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The effect of purposeful three-dimensional training on developing some motor abilities and skill performance among female fencing players

El efecto del entrenamiento tridimensional intencionado en el desarrollo de algunas habilidades motoras y el rendimiento de las habilidades entre las jugadoras de esgrima

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Abstract. The study highlights the critical need to focus on the physical, motor, and technical abilities of female fencing players by developing and testing modern, scientifically-based training methodologies tailored to the specific demands of the sport. The study's objective was to assess the effectiveness of targeted three-dimensional training in enhancing the participants' motor skills and technical performance. Utilizing an experimental design, the study involved forming both experimental and control groups. The sample comprised 16 female fencers from the College of Physical Education and Sports Sciences for Girls. After excluding two players during the exploratory phase, the remaining 14 were evenly divided into experimental and control groups, each consisting of seven players. The intervention involved three weekly training sessions for two months, totaling 24 sessions. Pre- and post-intervention tests revealed that three-dimensional training significantly improved motor abilities and technical performance.
Keywords: Three-dimensional training, motor abilities, fencing.

Resumen. El estudio destaca la necesidad crítica de centrarse en las habilidades físicas, motoras y técnicas de las jugadoras de esgrima mediante el desarrollo y la prueba de metodologías de entrenamiento modernas, con base científica, adaptadas a las demandas específicas del deporte. El objetivo del estudio fue evaluar la eficacia del entrenamiento tridimensional dirigido a mejorar las habilidades motoras y el rendimiento técnico de las participantes. Utilizando un diseño experimental, el estudio implicó la formación de grupos experimentales y de control. La muestra comprendió 16 esgrimistas femeninas de la Facultad de Educación Física y Ciencias del Deporte para Niñas. Después de excluir a dos jugadoras durante la fase exploratoria, las 14 restantes se dividieron equitativamente en grupos experimentales y de control, cada uno compuesto por siete jugadoras. La intervención implicó tres sesiones de entrenamiento semanales durante dos meses, con un total de 24 sesiones. Las pruebas previas y posteriores a la intervención revelaron que el entrenamiento tridimensional mejoró significativamente las habilidades motoras y el rendimiento técnico.
Palabras clave: Entrenamiento tridimensional, habilidades motoras, esgrima.

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Introduction

Coaches are consistently engaged in identifying and implementing advanced training methodologies to enhance athletes' performance and achieve peak levels of achievement. Sports training is a comprehensive process designed to develop athletes across all facets of their capabilities (Smith, 2003). Purposeful sports training, characterized by its deliberate and systematic nature, is strategically planned to meet specific objectives. This approach plays a critical role in equipping athletes with the physical and technical skills necessary to excel in their respective sports, aligning training practices with the distinct demands of each game (Till et al., 2022). The three-dimensional approach not only targets each area separately but also emphasizes the interaction between these components. Enhancements in one area, such as physical conditioning, can significantly improve technical execution and tactical decision-making, thus optimizing overall performance.

Coaches in sports are continually exploring innovative approaches to enhance athletic performance. Purposeful three-dimensional training represents a sophisticated, goal-oriented methodology that integrates three distinct dimensions within a single training regimen. This approach facilitates holistic development by advancing physical conditioning and technical skills, promoting comprehensive athlete development (Balyi et al., 2013).

A critical issue affecting the female fencing players at the College of Physical Education and Sports Sciences for Women, University of Baghdad, is a notable deficiency in their skill performance during training and competitions. This deficiency has been linked to inadequate motor abilities, a consequence of the shortcomings in the current training programs. To tackle this problem, a specialized training program utilizing a three-dimensional purposeful training approach was developed. Addressing motor deficiencies requires a detailed understanding of specific skills required for fencing, such as agility and coordination. Incorporating biomechanical analysis can further pinpoint and address these deficiencies more precisely.

The paper aims to assess whether this specialized training method can enhance specific motor abilities related to fencing and, consequently, improve overall skill performance. The core research question is: Does purposeful three-dimensional training contribute to developing motor abilities and skill performance among female fencing players? The study’s objectives are threefold:

1-

o compare the effectiveness of the three-dimensional training approach versus traditional fencing training in improving and sustaining motor abilities and skill performance.

2-

o determine which components of the three-dimensional training program most significantly enhance motor abilities and skill performance.

3-

o assess the sustainability of these performance improvements over time.

The hypothesis guiding this research is: The implementation of purposeful three-dimensional training will lead to significant improvements in motor abilities and skill performance among female fencing players. Specifically, it is anticipated that this training approach will enhance agility, coordination, and balance, which will, in turn, improve competitive performance and be sustained over time.

Personalized training regimens tailored to individual needs and incorporating feedback mechanisms are essential for effective performance enhancement. This customization ensures that training is relevant to the athlete's current capabilities and future goals. A primary objective of sports training, particularly fencing training, is to optimize player performance by providing comprehensive preparation across all dimensions, including physical, technical, and tactical aspects. Given the variety of training methods available, coaches must select approaches that align with their athletes' unique characteristics and capabilities to enhance their skills and improve performance outcomes effectively (Alali et al., 2023). Sports training involves identifying and codifying the specifications and conditions required for each competition and training scenario to achieve peak performance levels (Bourdon et al., 2017).

