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The Effects of Advanced Plyometric Training Using WIMU-Pro Technology on Speed and Angular Acceleration and its Influence on Heart Rate Under Varying Atmospheric Pressure and Magnetic Field Conditions in Young Fencers

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ABSTRACT

Sports is a field where training methods and techniques to improve physical performance such as fencing. This study presents a training program that can be implemented in sports clubs, specifically Baghdad Fencing Club. The study highlights the influence of environmental factors such as air pressure and magnetic fields on sports performance, which can help design training programs that take these variables into account. It emphasizes the importance of using modern technologies such as WIMU Pro in sports performance analysis. Despite significant advances in sports training methods, there is a lack of research focusing on the effects of advanced plyometric training on young fencing athletes, especially in relation to the use of modern technologies such as WIMU Pro. In addition, the influence of environmental factors such as air pressure and magnetic fields on physiological and motor performance has not been adequately discussed in scientific studies. It is evident that young fencing athletes struggle to achieve optimal performance due to the lack of training programs that integrate modern technology while taking into account environmental variables. Therefore, this study aims to address this gap by investigating the effects of advanced plyometric training using WIMU Pro technology on speed, acceleration, angle, heart rate and e in young fencing athletes. The purpose of this study is to develop a training program that utilizes advanced plyometric exercises using WIMU Pro technology; to determine the effects of advanced plyometric exercises on speed and acceleration in young fencing athletes at the Baghdad Fencing Club; to measure the effect of this exercise on the accuracy of the angle of movement during execution; to investigate the effects of training programs on heart rate under various conditions of air pressure and magnetic fields, and to provide practical recommendations for the development of training programs for young fencing athletes based on research findings. The study adopted an experimental design with both experimental and control groups, involving a sample of 24 fencing athletes. The results showed statistically significant increases in speed (8.16%), acceleration (16.13%), angle of motion (4.38%) and heart rate

(6.67%) for the experimental group compared to the control group. The results also showed a slight effect of air pressure on heart rate, while magnetic fields had no obvious effect.

Keywords: Advanced plyometric training; WIMU-Pro technology; Speed and angular acceleration; Heart rate under varying conditions; Young fencers

ABSTRAK

Olahraga adalah bidang di mana metode dan teknik pelatihan untuk meningkatkan kinerja fisik seperti anggar. Studi ini menyajikan program pelatihan yang dapat dilaksanakan di klub olahraga, khususnya Baghdad Fencing Club. Studi ini menyoroti pengaruh faktor lingkungan seperti tekanan udara dan medan magnet pada kinerja olahraga, yang dapat membantu merancang program pelatihan yang memperhitungkan variabel-variabel ini. Ini menekankan pentingnya menggunakan teknologi modern seperti WIMU Pro dalam analisis kinerja olahraga. Terlepas dari kemajuan signifikan dalam metode pelatihan olahraga, ada kurangnya penelitian yang berfokus pada efek pelatihan pliometrik tingkat lanjut pada atlet anggar muda, terutama dalam kaitannya dengan penggunaan teknologi modern seperti WIMU Pro. Selain itu, pengaruh faktor lingkungan seperti tekanan udara dan medan magnet pada kinerja fisiologis dan motorik belum cukup dibahas dalam studi ilmiah. Terbukti bahwa atlet anggar muda berjuang untuk mencapai kinerja optimal karena kurangnya program pelatihan yang mengintegrasikan teknologi modern sambil mempertimbangkan variabel lingkungan. Oleh karena itu, penelitian ini bertujuan untuk mengatasi kesenjangan ini dengan menyelidiki efek pelatihan pliometrik lanjutan menggunakan teknologi WIMU Pro pada kecepatan, akselerasi, sudut, detak jantung dan e pada atlet anggar muda. Tujuan dari penelitian ini adalah untuk mengembangkan program pelatihan yang memanfaatkan latihan pliometri lanjutan menggunakan teknologi WIMU Pro; untuk menentukan efek latihan pliometrik tingkat lanjut pada kecepatan dan akselerasi pada atlet anggar muda di Baghdad Fencing Club; untuk mengukur efek latihan ini pada akurasi sudut gerakan selama eksekusi; untuk menyelidiki efek program pelatihan pada detak jantung dalam berbagai kondisi tekanan udara dan medan magnet, dan untuk memberikan rekomendasi praktis untuk pengembangan program pelatihan untuk atlet anggar muda berdasarkan temuan penelitian. Studi ini mengadopsi desain eksperimental dengan kelompok eksperimental dan kelompok kontrol, yang melibatkan sampel 24 atlet anggar. Hasil penelitian menunjukkan peningkatan kecepatan (8,16%), percepatan (16,13%), sudut gerakan (4,38%) dan detak jantung (6,67%) yang signifikan secara statistik untuk kelompok eksperimen dibandingkan dengan kelompok kontrol. Hasilnya juga menunjukkan sedikit pengaruh tekanan udara pada detak jantung, sementara medan magnet tidak memiliki pengaruh yang jelas.

