experimental and control groups. The execution of each training session was tailored to its specific objective and based on employing the training method most effective in achieving that goal.

4.3. Post-tests

Upon completion of the main experiment, the researchers administered the post-tests to both the experimental and control groups on Thursday, December 28, 2023, at 10:00 a.m., following a standardized warm-up for all participants. All spatial and temporal conditions were kept consistent with those of the pre-tests to ensure experimental uniformity.

4.4. Statistical tools

The results were statistically analyzed using the Statistical Package for the Social Sciences (SPSS).

4.5. Results

Table 4 reveals significant differences between the mean values and standard deviations of the pre-test and post-test scores for the experimental group. To determine the statistical significance of these differences, a t-test for paired samples was applied. The calculated t-values indicated error levels lower than the significance level of 0.05, which confirms that the differences are statistically significant in favor of the post-test results.

5. Presentation and analysis of the control group's results

Table 5 indicates significant differences between the mean values and standard deviations of the pre-test and post-test scores for the control group. To assess the significance of these differences, a t-test for paired samples was employed. The calculated t-values revealed error levels lower than the significance level of 0.05, indicating that the differences are statistically significant in favor of the post-test results for the control group.

Table 5. Presents the statistical parameters used to identify the differences between the pre- and post-tests for the control group.

Tests	Arithmetic Mean (points)		Standard Deviation	Mean Difference	Degrees of Freedom	Calculated T-value	Significance Level	Sig. of Differences
First Skill	Pre-test	6.5 6	0.976	0.9	0.816	3.242	0.018	Significant
Performance Test	Post-test	7.57	0.786					
Second Skill	Pre-test	6.5 5	0.785	0.714	0.487	3.873	0.008	Significant
Performance Test	Post-test	7.28	0.755					
Third Skill	Pre-test	5.5 4	1.133	1.4	0.716	3.441	0.001	Significant
Performance Test	Post-test	6.5 8	0.534					

Statistically significant at a significance level of ≤ 0.05.

Table 6. Presents the statistical parameters used to identify the differences between the experimental and control groups in the post-test results.

Tests	Arithmetic Mean (points)		Standard Deviation	Calculated T-value	Significance Level	Sig. of Differences
First Skill	Experimental	9	0.816	3.333	0.006	Significant
Performance Test	Control	7.57	0.786			
Second Skill	Experimental	9.28	0.487	5.881	0.000	Significant
Performance Test	Control	7.28	0.755			
Third Skill	Experimental	8.71	0.755	6.124	0.000	Significant
Performance Test	Control	6.58	0.534			

Statistically significant at a significance level of ≤ 0.05.

6. Presentation and analysis of the post-test results for the experimental and control groups

Table 6 shows significant differences between the mean values and standard deviations of the experimental and control groups in the post-test measurements. To determine the significance of these differences, a t-test for paired samples was conducted. The calculated t-values yielded error levels lower than the significance threshold of 0.05, indicating that the differences are statistically significant in favor of the experimental group.

7. Results

The results presented in the tables above indicate that both research groups showed improvement in controlling foot spacing and skill performance. However, the experimental group demonstrated superior outcomes compared to the control group.

The researchers attribute the experimental group's enhanced performance to the nature of the exercises implemented using the device. This is supported by the findings of Hatem and Joudah (2024), who emphasize that "exercises designed with a clear and specific purpose—tailored to the type of specialized sports activity—contribute significantly to the effective development of skill-related abilities" (p. 89). These exercises had a positive impact on fencing movements, as fencers require coordination in every movement they perform—especially during advancing and retreating actions used to execute offensive and defensive techniques. This coordination may be either neuromuscular or muscular. For example, in the lunge movement, coordination occurs between the upper body—represented by the arms, head, and trunk—and the lower body—represented by the legs—guided by neural signals from the brain, which direct the body to advance, retreat, defend, or attack. Throughout this coordination, the fencer performs several integrated movements simultaneously (Maleh et al., 2021). The researchers attribute the improvement in skill performance within the control group to the continuity of training, in addition to the conventional exercises to which the group was subjected. This contributed to the enhancement of skill execution. As noted by Hatem and Abdul Hussein (2024), "the principle of repetition and consistent practice of any exercise over a specific period of time leads to adaptation and improvement in an individual's abilities—both motor and skill-based" (p. 161).

Regular, continuous, and well-structured training leads to positive improvements in both motor and skill performance levels—an outcome confirmed by the results of both groups in this study. In general, the exercises included in any training program are "a set of physical and motor positions and movements that target various physical and motor abilities, aiming to elevate the individual to the highest possible level of skill and motor performance" (Abdel Hadi, 2001, p. 26).

The foundations and nature of fencing require the athlete to execute a wide range of offensive movements that demand rapid forward and backward transitions with high levels of coordination, all while maintaining technically sound and biomechanically

accurate performance along defined movement paths. These actions are essential for executing defensive manoeuvres in response to immediate situations. Therefore, the fencer's movements must be fast, precise, and well-coordinated to achieve valid touches. As Hamza et al., (2023 p. 12) note, "training with advanced, AI-assisted devices and supportive tools—which accurately integrate motor and technical performance through high-speed, coordinated actions—represents one of the most modern trends in training methodology."