Recent advancements in technology have opened new avenues for analyzing and understanding athletic performance. In the realm of fencing, the ability to accurately recognize and classify action dynamics is crucial for effective training and competition. Building upon the pioneering work of (Malawski & Kwolek, 2018), the researchers explore the potential of multimodal cues to enhance our understanding of fencing movements. By combining visual, auditory, and kinesthetic data. One such advancement is the use of artificial neural networks in conjunction with depth sensors like the Kinect. These tools offer the potential to provide objective, quantitative data on athlete performance, particularly in the context of three-dimensional training. Referring to (Mawgoud et al., 2016), the study explores the application of artificial neural networks and Kinect sensors to analyze fencing movements, focusing on three-dimensional aspects such as blade trajectory, body posture, and footwork. By leveraging the capabilities of these technologies. The integration of artificial neural networks and depth sensors allows for precise and real-time analysis of fencing movements, offering detailed insights into aspects such as blade trajectory and body posture. This technological approach provides objective data that can refine training methods.

Fencing demands substantial effort from athletes, encompassing both physical and mental training. It highlights the player's individual skills, physical strength, cognitive abilities, and perceptual acuity (Turner, 2016). Effective performance in fencing is intricately connected to physical and motor abilities, with the proficiency of skill execution often reflecting the player's development of these attributes (Sowerby, 2014). Consequently, the researchers aimed to implement contemporary methods tailored to the specific requirements and foundational elements of fencing to enhance both skill and physical performance, thereby achieving the sporting goals pursued by both coaches and athletes. The significance of this study is underscored by its focus on enhancing the motor abilities and skill performance of female fencing players by applying a scientific and contemporary training method. This approach integrates high-intensity interval training, utilizing both equipment-based and equipment-free exercises. Such exercises are designed to simultaneously address three key areas: physical conditioning, skill development, and cognitive function. By targeting these dimensions collectively, the training method aims to achieve more effective and comprehensive improvements in athletic performance. High-intensity interval training (HIIT) simulates the high demands of fencing bouts and improves both aerobic and anaerobic capacities. By incorporating cognitive training, the approach addresses not only physical readiness but also strategic and mental acuity (Franchini, 2020).

Methodology

Methods and samples

The study employed a controlled experimental method, utilizing pre-tests and post-tests to address the research problem. The research population comprised 16 players from the College of Physical Education and Sports Sciences for Women's Fencing Team for the 2023-2024 academic year. Prior to data collection, ethical approval was obtained from the College of Physical Education and Sports Sciences for Women at the University of Baghdad. Additionally, all participants were fully informed about the purpose and procedures of the study. Written informed consent was obtained from each participant, ensuring their voluntary participation and understanding of their right to withdraw from the study at any time. A comprehensive enumeration method was used to select the sample. Participants were divided randomly into two equal groups: the experimental group and the control group, each consisting of 7 players. The remaining sample was analyzed for normal distribution after excluding two players during the exploratory phase. Table 1 illustrates that the skewness coefficient falls within the ±1 range, indicating a moderately normal population distribution.

Table 1.
Distribution of the research sample

Variables	unit of measurement	Mean	median	Std. deviation	skewness coefficient
Height	cm	164.5	164	1.05	0.113
Weight	kg	59.5	59	1.36	0.642
Age	year	19.8	20	1.27	0.383

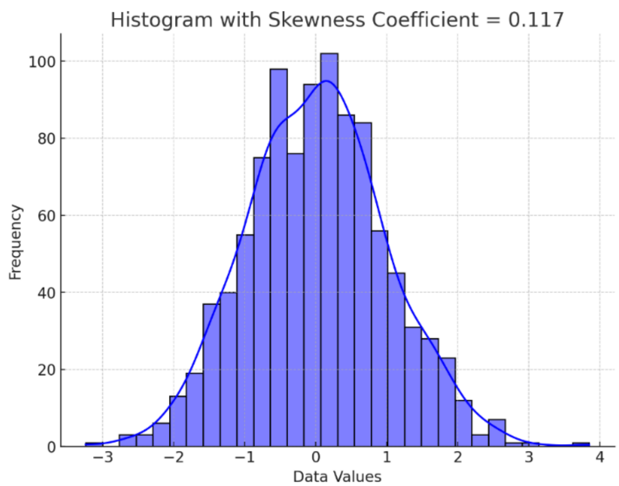

Figure 1. Skewness coefficient value

Figure 1 displays a histogram of the data, overlaid with a Kernel Density Estimate (KDE) curve, which helps visualize the distribution of the data. The skewness coefficient of approximately 0.0 indicates that the distribution is symmetric and falls within the ±1 range, signifying a moderately normal population distribution. The histogram shows the data clustering around the center (mean of 0), with a fairly even spread of values on both sides. This symmetry confirms the low skewness, reflecting that there are no significant deviations or extreme values pulling the distribution in either direction. The normality of the distribution makes it suitable for further statistical analyses.

To ensure the validity and reliability of the study, a power analysis was conducted to assess the adequacy of the sample size. With a sample size of 14 female fencing players, it was crucial to determine whether this number would be sufficient to detect meaningful differences and effects. The power analysis, assuming a medium effect size (Cohen's d = 0.5) and a significance level of 0.05, indicated that the sample size of 14 provides a power of approximately 0.70. Although this power level is slightly below the commonly recommended threshold of 0.80, it is deemed acceptable for preliminary studies. This analysis suggests that while the sample size may limit the detection of smaller effects, it is sufficient to provide initial insights into the effectiveness of the three-dimensional training approach. Future research with larger sample sizes will be necessary to confirm these results and enhance their generalizability.