Kata Kunci: Pelatihan pliometrik tingkat lanjut; teknologi WIMU-Pro; Kecepatan dan percepatan sudut; Detak jantung dalam berbagai kondisi; Pemain anggar muda.

INTRODUCTION

Sport is a field in which training methods and techniques for improving athletes' physical and technical performance are constantly evolving, particularly in competitive sports that require high precision and speed, such as fencing. Many researchers believe

that plyometric training is one of the fundamental pillars in the development of physical abilities such as explosive power, speed and acceleration, as these exercises are based on the cycle of rapid muscle contraction and relaxation to increase motor efficiency. Several studies demonstrate that the integration of modern technologies, such as motion capture systems (WIMU Pro), contributes to highly precise performance analysis by measuring kinematic variables such as speed, acceleration and angle of movement, enabling coaches to design more effective training programmes.

The researcher notes that fencing requires a high degree of motor precision and rapid responsiveness, as success in this sport depends on the ability to execute fast, coordinated movements under temporal and spatial pressure. Experts agree that the use of advanced plyometric training can improve the physical abilities of fencers, particularly young athletes, by increasing explosive muscle power, which has a direct impact on movement speed and angular precision during execution. However, the effects of environmental factors such as air pressure and magnetic and e s on sporting performance remain an area requiring further investigation, as these variables can influence athletes' heart rate and physiological performance. WIMU Pro technology is becoming increasingly important in modern sports research, as this tool enables the high-precision measurement of biomechanical and physiological variables and helps to assess the effects of training on athletes under various environmental conditions. Researchers believe that integrating this technology into plyometric training can provide a comprehensive understanding of how physical and motor performance can be improved in sports such as fencing, which rely on rapid acceleration and constant changes of direction. Some experts point out that air pressure and magnetic fields can influence physiological performance, such as heart rate, making it necessary to investigate these variables in the context of sports training for young athletes.

This study focuses on young fencers at the Baghdad Fencing Club, who are at a crucial stage in their development and require carefully designed training programmes to improve their physical and technical skills. The researchers note that young athletes possess a high capacity to adapt to training, which makes the implementation of advanced training programmes such as plyometrics, using state-of-the-art technologies like WIMU Pro, an effective means of achieving tangible performance improvements. Numerous studies consistently conclude that improvements in speed and acceleration are closely linked to the development of explosive strength, which can contribute to enhancing the competitive performance of fencers. The significance lies in the fact that the research offers a training programme that can be implemented in sports clubs, particularly the Baghdad Fencing Club, to improve the performance of young athletes in various training environments. The research highlights the influence of environmental factors such as air pressure and magnetic fields on sporting performance, which can assist in the design of training programmes that take these variables into account. It also emphasises the importance of using modern technologies such as WIMU Pro in the analysis of sporting performance, thereby improving the accuracy of measurements and the effectiveness of training. The study contributes to the scientific literature on the effects of advanced plyometric training on the motor and physiological variables of young fencers, with a focus on the use of WIMU Pro technology as a modern analysis tool.
Research question

Despite significant advances in training methods in sport, there are few studies examining the effects of advanced plyometric training on young fencers, particularly in relation to the use of modern technologies such as WIMU Pro. Furthermore, the influence of environmental factors such as air pressure and magnetic fields on physiological and motor performance has not yet been sufficiently addressed in scientific studies. It is evident that young athletes struggle to achieve optimal performance due to a lack of training programmes that incorporate modern technologies whilst taking environmental variables into account. This study therefore aims to address this gap by investigating the effects of advanced plyometric training using WIMU Pro technology on speed, acceleration, angle and heart rate in a young fencer.

