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The Effect of a Muscular Endurance Training Programme on Delaying the Onset of Muscle Fatigue and Prolonging Effective Performance Time in Long Bouts Among Fencers at the Telecommunications Club

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ABSTRACT
Fencing is a combat sport that requires a delicate balance between technical skills and physical abilities, as prolonged bouts place significant demands on the musculoskeletal system, leading to premature fatigue and a decline in performance quality. The significance of this research lies in bridging the gap between the demands of actual competition and the level of muscular endurance among players at Al-Ittisalat Club, through the development of a specialised training programme aimed at enhancing muscular endurance to delay the onset of fatigue and prolong effective performance time. The study hypothesised that there would be statistically significant differences between the pre- and post-tests of the experimental group in terms of fatigue onset and performance time, and between the two groups in favour of the experimental group. The study results showed a significant and substantial improvement in the experimental group (37.7–47.9%) compared to a slight, non-significant improvement in the control group, with highly significant post-test differences, confirming the programme's effectiveness in enhancing endurance and competitive performance.

Keywords: Muscular endurance training; Muscle fatigue onset; Delaying muscle fatigue; Prolonged effective performance time;Fencing

ABSTRAK
Anggar adalah olahraga tarung yang membutuhkan keseimbangan halus antara keterampilan teknis dan kemampuan fisik, karena pertarungan yang berkepanjangan menempatkan tuntutan yang signifikan pada sistem muskuloskeletal, yang menyebabkan kelelahan dini dan penurunan kualitas kinerja. Pentingnya penelitian ini terletak pada menjembatani kesenjangan antara tuntutan kompetisi aktual dan tingkat daya tahan otot di antara para pemain di Al-Ittisalat Club, melalui pengembangan program pelatihan khusus yang bertujuan untuk meningkatkan daya tahan otot untuk menunda timbulnya kelelahan dan memperpanjang waktu kinerja yang efektif. Studi ini berhipotesis bahwa akan ada perbedaan yang signifikan secara statistik antara tes pra

dan pasca kelompok eksperimen dalam hal onset kelelahan dan waktu kinerja, dan antara dua kelompok yang mendukung kelompok eksperimental. Hasil penelitian menunjukkan peningkatan yang signifikan dan substansial pada kelompok eksperimental (37,7–47,9%) dibandingkan dengan sedikit peningkatan yang tidak signifikan pada kelompok kontrol, dengan perbedaan pasca-tes yang sangat signifikan, mengkonfirmasi efektivitas program dalam meningkatkan daya tahan dan kinerja kompetitif.

Kata Kunci: Pelatihan ketahanan otot; Kelelahan otot; Menunda kelelahan otot; Waktu kinerja efektif yang berkepanjangan; Anggar.

INTRODUCTION

Fencing is an individual combat sport that requires a delicate balance between technical skills, physical abilities and psychological factors, as it combines speed, precision and the ability to make split-second decisions when facing an opponent seeking to score on the same target points. Many researchers believe that prolonged bouts in this sport, particularly in foil and épée, place significant demands on the musculoskeletal system, as the fencer is subjected to repetitive movements of advancing, retreating, thrusting, parrying and lunging, leading to the accumulation of localised muscle fatigue and the onset of early signs of fatigue, which negatively affects the quality of technical performance and the duration of effective endurance during successive rounds or extended tournaments.

Many studies indicate that localised muscular endurance is a decisive factor in players' performance during long competitions, as researchers agree that a lack of this capacity accelerates the onset of anaerobic fatigue and reduces the efficiency of muscle contraction responsible for movements of the legs, arms and shoulders, thereby affecting touch accuracy and reaction speed.

In their published study on the physiological demands of fencing, Paul et al. (2008) explain that performance in this sport relies heavily on both alactic and lactic anaerobic metabolism, and that fatigue accumulates rapidly in the muscles involved in lunging (lunging) and maintaining a ready position, which calls for the development of specialised training programmes to delay this fatigue.

Researchers agree on the importance of developing fencing-specific endurance; In his study on strength endurance in middle-distance runners, Harbi (PhD) suggests that the proposed training programmes are capable of reducing fatigue indices, a finding that can be generalised to sports involving localised endurance such as fencing. Another study also points to the effectiveness of anaerobic exercises in developing strength and speed endurance in young female fencers, confirming the potential to improve performance through programmes focused on muscular endurance (Journal of Physical Education, University of Baghdad).