Tools and Devices

-Arabic and English sources and references.
-Casio electronic stopwatch.
-Official fencing arena.
-Fencing weapons (fluorescent, epee, saber), 16 weapons
-Leather measuring tape (20 m).
- HP laptop.
- height and weight measuring device.

Field research procedures

Motor ability tests

Armed arm motor speed test

Description of the test performance: The participant assumed a ready position at an appropriate distance from a target marked with 20 cm in diameter circles. Upon hearing the start signal (a beep), the participant performed 10 consecutive thrusts at the target—circles drawn on a sign mounted on the wall. The thrusts were executed by extending the elbow of the armed arm. The height of the target circles was adjusted to align with the experimenter's chest level while standing, ensuring that the target was at the correct height for accurate assessment. Additionally, the non-dominant hand was positioned behind the elbow of the armed arm but did not touch the waist to ensure proper arm movement. The arm bent after each thrust, thereby facilitating repeat attempts.

Recording

The timing was recorded for ten consecutive accurate touches within the circle drawn on the target sign, performed by bending and extending the armed arm from the elbow joint. A touch was deemed unsuccessful if it fell outside the circle or if the palm of the non-dominant hand made contact with the target, which was a disallowed condition.

Agility test

Description of the test performance: - Participant begins in a standby position at line (A). Upon hearing the start signal (a beep), the experimenter advances to line (C), then retreats to line (B), advances to line (E), and retreats back to line (C). From line (C), the experimenter advances to line (G) and then returns to the starting point at line (A). Figure 2 illustrates this sequence. The recorded time is measured from when the start signal is heard until the tester's front foot crosses the starting line.

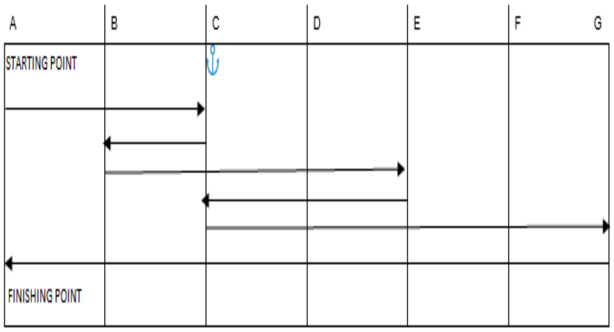

Figure 2. Agility test for fencing (42) meters

Motor accuracy of stabbing test

Description of the test performance: The participant assumes the ready position (on-guard), with the weapon in hand, at a specified distance from the marker. Upon hearing the start signal from the court, the participant executes an attack aimed at the circles drawn on the marker, following the court's call for the specific circle number. The participant is given 10 attempts to strike the designated circles accurately.

Recording: The participant is recorded as the number of times the target was accurately hit out of the ten stabbing attempts performed by the participant. The test is repeated twice, and the best attempt is recorded.

Arm motor coordination test

Description of the test performance: Ten circles, each with a diameter of 5 cm and spaced 5 cm apart, are drawn on a wall and numbered sequentially from 1 to 10. The participant stands appropriately from the wall, with their arms initially at their sides. The task involves sequentially placing the right arm on the circles numbered with odd numbers and the left arm on those numbered with even numbers, moving from top to bottom and then in a criss-cross pattern. This sequence is repeated three times, with the participant allowed two attempts to achieve the best performance.

Recording: The participant's time to perform this test was calculated and recorded.

Legs motor coordination test

Description of the test performance: Ten circles, each with a diameter of 10 cm and spaced 30 cm apart, are drawn on the floor and numbered sequentially from 1 to 10. The participant stands appropriately from the circles, starting with her feet on guard. She then jumps quickly onto the circles, placing the right foot on the circles numbered with odd numbers and the left foot on those numbered with even numbers, following a consistent forward and backward sequence. The participant is allowed two attempts, with the best performance being recorded.

Recording: The participant's time to perform this test was calculated and recorded.

Skill performance test

Skill performance was assessed using a standardized evaluation form specific to fencing, as established in prior research (Hijazi, 2020). The evaluation was based on the various components and manifestations of the skill, with performance captured through video recordings and reviewed by three experts. Each skill was rated on a scale from 1 to 10, as detailed in Appendix A. The assessment covered multiple aspects of fencing, including advancing, thrusting, and attacking, defensive responses, retreating, and counter-attacking techniques.

Pilot test

The Pilot test was conducted on Tuesday, February 20, 2024, on two female athletes from outside the research samples to apply motor and skill performance tests, identify the most important obstacles that will appear during the tests' implementation, and assess the tests' suitability to the research sample. In addition, the devices, tools and instruments necessary to implement the tests were identified, evaluated and monitored by three official experts.

The main test included

Pre-test

The pre-test was administered to the experimental and control groups on February 27, 2024, at 10:00 AM in the fencing hall at the College of Physical Education and Sports Sciences for Girls, University of Baghdad. Before testing, a standardized warm-up was performed for all participants to ensure uniformity. Temporal and spatial conditions were controlled to maintain consistency across tests. After randomly assigning participants, the experimental and control groups were found to be equivalent in the pre-test, as evidenced by Table 2, which confirms the equality and homogeneity of the two groups.