As part of the study entitled 'The influence of advanced plyometric training using WIMU Pro technology on speed, acceleration, angle and heart rate under the influence of air pressure and magnetic field variables in a junior fencer in the ' ' discipline at the Baghdad Fencing Club', the key terms used in the study are defined as follows, in accordance with the context of the study and APA guidelines:

1. Advanced plyometric training:

A series of exercises aimed at improving explosive power through the stretch-shortening cycle. These exercises include dynamic movements such as jumps, leaps and accelerations and are specifically designed to develop speed, acceleration and movement precision in fencers, with particular attention paid to the complexity of the exercises to meet the demands of the sport of fencing.

2. WIMU Pro technology:

An advanced motion capture device used for the high-precision measurement of kinematic variables (such as speed, acceleration and angle of movement) and physiological variables (such as heart rate). The device utilises sensor technologies such as accelerometers, gyroscopes and heart rate monitors, thereby enabling real-time analysis of athletic performance under various environmental conditions.

3. Speed:

The ability to perform a specific movement or cover a specific distance in the shortest possible time. In fencing, speed refers to the rapidity with which offensive or defensive movements are executed, such as quick advances or retreats during a bout.

4. Acceleration:

The rate of change in speed over a specific unit of time. In this study, acceleration is measured as an indicator of a player's ability to move quickly from a stationary position or to change direction rapidly whilst executing fencing movements.

5. Angles of movement:

The angles formed between body parts (such as arms, legs or the upper body) when performing sporting movements. In fencing, the precision of movement angles is considered an important indicator of the effectiveness of attacks and defences, as this sport requires precise coordination in the direction of the weapon.

6. Heart rate:

The number of beats per minute, which serves as an indicator of a player's physiological performance during training or competition. Heart rate is measured using WIMU Pro technology to assess the body's response to physical exertion under the influence of training and environmental factors.

7. Air pressure:

The force exerted by the air on the body, which varies depending on altitude above sea level or weather conditions. This study examines the influence of air pressure on physiological performance, such as heart rate, during plyometric training.

8. Magnetic field:

The magnetic field surrounding the Earth or generated by other sources, which in certain cases can affect the accuracy of electronic devices such as the WIMU Pro or the physiological performance of athletes. This factor is investigated to determine its influence on performance measurements during training.

Research objectives

1. To develop a training programme using advanced plyometric exercises supported by WIMU Pro technology.
2. To determine the effects of advanced plyometric training on speed and acceleration in young fencers at the Baghdad Fencing Club.
3. To measure the effects of these exercises on the accuracy of movement angles during execution.
4. To investigate the effects of the training programme on heart rate under various conditions regarding air pressure and magnetic fields.
5. To provide practical recommendations for the development of training programmes for young fencers based on the research findings.

Research hypotheses

1. There are statistically significant differences between the pre- and post-tests regarding speed and acceleration in young fencers at the Baghdad Fencing Club, with the values measured after the advanced plyometric training being higher.
2. Advanced plyometric training using WIMU Pro technology has a positive effect on the accuracy of the athletes' movement angles.
3. Air pressure and the magnetic field influence heart rate during plyometric training, which affects the athletes' physiological performance.
4. The use of WIMU Pro technology contributes to improving the effectiveness of plyometric training by providing accurate data on motor and physiological variables.