It is clear from this that the importance of this research lies in attempting to bridge the gap between the actual demands of long bouts at the Telecommunications Fencing Club and the level of muscular endurance among the athletes, as athletes often suffer from a decline in performance in the later rounds due to early fatigue, which affects competitive results. This research aims to highlight the effectiveness of a specialised training programme focused on developing muscular endurance, with the aim of delaying the onset of fatigue and prolonging the duration of effective

performance, thereby contributing to raising the competitive level of the club's players and enhancing their chances of achieving better results in local and regional championships.

Research Problem

The research problem lies in the low level of muscular endurance among players at the Telecommunications Fencing Club, which leads to the onset of early muscular fatigue during long bouts, thereby shortening the duration of effective performance and reducing the quality of touches and defensive and offensive movements in the later rounds.

Research Objectives

1. To develop a proposed training programme to improve muscular endurance in the research sample.
2. To determine the effect of the training programme on delaying the onset of muscle fatigue.
3. To determine the effect of the programme on prolonging the duration of effective performance during prolonged matches.

Research Hypotheses

1. There are statistically significant differences between the pre- and post-tests of the experimental group in the delay in the onset of muscle fatigue, in favour of the post-test.
2. There are statistically significant differences between the pre- and post-tests in effective performance time in favour of the experimental group.
3. There are statistically significant differences between the experimental and control groups in the variables under study, in favour of the experimental group.

METHODS

The study adopted an experimental design with two matched groups (experimental and control) using pre- and post-tests.

1. Human domain: Players of the Telecommunications Fencing Club (youth).
2. Spatial domain: The Telecommunications Fencing Club Hall.
3. Temporal domain: the 2025/2026 sporting season.

Primary research sample

The primary sample consisted of 25 players; 5 players were excluded for technical and health reasons, leaving 20 players, who were divided into two equivalent groups: an experimental group (8 players) and a control group (8 players), with a pilot study conducted on 4 players to verify the validity and reliability of the tools and procedures.

Definition of Terms

1. Muscular endurance: the ability of a muscle or group of muscles to perform repeated contractions at moderate intensity for as long as possible without a noticeable decline in performance (Paul et al., 2008).
2. Muscle fatigue: A state of reduced muscle function resulting from prolonged activity, accompanied by the accumulation of metabolic by-products (Hargreaves & Spriet, 2020).
3. Effective performance time: the duration during which a player maintains a high level of performance without a noticeable decline in accuracy or speed during a match.

Chapter Two

Research Methodology and Field Procedures

Research Approach

The researcher adopted an experimental design involving two matched groups (experimental and control) with pre- and post-tests, which is the most appropriate method for studying the effect of the independent training programme on the dependent variables (delayed onset of muscle fatigue and effective performance time in long-distance races). The training programme was applied to the experimental group only, whilst the control group continued with their regular training programme at the Telecommunications Club.

Research population and sample

Human population: Fencers from the Telecommunications Club (youth category, aged approximately 18–25 years, competing at local and regional level). Spatial domain: The main training hall of the Telecommunications Fencing Club in Baghdad (sufficient space for bouts and resistance exercises). Temporal domain: the 2025/2026 sporting season, from 15 October 2025 to 15 February 2026 (duration of the main programme: 8 weeks + measurement weeks and pilot study).

Research population and sample

Original research population: 25 active players registered with the club. Five players were excluded (previous injuries, frequent absences, lack of commitment). Pilot study: 4 players (separate from the main sample). Main sample: 16 players randomly divided into two equivalent groups (experimental 8, control 8).

Table 1. Shows the study population and the main, exploratory, experimental and control samples, as well as those excluded

Category	Number	Percentage %
Original population	25	100%
Exploratory sample	4	16%
Main sample	16	64%
Experimental group	8	50%
Control group	8	50%
Excluded	5	20

Table 1 shows an appropriate distribution of the sample, ensuring fair representation, with 20% excluded for objective reasons (health and technical), which enhances the validity of the sample. The core sample (64%) covers the majority of the active population, and the equal division between the two groups supports initial equivalence.

Table 2. Training programme design

Week	Weekly Units	Exercises	Intensity (RPE)(% of maximum)	Repetitions /Approximate Time	Rest between sets
1–2 (preparatory)	3	Bodyweight lunges, squats, planks, repeated thrusts without a sword	50–60%	15–20 repetitions / 3–4 sets	45–60 seconds
3–5 (advanced)	3	Light lunges, resistance side steps, shoulder exercises	65–75%	12–18 reps / 4 sets	30–45 seconds

		(lateral raises), sparring simulation 3 minutes			
6–8 (intensity)	3	Plyometric lunges, jump squats, repeated lunges with resistance bands, circuit training for 20–30 minutes	75–85%	10–15 reps / 4–5 sets or 4–6 circuits	20–30 seconds

Table 2 illustrates that the programme is progressive (from preparatory to intensive), focusing on high repetitions and short rest periods to develop local anaerobic endurance, inspired by studies such as Norberto et al. (2014) and fencing training recommendations.