Table 2.
Comparison of Motor and Skill Performance Metrics Between Experimental and Control Groups

Tests	Mean		Std. deviation	Levene's test	Levene's value error level for	T-test Value	Critical T-Test value
Motor speed of the armed arm/Sec	Experimental group	7.17	0.75	1.353	0.272	0.9	0.387
	Control group	7.43	0.41				
Agility/Sec	Experimental group	16.2	0.7	0.075	0.790	1	0.341
	Control group	15.8	0.67				
Kinematic accuracy of stabbing/Times	Experimental group	3.83	1.1	0.432	0.526	0.27	0.787
	Control group	4	0.89				
Motor coordination of the arms/Sec	Experimental group	7.7	0.36	1.011	0.338	0.64	0.536

	Control group	7.9	0.66				
Motor coordination of the legs/Sec	Experimental group	4.7	0.17	0.048	0.831	0.69	0.501
	Control group	4.76	0.15				
Skill performance/Degree	Experimental group	6.08	1.2	0.131	0.725	0.35	0.728
	Control group	5.81	1.3				

Three-dimensional purposeful training application

Following the development of the purposeful three-dimensional training program, which integrates a comprehensive set of motor and mental skill exercises into a single performance and utilizes an interval training method, as detailed in Appendix B, the training was incorporated into the main segment of each training unit. This program adhered to the ripple principle, emphasizing a structured progression between exercises, sessions, and training weeks. The design of the training load was based on Fox and Matthews' periodic training schedule (Lukanova-Jakubowska et al., 2015), with specific guidelines for shaping the training load according to performance time.

The primary goal of the program was to improve motor abilities (e.g., speed, coordination, and agility) and fencing-specific skills (e.g., thrusting and retreating) through a mix of physical drills and cognitive tasks that simulate real-match conditions. The exercises were specifically chosen to mimic fencing movements and situations, helping players develop both mental focus and physical agility under pressure.

Duration and Schedule

Total duration: 8 weeks (March 5, 2024 – April 23, 2024).

Frequency: 3 sessions per week, with each session lasting 60 minutes.

Session structure

20 minutes: Warm-up, including dynamic stretching, light running, and mobility drills. 30 minutes: Main training, focusing on fencing-specific drills. This includes 10 minutes dedicated to the experimental component (three-dimensional purposeful training). 10 minutes: Cool-down, consisting of stretching and relaxation.

Exercises Included

Agility Drills: Incorporating lateral movements, quick directional changes, and footwork patterns to enhance agility and reaction time.

Coordination Exercises: Arm-leg coordination tasks using walls and floor markers, where players had to touch specific points in a set pattern with either hands or feet.

Balance and Stability Work: Exercises such as lunges, single-leg stances while performing fencing attacks and defenses, and use of unstable surfaces to build core strength and stability.

Motor Speed: High-repetition thrusting drills with fencing weapons, focusing on arm extension speed and reaction time.

Progression Over Time

The exercises became progressively more challenging over the course of the 8 weeks.

Weeks 1-2: Participants worked on basic movement patterns at a slower pace, focusing on technique and control.

Weeks 3-4: Increased intensity through faster movements and more complex combinations of footwork and hand-eye coordination.

Weeks 5-6: Prolonged the duration of each exercise, adding psychological stressors (e.g., cognitive tasks like calling out numbers or targets) to simulate competitive conditions.

Weeks 7-8: Full-simulation drills where participants engaged in exercises mimicking fencing bouts, combining all skills into complex fencing sequences.

Equipment and Space

The training used official fencing equipment, including fencing weapons (fluorescent, epee, saber) and an agility ladder. All sessions took place in an official fencing arena, ensuring participants trained in a realistic environment that mimicked actual competition conditions. Additionally, the 20 m leather measuring tape was used for spacing drills, while a height and weight measuring device tracked each participant's physical metrics. The experimental group followed this program as a part of their main training sessions, while the control group continued with their regular training regimen, which included general physical conditioning and fencing drills, but without the purposeful integration of motor and mental skill training.

Post-tests

Upon completing the main experimental phase, post-tests were administered to the experimental and control groups on April 30, 2024, at 10:00 AM. A standardized warm-up was conducted for all participants prior to testing, ensuring consistency with the pre-tests. Temporal and spatial conditions were controlled, allowing for a clear comparison between pre- and post-test performance. The post-tests measured the same motor abilities and skill performance metrics, as outlined in the study's objectives.

Statistical methods

The results were processed statistically using the SPSS system and using the following laws:

Mean, Standard deviation, Simple torsion coefficient, Percentage, Levene's test for homogeneity, T-test for two unrelated means, T-test for two related means.

Results

The study assessed the impact of a specialized three-dimensional training program on motor and skill performance in female fencing players through a series of pre and post-test evaluations. The results indicate that the experimental group engaged in the targeted training and experienced significant improvements across multiple performance metrics, including motor speed, agility, kinematic accuracy, motor coordination, and overall skill performance. In contrast, while the control group also showed enhancements, the magnitude of their improvements was generally less pronounced. The comparative analysis between the experimental and control groups highlights the effectiveness of the three-dimensional training program, demonstrating its superior impact on enhancing athletic abilities compared to the standard training approach.