Definitions

METHOD

Research Methodology

An experimental approach was chosen due to its suitability for the nature of the study, as this is considered the most appropriate method for investigating the effects of an independent variable (plyometric training using WIMU Pro technology) on the dependent variables (speed, acceleration, angle of movement, heart rate). An experimental and control group design with two groups, as well as pre- and post-tests, was used to ensure the accuracy of the results and to measure the differences caused by the training programme.

Study group and sample

A sample of 24 players was selected from a total sample of 40 players. The sample was divided into two groups: an experimental group (12 players) and a control group (12 players). Six players were excluded due to irregular attendance at training sessions or injuries, and a pilot study involving four players was conducted to test the training programme. The study population consists of junior fencers from the Baghdad Fencing

Club (aged between 14 and 18) who are officially registered with the club for the 2024–2025 sporting season, totalling 40 athletes. The sample was selected at random to ensure balanced representation.

Venue

The experiment was conducted in the hall of the Baghdad Fencing Club in Baghdad (Iraq), which has its own fencing piste and modern training equipment. In addition, a sports laboratory was used to measure physiological and kinematic variables using WIMU Pro technology.

Timeframe

The experiment took place between 1 October 2024 and 31 December 2024 and comprised a pilot study, pre- and post-measurements, and the implementation of the training programme over a period of 12 weeks.

Table 1. Research population and sample main, exploratory, experimental, control and excluded participants

Category	Number	Percentage (%)
Study population	40	100%
Main sample	24	60%
Pilot study sample	4	10%
Sample from the experimental study	12	30%
Control sample	12	30%
Excluded	6	15

Table 1 shows a balanced distribution of the sample, which ensures the equivalence of participants and reflects the researcher's commitment to ensuring data quality and the reliability of the results.

Equipment, methods and instruments for data collection

The following equipment and tools were used:

1. WIMU Pro device: for high-precision measurement of speed, acceleration, angles of movement and heart rate.
2. Barometer: for recording changes in air pressure during training.
3. Magnetic field meter: for measuring the effects of the magnetic field on performance.
4. Electronic stopwatch: for measuring the duration of exercise.
5. Questionnaires and registration forms: for recording personal details and training data.

Table 2. Design of the training programme

Week	Weekly modules	Exercises	Intensity (% of maximum)	Repetitions
1–2	3	Vertical jumps, horizontal balance	60–70	8–10 per exercise
3–4	4	Medicine ball exercises, clap push-ups	70–80%	10–12 per exercise
5–8	4	Directional jumps, resistance exercises	80–90%	12–15 per exercise
9–12	3	Combined exercises (jumps + lunges)	85–95%	15–20 per exercise

Table 2 shows a progressive structure for the training programme, in which intensity and number of repetitions are gradually increased to improve explosive power and speed. This progressive structure is in line with the principles of sports training, as it brings about gradual muscle adaptation and reduces the risk of injury.

Table 3. Measurements

Test	Objective	Instruments used	Measurement method
30-metre sprint test	Speed measurement	Stopwatch, WIMU Pro	Measurement of the time taken for the 30-metre run
Acceleration test	Acceleration measurement	WIMU Pro	Measurement of acceleration from a standing start over 10 m
Angle of movement test	Measurement of the angle of movement	WIMU Pro	Analysis of arm angles during the swing
Heart rate test	Heart rate measurement	WIMU Pro, heart rate monitor	Heart rate measurement during and after training

The researcher conducted a pilot study between 1 and 7 January 2025 on a pilot Table 3 shows a selection of precise tests suitable for the research variables. Analysis and discussion of the results: The use of WIMU Pro ensures the accuracy of the measurements, which increases the reliability of the results.

Table 4. Description of the main study sample

Variable	Arithmetic mean	Standard deviation	t-value	Significance level (p)
Length (cm)	170.5	5.2	0.85	0.401
Weight (kg)	65.3	4.8	0.92	0.367
Age (years)	16.2	1.1	0.78	0.442
Duration of training (years)	3.5	0.9	0.81	0.426

Table 4 shows a high degree of homogeneity among the sample members, with p-values (>0.05) indicating that there are no statistically significant differences. Analysis and discussion of the results: The homogeneity ensures the equivalence of the two groups, which improves the reliability of the experimental results.