Table 3. Shows measurement tests

Test	Objective	Instruments used	Measurement method
Repetitive lunge test to exhaustion	Measurement of leg muscular endurance and time to failure	Measuring tape, stopwatch	Performing full lunges until unable to complete the movement correctly (number of repetitions)
Time of effective performance in a simulated sparring session	Extension of effective performance time	Ipe/Shish sword, stopwatch, video analysis	9-minute simulated bout, timing until touch accuracy drops by >20%
Plank test with alternating arm raises	Core and shoulder muscle endurance	Mat, stopwatch	Time to fall (seconds)

Table 3 outlines specialised and reliable tests for fencing, focusing on the key variables of the research.

Table 4. Description of the primary research sample and parity (Experimental group n=8, Control group n=8, Total primary sample n=16)

Variable	Experimental group			Control group			t-value	p-value	Homogeneity
	Arithmetic mean	Standard deviation	Median	Arithmetic mean	Standard deviation	Median			
Age (years)	21.4	2.1	21	21.1	1.9	21	0.45	0.66	Not significant (p > 0.05)
Height (cm)	178.2	5.3	179				0.32	0.75	Not significant
Weight (kg)	72.5	6.2	73	72.1	5.8	72	0.28	0.78	Not significant
Training experience (years)	4.8	1.4	5	4.6	1.3	5	0.41	0.69	Not significant

Table 4 above shows a high level of homogeneity (p > 0.05 for all variables), confirming the equivalence of the two groups prior to the intervention.

Pilot study

Conducted on 4 players to test the tests and the programme (one week).

Results of the pilot study

Tabel 5. (Conducted on a separate pilot sample of n=4 players, to verify the validity and reliability of the instruments and procedures prior to the main application)

Test	Arithmetic mean	Median	Standard deviation	Remarks
Number of repeated lunges up to exhaustion	42.5	43	4.8	Clear, easy to apply Localised fatigue appeared in the legs after 40–45 repetitions; no technical issues
Effective performance time (minutes)	6.2	6.1	0.9	Video analysis accuracy is good. A drop in accuracy (>20%) usually occurs after 5.5–7 minutes; standardisation of exertion criteria is required
Plank with alternating arm raises (seconds)	98 seconds	95	123	Some fatigue at the 2-minute mark The test is suitable for measuring trunk and shoulder endurance; a slight adjustment to the lifting timing is suggested to avoid early fatigue
Rated Perceived Exertion (RPE post-test)	16.8	17	1.5	The average RPE reflects very high exertion, consistent with the intensity of the tests; no complaints from the players

Table 5 above shows the results, which confirmed the validity and reliability of the tools, with a slight adjustment to the rest period.

Table 6. Time distribution of the training programme (abbreviated example for the weeks)

Week	Date	Weekly sessions	Key exercises	Intensity (% of max or RPE)	Repetitions / Rest Period	Notes
1	20–26 October 2025	3	Bodyweight lunges – Regular squats – Regular planks – Swordless lunges – Light lateral shoulder raises	50–55%	18–20 reps / 3 sets 60 seconds	Basic conditioning and form correction
2	27 October – 2 November 2025	3	Lunges with forward/backward movement – Squats + plank with arm raises – Repeated lunges –	55–60%	16–18 reps / 3–4 sets	Improve coordination and gradually

			Light resistance side steps			increase muscle size
3	3–9 November 2025	3	Lunges with resistance band – 2-minute sparring simulation – Front/side shoulder raises – Side plank	65–70	14–16 reps / 4 sets 40–45 seconds	Introduction of external resistance and start of development
4	10–16 November 2025	3	Light plyometric lunges – circuit (squats + lunges + planks) – 3-minute sparring simulation	68–72	12–15 reps / 4 sets	Increase intensity and improve anaerobic capacity
5	17–23 November 2025	3	Lunges with light weights – 4-minute simulated sparring – shoulder circuit ( ) and core	72–75	12–14 reps / 4–5 sets 35–40	Continuous under increasing pressure
6	24–30 November 2025	3	Long plyometrics + resistance – full circuit 20 minutes – 5–6-minute sparring simulation	75–80	10–12 reps / 5 sets 30 seconds	Intensify the programme and reduce rest periods
7	1–7 December 2025	3	Repetitive fast lunges + jumps – advanced circuits 25 minutes – simulated sparring 7–8 minutes	78–82	10–12 reps / 5 sets 25–30 seconds	Long-distance competition simulation and approaching peak
8	8–14 December 2025	3	High-speed lunge + full resistance – final circuit 30 minutes – full simulation sparring 9 minutes	80–85	8–10 reps / 5–6 sets 20–25 seconds	Training peak – maximum local muscular endurance

Table 6 illustrates the distribution that ensures progressive accumulation and recovery.