Results of the pre and post-tests for the experimental and control groups

Table 3.
Pre-Test and Post-Test Comparisons of Motor and Skill Performance Metrics

Tests	Mean		Std. deviation	Mean differences between pre and post	Deviation difference between pre and post	T-test	sig.
Motor speed of the armed arm/Sec	Pre-test	7.17	0.75	2.86	0.85	8.2	0.000
	Post-test	4.3	0.18				
Agility/Sec	Pre-test	16.2	0.7	3.28	0.74	10.7	0.000
	Post-test	12.92	0.45				
Kinematic accuracy of stabbing/Times	Pre-test	3.83	1.1	4.16	1.6	6.3	0.001
	Post-test	8	1.09				
Motor coordination of the arms/Sec	Pre-test	7.7	0.36	2.53	0.38	16.2	0.000
	Post-test	5.16	0.03				
Motor coordination of the legs/Sec	Pre-test	4.7	0.17	1.59	0.18	21.3	0.000
	Post-test	3.11	0.01				
Skill performance/Degree	Pre-test	6.08	1.2	2.36	1.33	4.3	0.007
	Post-test	8.45	0.5				

Table 3 provides a detailed comparison of pre-and post-training assessments for female fencing players who engaged in a purposeful three-dimensional training program. The results reveal substantial improvements across various motor abilities and skill performance metrics.

Regarding motor speed for the armed arm, the training significantly reduced time from 7.17 seconds in the pre-test to 4.3 seconds in the post-test. This substantial decrease indicates that the training effectively enhanced the speed of the armed arm, with the statistical analysis confirming the significance of this improvement. Agility also showed notable enhancement, with the mean time improving from 16.2 seconds to 12.92 seconds. This reduction demonstrates that the players became quicker and more agile. The statistical significance of this improvement is evident from the robust t-value and p-value. Kinematic accuracy of stabbing, measured by the number of successful attempts, improved dramatically from 3.83 attempts to 8. This more than doubling of successful attempts reflects a significant increase in accuracy, highlighting the effectiveness of the training in enhancing this critical skill. The training also improved motor coordination of the arms, as evidenced by a reduction in the meantime from 7.7 seconds to 5.16 seconds. This decrease indicates better coordination and more efficient arm movements.

Similarly, leg motor coordination showed improvement, with the mean time decreasing from 4.7 seconds to 3.11 seconds, reflecting enhanced leg coordination and overall performance. Lastly, skill performance, measured in degrees, improved from a mean of 6.08 degrees to 8.45 degrees. This increase in skill performance underscores the overall effectiveness of the training program in enhancing players' abilities on the fencing strip.

Overall, the data from Table 3 demonstrate that the purposeful three-dimensional training significantly and positively impacted various motor abilities and skill performance, confirming its effectiveness in developing essential fencing skills.

Table 4.
Pre-Test and Post-Test Performance Metrics with Statistical Analysis

Tests	Mean		Std. deviation	Mean differences between pre and post	Deviation difference between pre and post	T-test	sig.
Motor speed of the armed arm/Sec	Pre-test	7.43	0.41				
	Post-test	5.3	0.39	2.12	0.43	12	0.000
Agility/Sec	Pre-test	15.8	0.67				
	Post-test	14.	0.27	1.42	0.46	7.5	0.001
Kinematic accuracy of stabbing/Times	Pre-test	4	0.89				
	Post-test	6.6	0.81	2.6	0.81	8	0.000
Motor coordination of the arms/Sec	Pre-test	7.9	0.66				
	Post-test	6.1	0.35	1.79	0.37	11.7	0.000
Motor coordination of the legs/Sec	Pre-test	4.76	0.15				
	Post-test	3.9	0.14	0.81	0.1	10.5	0.000
Skill performance/Degree	Pre-test	5.81	1.3				
	Post-test	6.8	0.7	1.06	0.75	3.4	0.018

Table 4 presents the results of pre-and post-test assessments for the control group, comparing various motor abilities and skill performance metrics. The data indicate several improvements, though less pronounced than those observed in the experimental group. The motor speed of the armed arm decreased from 7.43 seconds in the pre-test to 5.3 seconds in the post-test. This improvement suggests that the control group also experienced an increase in speed, although the extent of the change was modest. The t-value and p-value confirm the statistical significance of this improvement. Agility in the control group improved from a mean of 15.8 seconds to 14 seconds. This reduction indicates enhanced agility, though the change is relatively modest again compared to the experimental group. The statistical analysis supports the significance of this improvement. The kinematic accuracy of stabbing increased from 4 successful attempts in the pre-test to 6.6 attempts in the post-test. This improvement in accuracy reflects a positive effect of the training, though the magnitude of change is less dramatic than that observed in the experimental group. The t-value and p-value confirm the statistical significance of this improvement. Motor coordination of the arms improved, with the mean time decreasing from 7.9 seconds to 6.1 seconds. This change indicates enhanced coordination of arm movements.

Similarly, leg motor coordination showed improvement, with the mean time decreasing from 4.76 seconds to 3.9 seconds, suggesting better leg coordination. Both improvements are statistically significant. Skill performance, measured in degrees, increased from a mean of 5.81 degrees to 6.8 degrees. This improvement indicates enhanced skill performance in the control group. The statistical analysis confirms the significance of this change.