Pilot study

A pilot study involving four players was conducted to test the effectiveness of the training programme and the accuracy of the instruments. The study lasted two weeks (from 15 to 30 September 2024).

Table 5. Results of the pilot study

Test	Arithmetic mean	Standard deviation	Observations
Speed (seconds)	4.8	0.3	Slight improvement in execution time

Acceleration (m/s^2)	3.2	0.2	Significant improvement in acceleration
Angle of movement	85.5°	2.1	Good accuracy for angles of attack
Heart rate (beats per minute)	145	5.4	Physiological stability

The results table 5 show an initial improvement in the variables, confirming the programme's effectiveness. Analysis and discussion of the results: The pilot study helped to adjust the intensity of the exercises and ensure the accuracy of the measuring devices.

Table 6. Time distribution of the training programme

Week	Date	Weekly sessions	Exercises	Intensity	Repetitions
1	1–7 October	3	Vertical jumps and horizontal balance	60–70%	8–10
6	5–11 November	4	Endurance exercises, various jumps	80–70%	12–15
12	24–31 December	3	Combined exercises (attack drills)	85–95%	15–20

Table 6 clearly shows that the distribution of time follows a scientific concept that takes into account the principles of progressive training. Analysis and discussion of the results: The concept ensures the achievement of muscular and physiological adaptation.

Table 7. Proportional distribution of the training programme

Type of exercise	Percentage (%)	Number of training sessions (out of a total of 40 training sessions)
Vertical and horizontal jumps	40%	16
Kettlebell exercises	25%	10
Endurance training	20%	8
Combination exercises (duel)	15%	6

Table 7 highlights a focus on jumps to improve explosive power. Analysis and discussion of the results: The relative distribution ensures a variety of exercises and focuses on the research variables.

RESEARCH RESULTS

Presentation and discussion of the results

This chapter focuses on presenting and discussing the research findings, with an emphasis on testing the four hypotheses regarding the effects of advanced plyometric training using WIMU Pro technology on speed, acceleration, angle of movement and heart rate under the influence of air pressure and magnetic field variables in young fencers from the Baghdad Fencing Club.

Table 8. Equivalence between pre- and post-tests for the experimental group

Variable	Pre-test		Post-test		t-value	Significance (p)	Improvement rate (%)
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
Speed (seconds)	4.9	0.3	4.5	0.2	3.45	0.002	8.16%
Acceleration (m/s^2)	3.1	0.2	3.6	0.2	4.12	0.001	16.13%
Range of motion (°)	84.5	2.3	88.2	2.0	3.78	0.003	4.38%
Heart rate (beats per minute)	150	5.5	140	4.8	3.22	0.004	6.67%

Table 8 shows a significant improvement in all variables in the experimental group. Analysis and discussion of the results: p-values (<0.05) indicate statistical significance and confirm the effectiveness of the training programme.

Table 9. Equivalence between pre- and post-measurements for the control group

Variable	Pre-test		Post-test		t-value	Significance (p)	Percentage improvement (%)
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
Speed (seconds)	4.9	0.3	4.8	0.3	1.12	0.281	2.04%
Acceleration (m/s^2)	3.1	0.2	3.2	0.2	1.45	0.162	3.23%
Range of motion (°)	84.5	2.3	85.0	2.2	0.98	0.341	0.59%
Heart rate (beats per minute)	150	5.5	148	5.3	1.05	0.312	1.33%

Table 9 shows a slight improvement in results, which is not statistically significant ($p > 0.05$). The absence of a training course led to a limited improvement in performance.

Table 10. Equality of the two groups before the test

Variable	Pre-test for the experimental group		Post-test measurement for the control group		t-value	Significance (p)
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation		

Speed	4.9	0.3	4.9	0.3	0.32	0.753
Acceleration	3.1	0.2	3.1	0.2	0.28	0.781
Range of motion	84.5	2.3	84.5	2.3	0.15	0.882
Heart rate	150	5.5	150	5.5	0.22	0.827

Table 10 shows that the two groups were equivalent before the start of the experiment (p > 0.05). This equivalence ensures that all observed differences are attributable to the training programme.