The researchers believe that modern training using electronic devices reflects one of the key outcomes of the scientific advancements in artificial intelligence. This purposeful training approach has rapidly gained traction in the sports field, leading to qualitative achievements due to its incorporation of elements such as excitement, engagement, and efficiency. It fosters an enjoyable training environment for athletes while significantly contributing to the development of their physical and motor capacities, which are foundational components of sports training science. These training methods are characterized by "dynamic execution, enjoyable performance, and the enhancement of physical and motor abilities. They increase training motivation and continuity, while promoting the integration of various movements under neuromuscular rhythm and coordination" (Ali Rabeeah & Malih, 2022, p. 26). Training, therefore, has a profound impact on the entire musculature of the body through diverse approaches (Abdulaziz, 2001). In addition, the data provided to the coach through such methods offer valuable insights into the fencer's physical and technical capabilities, enabling the analysis and identification of performance errors and allowing for more accurate correction by the coach.

In fencing, reaching precise spatial control requires extensive training over a prolonged period, with numerous repetitions in order to master the optimal distance that enables the athlete to execute offensive and defensive movements without hesitation. For this reason, the exercises utilizing the custom-designed device effectively contributed to establishing and maintaining the appropriate distance during the training period (Mohsen & Maleh, 2020).

When an athlete is required to perform numerous repetitions, their motivation to continue training tends to decline, and feelings of boredom may emerge, in addition to the physical and mental fatigue incurred during training (Saeed et al., 2019, p. 75).

According to Odeh et al. (2021), "the use of artificial intelligence and modern technologies allows for the real-time analysis and measurement of athletes' performance, enabling the development of training programs based on precise data that support rigorous scientific analysis and ultimately contribute to improved outcomes" (p. 161).

Artificial intelligence and modern technology have become essential requirements in athletic training, as they rely on precision controllers and computerized systems that enhance the training environment across all sports disciplines (Abbas & Malih, 2021).

As noted by Al-Haddad (2024), "artificial intelligence is transforming the sports industry in multiple ways, making the training process more competitive and more efficient" (p. 155). Furthermore, incorporating technological devices into training programs helps capture trainees' attention, increases their motivation to continue, and supports time and energy efficiency for both athletes and coaches (Awaj & Al-Haddad, 2024).

8. Conclusion

- The newly designed device proved to be effective and functional for its intended purpose.
- The manufactured device had a measurable impact on the research sample, contributing to the development of the targeted variables.
- The use of newly developed devices and tools stimulates athletes and enhances their motivation to perform.

9. Recommendations

1. Conduct further studies utilizing modern devices and tools due to their importance in enhancing skill performance.
2. Emphasize the use of such devices for their psychological impact, particularly in reducing monotony among female athletes.
3. Employ innovative devices to support the development of specific abilities related to skill performance in female athletes.
4. Carry out similar research involving different samples, sports, and types of activities.

Conflicts of interest

None.

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Author's contributions:

- Prof. Dr. Fatima Abd Maleh contributed the concept of the device.
- Prof. Dr. Noor Hatem contributed the research title and supervised the implementation of the experiment.

- Asst. Lect. Rimah Mohammed contributed to the discussion and formulation of the conclusions.

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Data availability

The data that support the findings of this study are available on request from the corresponding author.

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Appendix 1

Exercises Using the Device

1. From the standing (ready) position: advance one step, retreat one step, then advance and lunge toward a fixed target, followed by standard advance and retreat.
2. From the standing (ready) position: advance one step, retreat one step, then advance and lunge toward a fixed target, followed by reverse advance and retreat.
3. From the standing (ready) position: advance one step, retreat one step, then advance and lunge toward a fixed target, followed by jumping advance and retreat.
4. From the standing (ready) position: advance three steps and retreat three steps using the standard method, with eyes blindfolded.
5. From the standing (ready) position: advance three steps and retreat three steps using the reverse method, with eyes blindfolded.
6. From the standing (ready) position: advance three steps and retreat three steps using the jumping method, with eyes blindfolded.
7. From the standing (ready) position: advance one step, retreat one step, then advance and lunge toward the opposing partner, followed by reverse advance and retreat.
8. From the standing (ready) position: advance one step, retreat one step, then advance and lunge toward the opposing partner, followed by jumping advance and retreat.

Appendix 2

Training Unit: *Session One*
Unit Objective: *Developing skill performance*
Week: *One* ***Intensity:*** *90%* ***Session Duration:*** *90 minutes* ***Work Duration:*** *25 minutes*

No.	Exercises Using the Innovative Device	Exercise Duration	Repetitions	Rest Between Repetitions	Number of Sets	Rest Between Sets
1	From the standing (ready) position: advance two steps and retreat two steps using the standard method.	12 sec.	5	30 sec.	2	60 sec.
2	From the standing (ready) position: advance two steps and retreat two steps using the reverse method.	15 sec.	5	30 sec.	2	75 sec.
3	From the standing (ready) position: advance two steps and retreat two steps using the jumping method.	12 sec.	5	30 sec.	2	60 sec.