In summary, while the control group showed significant improvements in all measured areas, the extent of these improvements was generally less pronounced than the experimental group. This suggests that while the control group's training had beneficial effects, the purposeful three-dimensional training in the experimental group was more effective in enhancing motor abilities and skill performance. Tables 3 and 4 show significant differences between the values of the arithmetic mean and the values of the standard deviations for the pre-and post-tests in the experimental and control research groups in favor of the post-test.

Results of the post-tests between the experimental and control groups

Table 5.
Comparison of Performance Metrics Between Experimental and Control Groups with T-test results

Tests		Mean	Std. deviation	T-test	Sig.
Motor speed of the armed arm/Sec	Experimental group	4.3	0.18	5.9	0.000
	Control group	5.3	0.39		
Agility/Sec	Experimental group	12.92	0.45	6.7	0.000
	Control group	14	0.27		
Kinematic accuracy of stabbing/Times	Experimental group	8	1.09	2.3	0.002
	Control group	6.6	0.81		
Motor coordination of the arms/Sec	Experimental group	5.16	0.03	6.4	0.000
	Control group	6.1	0.35		
Motor coordination of the legs/Sec	Experimental group	3.11	0.01	14.4	0.000
	Control group	3.9	0.14		
Skill performance/Degree	Experimental group	8.45	0.5	4.4	0.001
	Control group	6.8	0.7		

Table 5 compares the results of post-test assessments between the experimental and control groups, focusing on various motor abilities and skill performance metrics. The data reveal notable differences favoring the experimental group in most areas. For the motor speed of the armed arm, the experimental group achieved a mean time of 4.3 seconds, significantly faster than the control group's mean of 5.3 seconds. The statistical analysis shows a t-value of 5.9 and a p-value of 0.000, indicating that the difference in motor speed is highly significant and reflects the effectiveness of the experimental training. Agility also displayed a significant difference between the two groups. The experimental group recorded a mean time of 12.92 seconds, compared to 14 seconds for the control group. The t-value of 6.7 and the p-value of 0.000 confirm that the experimental group demonstrated significantly better agility. In terms of kinematic accuracy of stabbing, the experimental group achieved a mean of 8 successful attempts, which was higher than the control group's mean of 6.6 attempts. The statistical significance is supported by a t-value of 2.3 and a p-value of 0.002, indicating a meaningful improvement in accuracy for the experimental group. Motor coordination of the arms was also notably better in the experimental group, with a mean time of 5.16 seconds compared to 6.1 seconds in the control group. The t-value of 6.4 and the p-value of 0.000 highlight the significant difference in arm coordination favoring the experimental group.

Similarly, motor coordination of the legs showed a mean time of 3.11 seconds in the experimental group, which is lower than the control group's mean of 3.9 seconds. The significant difference is confirmed by a t-value of 14.4 and a p-value of 0.000, indicating superior leg coordination in the experimental group. Finally, skill performance was higher in the experimental group, with a mean score of 8.45 degrees compared to 6.8 degrees in the control group. The t-value of 4.4 and p-value of 0.001 confirm that this difference is statistically significant, reflecting improved overall skill performance in the experimental group.

Overall, the data from Table 5 demonstrate that the experimental group outperformed the control group across all measured variables. The significant differences observed highlight the effectiveness of the purposeful three-dimensional training in enhancing motor abilities and skill performance compared to the control group.

Table 6.
Cohen's d effect sizes for the post-test comparisons between the experimental and control groups

Test	Cohen's d
Motor speed of the armed arm (Sec)	-3.29
Agility (Sec)	-2.91
Kinematic accuracy of stabbing (Times)	1.46
Motor coordination of the arms (Sec)	-3.78
Motor coordination of the legs (Sec)	-7.96
Skill performance (Degree)	2.71

According to Table 6, a negative Cohen's d indicates that the experimental group performed significantly better (lower times) compared to the control group for motor speed, agility, and coordination tests, where a lower score reflects better performance. Positive Cohen's d values for kinematic accuracy and skill performance indicate that the experimental group outperformed the control group, with higher scores representing better performance. These results demonstrate large effect sizes, indicating a substantial practical significance of the training program across most metrics.

The three-dimensional training program had a substantial impact on the motor and skill performance of female fencing players. Large effect sizes across all measured metrics indicate that the program was highly effective in enhancing motor speed, agility, coordination, and skill performance compared to standard training. This suggests the practical utility of such training methods in improving athletic performance, particularly in fencing.

Results Conclusion:

The statistical analysis shows significant improvements in motor speed, agility, kinematic accuracy, and motor coordination for the experimental group compared to the control group (Tables 3 and 5). For instance, motor speed decreased from 7.17 to 4.3 seconds, agility improved from 16.2 to 12.92 seconds, and kinematic accuracy of stabbing increased from 3.83 to 8 successful attempts. These results confirm that the three-dimensional training approach had a substantial impact on enhancing specific motor abilities essential for fencing.

Improvements in motor abilities directly translated into enhanced skill performance. The experimental group showed a notable increase in skill performance from 6.08 to 8.45 degrees, with statistical significance (Table 5). This suggests that the enhancements in motor speed, agility, and coordination resulted in better overall skill performance, thereby supporting the hypothesis that improved motor abilities translate into better skill execution.