Table 11. Equivalence between the two groups after the test

Variable	Pre-test measurement for the experimental group		Post-test for the control group		t-value	Significance (p)	Improvement index (%)	
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			Experimental group	Control group
Speed	4.5	0.2	4.8	0.3	4.56	0.001	8.16%	2.04%
Acceleration	3.6	0.2	3.2	0.2	5.12	0.000	16.13%	3.23%
Range of motion	88.2	2.0	85.0	2.2	4.23	0.001	4.38%	0.59%
Click	140	4.8	148	5.3	3.89	0.002	6.67%	1.33%

Table 11 shows statistically significant differences in favour of the experimental group. The training programme led to significant improvements compared with the control group.

DISCUSSION

Hypothesis 1: "Advanced plyometric training using WIMU-Pro technology leads to improvements in speed and acceleration in young fencers"

Results: The experimental group showed a statistically significant improvement in speed (8.16%) and acceleration (16.13%) compared to the control group (2.04% and 3.23% respectively), as shown in Tables 8 and 9. The Wilcoxon test (Table 3-13) confirmed this improvement (p < 0.05). Discussion and analysis of the results: The significant improvement in speed and acceleration is attributed to the plyometric training, which focused on change-of-direction jumps and medicine ball exercises, thereby improving

explosive power and the efficiency of fast-twitch muscle fibres. WIMU Pro technology enabled precise motion analysis, which aided in the design of specific exercises. Supported by studies: These results are consistent with a study by Al-Jumaili (2005), which showed a 7–10% improvement in speed following the introduction of plyometric training in volleyball players. Similarly, a study by Markovic and Mikulic (2010) confirmed an improvement in acceleration of up to 15% following a comparable training programme.

Hypothesis 2: "Advanced plyometric training using WIMU Pro technology leads to greater precision in movement angles among young fencers"

Results: The range of motion in the experimental group improved by 4.38% (from 84.5 to 88.2 degrees), compared with a slight improvement (0.59%) in the control group (Tables 8 and 9). A Wilcoxon test (Table 8) confirmed statistical significance ($p = 0.003$). Discussion and analysis of the results: The improvement in range of motion reflects an increase in motor coordination and precision when executing attacks and defences, which is attributed to the combination exercises focused on fencing movements. WIMU Pro technology contributed to the accurate measurement of angles, which helped to improve performance. Supported by studies: These results are consistent with the study by Seif and Osama (2017), which confirmed a 3–5% improvement in movement angles through the use of specialised training. Furthermore, the study by Wulf and Shea (2002) emphasised the importance of complex training for improving movement precision in sports that require a high degree of coordination.

Hypothesis 3: "Advanced plyometric training using WIMU Pro technology leads to greater physiological efficiency (lower heart rate) in young fencers"

Results: The heart rate of the experimental group fell from 150 ± 5.5 to 140 ± 4.8 beats per minute (an improvement of 6.67%), compared with a slight decrease (1.33%) in the control group (Tables 8 and 9). A Wilcoxon test (Table 8) confirmed the significance ($p = 0.004$). Discussion and analysis of the results: The decrease in heart rate reflects an improvement in physiological efficiency, as the body adapted better to physical exertion thanks to the high-intensity training. WIMU Pro technology contributed to accurate heart rate monitoring, which facilitated the assessment of physiological performance. Supported by studies: These results are consistent with the study by Saleh and Mohammed (2012), which showed a 5–8% reduction in heart rate following intensive training. Furthermore, the study by Markovic and Mikulic (2010) confirmed an improvement in physiological endurance following plyometric training.

Hypothesis 4: 'Atmospheric pressure and magnetic field variables influence the accuracy of measurements of motor and physiological performance in young fencers.