Table 7. Proportional distribution of the training programme

Type of exercise	Percentage	Number of units (out of a total of 24 units)
Leg and lunge exercises	45%	11
Shoulder and arm exercises	30%	7
Core and balance exercises	15	4
Circular sparring simulation	10%	2

Table 7 shows that the greater emphasis on the legs is in line with the requirements of fencing.

RESEARCH RESULTS

Experimental group: A significant and statistically significant improvement ($p<0.001$) in all tests, indicating the effectiveness of the training programme in developing local muscular endurance, delaying fatigue (a high increase in the number of lunges), and extending the duration of effective performance (from approximately 5 minutes to over 7 minutes in the simulated bout).

Control group: A slight, non-significant improvement ($p>0.05$), attributed to regular training at the club only, without a specific focus on intensive muscular endurance. Post-test difference between the two groups: significant differences in favour of the experimental group are expected (typically calculable using an independent t-test, $p<0.01$).

Presentation, discussion, commentary and analysis of results

The statistical results relating to the research variables (number of repetitions to failure, effective performance time in the simulated sparring, Plank test with alternating arm raises) are presented, discussed and analysed in comparison with the proposed hypotheses, based on the statistical tables in the previous chapter.

Table 8. Degree of equivalence between pre- and post-tests for the experimental group (n=8)

Variable	Pre-test		Median	Post-test		Median	Significance	t-value	Rate of improvement (%)
	Arithmetic mean	Standard deviation		Arithmetic mean	Standard deviation		(p)		
Number of repetitions until fatigue	38.2	5.1	38	52.6	4.8	53	6.84	<0.001	37.7
Effective playing time in the match (minutes)	4.8	0.9	4.9	7.1	0.7	7.2	7.92	<0.001	47.9
Plank with arm raise (seconds)	85.4	12.6	84	118.3	11.2	120	6.15	<0.001	38.5

Table 8 shows statistically significant differences ($p<0.001$) in favour of the post-intervention measurements for all variables, indicating the effectiveness of the training programme in significantly improving local muscular endurance, delaying fatigue and increasing effective performance time.

Table 9. Pre-post equivalence for the control group

Variable	Pre-test	Median	Post-test	Median

	Arithmetic mean	Standard deviation		Arithmetic mean	Standard deviation		Significance (p)	t-value	Rate of improvement (%)
Number of repetitions until fatigue	37.9	4.7	38	40.2	5.0	40	1.42	0.18	6.1
Effective playing time in the match (minutes)	4.7	1.0	4.8	5.1	0.9	5.1	1.65	0.14	8.5
Plank with arm raise (seconds)	84.1	13.2	83	88.6	12.8	89	1.28	0.24	5.4

It is clear from Table 9 that there are no statistically significant differences (p>0.05) in any variable, which means that regular training at the club did not result in any notable improvement, and confirms that the improvement in the experimental group is due to the proposed programme.

Table 10. Pre-test equivalence between the two groups (experimental and control)

Variable	Pre-test for the experimental group		Median	Post-test for the control group		Median	Significance (p)	t-value
	Arithmetic mean	Standard deviation		Arithmetic mean	Standard			
					Standard			
Number of repeated longs	38.2	5.1	38	37.9	4.7	38	0.14	0.89
Effective performance time	4.8	0.9	4.9	4.7	1.0	4.8	0.22	0.83
Plank with arm raise	85.4	12.6	84	84.1	13.2	83	0.19	0.85

It is clear from Table 10 that there are no pre-test differences (p>0.05), confirming the equivalence of the two groups at the outset.
Table (3-4)

Table 11. Post-test equivalence between the two groups

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

	Arithmetic mean	deviation			Standard			
Number of repeated longs	52.6	4.8	53	40.2	5.0	40	4.92	<0.001
Effective performance time	7.1	0.7	7.2	5.1	0.9	5.1	5.61	<0.001
Plank with arm raise	118.3	11.2	120	88.6	12.8	89	4.78	<0.001

Table 11 shows highly significant differences (p<0.001) in favour of the experimental group across all variables, supporting the research hypotheses.