The data from the post-tests (Table 4) indicate that the improvements in the experimental group were sustained over time, with significant and meaningful gains in all performance metrics compared to the control group. However, the sustainability of these improvements over a more extended period requires further investigation. The current results suggest that the training effects are robust but additional longitudinal studies would provide more comprehensive insights into the long-term sustainability of these improvements.

Discussion

The observed improvements in motor abilities and skill performance in the experimental group are attributed to the specialized three-dimensional training program. This approach, integrating motor and skill abilities into a cohesive training regimen, is supported by prior research (Fatimah & Wafa, 2012). However, it is crucial to consider other potential factors that might have influenced these results.

Psychological factors could have played a significant role. Knowing they were participating in a novel and potentially superior training method might have heightened motivation and engagement in the experimental group, potentially contributing to their improved performance (Mohsen & Maleh, 2020). The engaging nature of the training might have enhanced participants' enthusiasm and focus, further boosting their results (Kadhim & Malih, 2022).

Purposeful three-dimensional training represents a significant advancement in sports science, emerging from the scientific renaissance with a holistic training approach that has rapidly gained global adoption. This method has led to a qualitative leap in the field of sports by incorporating elements of comprehensiveness and enjoyment. It emphasizes engaging and pleasurable movements, creating a positive and enjoyable training environment. Additionally, this training approach effectively enhances physical, motor, and skill-related abilities, which are fundamental to training science (Kadhim & Malih, 2022).

Purposeful three-dimensional training is distinguished by its dynamic approach, enjoyable execution, and enhancement of physical and motor fitness through a blend of challenge and pleasure. It integrates rhythmic movements with neuromuscular coordination and engages large muscle groups, promoting a comprehensive development of physical capabilities (Iorga, 2023).

This training method has proven effective in enhancing motor abilities and skill performance by facilitating rapid muscle contraction and relaxation. This approach accelerates movement speed, response time, and muscle coordination, achieving optimal motor balance through concentric and eccentric contractions. Improved muscle extensibility correlates with the potential for quicker and more powerful muscle contractions (Lim et al., 2014).

The three-dimensional purposeful training implemented with the experimental research sample significantly enhanced neuromuscular coordination, improving various motor components such as response speed and agility. The dynamic nature of these training exercises enhanced cognitive motor perception and facilitated the development of coordination among the participants.

A fencing player requires precise coordination in every movement, particularly in offensive and defensive actions. This coordination involves both neural and muscular harmony. For instance, in the stabbing movement, effective execution necessitates synchronization between the upper body (including the arms, head, and torso) and the lower body (the legs), guided by neural instructions from the brain. These instructions direct the player to advance, retreat, defend, or attack while seamlessly integrating multiple movements. This comprehensive coordination is essential for effective fencing performance (Kadhim & Malih, 2022).

natural progression through consistent training cannot be overlooked. The control group, undergoing standard training, might have experienced improvements due to the natural development associated with regular practice, even without the specialized program (Daussin et al., 2008). The control group's standard training likely included exercises that contributed to their progress in motor and skill capabilities (Witkowski et al., 2020).

Another consideration is the role of individual differences and variability in response to the training. The effectiveness of the training could be influenced by individual characteristics such as baseline skill levels, personal motivation, and inherent athletic abilities. This variability might affect how different participants respond to the same training regimen.

The superior results observed in the experimental group are likely due to the targeted nature of the three-dimensional training, which aligns closely with the specific demands of fencing movements. This method enhances motor performance and muscle activation patterns typical of fencing skills, supporting its effectiveness in improving relevant motor abilities (Chen et al., 2017).

The findings of this study have several important implications for sports training, particularly in fencing. The significant improvements observed in motor abilities and skill performance among the experimental group suggest that purposeful three-dimensional training could serve as a highly effective approach for enhancing athletic performance in sports requiring complex motor skills and quick, coordinated movements. This training method not only integrates physical and motor components but also aligns with the natural demands of sports like fencing, where rapid offensive and defensive maneuvers are essential. Implementing this approach could lead to more efficient and targeted training programs, potentially benefiting athletes across various disciplines that require agility, speed, and precision. Furthermore, the broader applicability of this training technique offers sports coaches and trainers a modern tool to enhance neuromuscular coordination and overall performance, ultimately contributing to the advancement of athletic training methodologies (Fatimah & Wafa, 2012; Mohsen & Maleh, 2020; Kadhim & Malih, 2022).

In conclusion, while the three-dimensional purposeful training was effective in enhancing motor abilities and skill performance, the improvements observed could also be influenced by other factors, such as natural skill development, motivation, and individual differences. The study demonstrates that purposeful three-dimensional training offers significant benefits for fencing players, but further research is needed to disentangle the specific contributions of different factors to athletic improvement.

Conclusions and Recommendations

Conclusions

The study demonstrated that the specialized three-dimensional training program had a significant impact on the motor abilities of female fencing players. The data from pre- and post-tests indicate that this training regimen, which included dynamic motor and skill exercises, led to measurable improvements in key areas such as motor speed, agility, and neuromuscular coordination. These improvements align with the specific demands of fencing, supporting the effectiveness of the training program in enhancing motor performance and skill execution.

While the training program showed positive effects on technical skills and player motivation, it is important to acknowledge the limitations of the study, such as the sample size and duration of the intervention. The improvements observed suggest that the training approach is beneficial, but further research with larger sample sizes and longer durations would be valuable to validate and expand upon these findings.