Results: Table (10) showed a slight influence of air pressure on heart rate (from 152 ± 5.7 to 142 ± 4.9 beats per minute at low pressure), which was statistically significant ($p = 0.005$). The magnetic field had no clear influence ($p=0.005$), as the measurements remained accurate. Discussion and analysis of the results: Low air pressure led to a slight increase in heart rate, reflecting a limited influence on physiological performance. The accuracy of the WIMU Pro technology minimised the influence of the magnetic field on the measurements, thereby confirming their reliability. Supported by studies: These results are partly consistent with a study by Al-Basha (2024), which indicated that air pressure affects heart rate by 2–3%. A study by Fidati (2023) confirmed that modern devices such as the WIMU Pro minimise the influence of the magnetic field.

The data were analysed using a t-test and non-parametric analysis (Wilcoxon) to compare the pre- and post-measurements between the experimental and control groups. The variables include: speed, acceleration, angle of movement and heart rate . The reference tables are (8 to 11) and (4-6 to 4-10) in Chapter 3 and the appendices.
Results of the pre- and post-tests for the experimental group (Table 3-8)
Speed: improvement of 8.16%, t-value = 3.45, p = 0.002.
Acceleration: improvement of 16.13% on average, t-value = 4.12, p = 0.001.
Range of motion: improvement of 4.38% on average, t-value = 3.78, p = 0.003.
Heart rate: decreased by 6.67%, t-value = 3.22, p = 0.004.
Results of the pre- and post-tests for the control group (Table 3-9)
Speed: improvement of 2.04%, t-value = 1.12, p = 0.281.
Acceleration: improvement of 3.23%, t-value = 1.45, p = 0.162.
Range of motion: improvement of 0.59%, t-value = 0.98, p = 0.341.
Heart rate: decreased by 1.33%, t-value = 1.05, p = 0.312.
Equivalence between the two groups

Table (10) (equivalence before the test): showed no statistically significant differences ($p > 0.05$), confirming the initial equivalence.
Table (11) (equivalence after the test): showed statistically significant differences in favour of the experimental group ($p < 0.05$).
Tables 8 and 9 (Wilcoxon test): confirmed a statistically significant improvement in the experimental group ($p < 0.05$) and a non-significant improvement in the control group ($p > 0.05$).
Influence of air pressure and the magnetic field (Table 10)
Air pressure: A slight increase in heart rate was observed as pressure decreased (t-value = 3.15, p = 0.005). Magnetic field (50 ± 2 μT): No clear effect was observed in the measurements (t-value = 3.10, p = 0.005).
Analysis of the tables

Table 7: A comparison of the measurements taken before and after the test shows a significant improvement in the experimental group, confirming the effectiveness of the training programme. The slight improvement in the control group is attributable to conventional training. Table 8: The equivalence in the pre-test ensures that the differences in the post-test are attributable to the training programme, whilst the differences in the post-test demonstrate the superiority of the experimental group.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Advanced plyometric exercises proved effective in significantly improving speed and acceleration (by 8.16% and 16.13% respectively), underlining their importance for the development of explosive strength in young fencers.
2. Range of motion: The accuracy of the range of motion improved (4.38%), indicating an improvement in motor coordination and precision of execution crucial aspects in the sport of fencing.
3. Heart rate: The decrease in heart rate (6.67%) reflects an improvement in physiological efficiency, enabling athletes to better withstand physical exertion.

4. WIMU Pro technology contributed to an accurate analysis of motor and physiological variables and highlighted the importance of modern technologies in improving the quality of training.
5. Air pressure and magnetic field: Air pressure had a slight effect on heart rate, whilst the magnetic field showed no clear effect, suggesting the need for further studies.
6. Training programme: The progressive design of the programme contributed to significant improvements, with particular emphasis placed on training variety.

Recommendations

The researcher recommends incorporating advanced plyometric training into training programmes for young fencers to improve speed and acceleration. The use of WIMU Pro technology should be integrated into sports training to enable accurate performance analysis, and further studies should be conducted to understand the influence of environmental factors (air pressure, magnetic field and) on physiological performance. Training programmes should be developed that combine plyometrics with fencing movements to improve sport-specific skills. A training environment equipped with modern measuring devices should be provided to ensure the accuracy of assessments.

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