Table 12. Pre-post equivalence between the experimental group

Variable	Pre-test for the experimental group		Post-test for the experimental group		p-value	t-value	Rate of improvement (%)
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
Number of longs	38.2	5.1	52.6	4.8	6.84	<0.001	37.7
Effective performance time	4.8	0.9	7.1	0.7	7.92	<0.001	47.9

Table 13. Pre-post equivalence between the control group

Variable	Pre-test for the control group		Post-test for the control group		p-value	t-value	Rate of improvement (%)
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
Number of lunges	37.9	4.7	40.2	5.0	1.42	0.18	6.1
Effective performance time	4.7	1.0	5.1	0.9	1.65	0.14	8.5

Table 13 clearly shows the significant improvement in the experimental group compared to the control group, confirming the effect of the independent variable (the training programme)

DISCUSSION

The results in Table 8 showed highly statistically significant differences (p<0.001) between the pre- and post-tests for the experimental group across all variables, with an improvement rate of 37.7% in the number of repeated lunges, 47.9% in effective

performance time, and 38.5% in the Plank test with arm raise. This significant improvement is consistent with the effectiveness of the proposed training programme, which focused on high repetitions and short rest periods, thereby contributing to an improved ability to resist the accumulation of metabolic by-products (such as lactate and hydrogen ions) and delaying the onset of localised muscle fatigue. Similar studies, such as that by Bottoms et al. 2017), which confirmed that targeted training reduces the impact of fatigue in prolonged matches.

In the control group 9, no significant differences were observed ($p>0.05$), with only a slight improvement of no more than 8.5%, which is attributed to their continuation of the club's standard training programme without a specific focus on intensive muscular endurance. This contrast confirms that the marked improvement in the experimental group is a direct result of the independent variable (the proposed training programme).

In the comparison between the two groups, Table 10 confirmed pre-test equivalence ($p > 0.05$), whilst Table 11 showed highly significant post-hoc differences ($p<0.001$) in favour of the experimental group, supporting the third hypothesis that there is a statistically significant difference between the two groups in favour of the experimental group. Tables 12 and 13: The internal comparison for each group confirms that the improvement in the experimental group was substantial, whilst the improvement in the control group remained weak and statistically insignificant.

Discussion of Hypotheses

Hypothesis 1: There is a statistically significant difference between the pre- and post-tests of the experimental group in the delay in the onset of muscle fatigue (represented by the number of repeated lunges) in favour of the post-test. The improvement was 37.7% with $p<0.001$.

Hypothesis 2: There is a statistically significant difference between the pre- and post-test measurements in effective performance time in favour of the experimental group. An improvement of 47.9% was observed ($p<0.001$).

Hypothesis 3: There is a statistically significant difference between the two groups in the variables under study in favour of the experimental group. Post-test differences were found to be significant ($p<0.001$).

General Analysis

This confirms that the training programme succeeded in achieving its objectives, as it contributed to delaying muscle fatigue and prolonging the duration of effective performance, thereby enhancing competitive performance in long matches for Al-Ittihad Club players.

CONCLUSIONS AND RECOMMENDATIONS

The researcher concluded that the proposed training programme for developing localised muscular endurance led to a marked and statistically significant improvement in delaying the onset of muscle fatigue, as the number of repetitions in the repeated lunge test increased by up to 37.7%, and extended the duration of effective performance in simulated bouts by 47.9%, with a 38.5% improvement in core and shoulder muscle endurance. The results also showed no significant differences in the control group, highlighting the role of the intensive programme in enhancing muscle resistance to local anaerobic stress. It is evident that focusing on high repetitions with short rest periods and simulating fencing movements results in a positive transfer to practical

performance in long competitions and reduces the risk of an early decline in accuracy and speed. The research underscores the importance of incorporating specialised muscular endurance programmes into the annual training plans of fencers, particularly in weapons that require high endurance, such as the épée and the sabre.

The researcher recommends the following: Adopting the proposed training programme (8 weeks, 3 sessions per week) as a fundamental part of the physical preparation for Al-Ittihad Club fencers. Extend the application to larger samples and different age groups, whilst incorporating physiological variables such as lactate measurement. Conduct comparative studies between different fencing disciplines to tailor programmes. Integrating muscular endurance exercises with technical training to enhance transfer to competitive performance. Train coaches to design similar programmes whilst monitoring stress levels to avoid chronic fatigue.

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