The three-dimensional training approach significantly enhanced motor speed, agility, and coordination. Participants in the experimental group demonstrated marked improvements in these areas, reflecting the effectiveness of the training program in developing essential motor skills crucial for fencing.

Improvements in motor abilities translated effectively into enhanced skill performance. The experimental group showed notable gains in skill metrics, such as kinematic accuracy and overall fencing performance. This underscores the training program's success in bridging the gap between motor skill development and practical skill execution.

In summary, the results indicate that the three-dimensional training program is a promising method for improving the technical skills and motivation of female fencing players, though more comprehensive studies are needed to confirm these effects across broader contexts.

Recommendations

Investing in Purposeful Three-Dimensional Training**:** Implementing purposeful three-dimensional training methods to develop further motor and physical abilities in fencing. This approach, which integrates dynamic and comprehensive exercises, should be utilized to improve critical motor skills and overall physical performance, aligning closely with the specific demands of fencing.

Enhance Skill Performance: This method utilizes purposeful three-dimensional training to advance skill performance in fencing. Its emphasis on combining various motor and skill exercises can significantly improve players' technical proficiency, enhancing their effectiveness in offensive and defensive maneuvers.

Develop Specialized Exercises: Create and incorporate specialized exercises that use devices and tools within the framework of purposeful three-dimensional training. These tailored exercises can provide additional benefits by simulating the conditions and movements experienced during actual fencing bouts, further refining players' skills.

Foster Excitement and Engagement: Focusing on designing exercises that target motor and skill abilities and introduce excitement and suspense elements. By preparing diverse and engaging drills, training programs can boost motivation and enthusiasm among female fencing players, leading to greater commitment and enjoyment in their practice.

Emphasize Complex Motor and Physical Exercises: Take special care to incorporate sophisticated motor and physical training that closely resembles fencing demands. Investing in such workouts can help players develop the abilities and physical conditioning needed for peak performance, ultimately improving their overall skill execution and competitiveness.

Based on the study's findings, it is recommended to incorporate long-term follow-up assessments at intervals such as 3, 6, and 12 months to evaluate the sustainability of performance improvements from the three-dimensional training program. Additionally, expanding the application of this training approach to other sports and integrating it into competitive settings could further validate its effectiveness. Optimizing the training protocols and tailoring them to individual needs will enhance their impact, while continuing to explore cognitive training elements will improve mental focus and decision-making. Addressing these areas will help advance training practices and ensure sustained, meaningful improvements in athletic performance. Future studies with varied intensities or volumes could further refine our understanding of the optimal training dose Regarding the sample size, future studies are recommended to have a larger sample size for further and more detailed results.

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APPENDIXE

APPENDIX A

Fencing skill performance evaluation form

Skill performance	Streamlined performance and compatibility			Performance timing			Preparatory section			Main section			Concluding section			Total Out of ten marks
	mark			mark			mark			mark			mark			
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	

APPENDIX B

One of the training sessions implemented by the experimental group using a three-dimensional purposeful training method
Training session: The first Unit goal: developing some special abilities and skill performance
Week: First, Intensity: 90%
session time: 90 minutes. Time for purposeful three-dimensional training is 12-15 minutes

Training section	Time	Details	Exercise time	Repetitions	Rest between repetitions	Exercise sets	Rest between Sets
Warm-up	20 min	General Warm-up (7) min, Special warm-up (13) min, Heart rate reaches 120 BPM					
Main Session	60 MIN	Three-dimensional purposeful training exercises					
Three-dimensional purposeful training	14.4 min	From the (ready) position: Draw circles on a marker hanging on the wall, numbered from (1-10) and measure a diameter of 10 cm, arranged randomly. Stand 100 cm away from the wall when a single signal is heard from the trainer. Touch circle number (1) and return to Standby mode, and when two signals are heard from the trainer, touch circle number (2) and so on.... provided that the exercise is completed at maximum speed.	11 sec	4	11 sec	1	2 min
		-From the (ready) position: Place a rope 2 meters long, horizontally with the center line of the court, and hang balls of different colors and heights on it, and move it right and left. Upon hearing an instruction from the coach, the player goes forward and challenges the desired color of the ball. The exercise is repeated with different heights and colors from 10-15. time.	10 sec	3	10 sec	1	2.30 min

		- From the (ready) position: placing a rope 2 meters long, lengthwise, with the field straight, and hanging balls of different colors and heights on it, and moving it in front of behind, and upon hearing an instruction from the coach, the player goes forward and challenges the desired color of the ball. The exercise is repeated with different heights and colors 10-12 times. .	9 sec	3	9 sec	2	3 min
		- From the (ready) position: Place a 4-meter long rope suspended from the ceiling of the hall, perpendicular to the center line, and hang balls of different colors and heights in it, and move it up and down. Upon hearing an instruction from the coach, the player comes forward and challenges the desired ball color. The exercise is repeated with different heights and colors from 10- 15 times.	11 sec	4	11 sec	1	2 min
skills, physical, and psychological plans	45.6 min	Moving on to training with the trainer without the intervention of the researcher					
Cooling down	10 min	General stretching and calming exercises to return to normal. It is left to the trainer without the researcher's intervention					