



Cross-Training Exercises and Their Effects on Strength-Endurance Performance and Selected Electromyographic (EMG) Indicators in Strongman Competitions among Iraqi National Team Elite Athletes

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Abstract

The study aimed to design cross-training exercises to develop performance and selected special physical abilities of the muscles involved in Strongest Man competitions in the advanced weight category (100–105 kg). The researcher adopted the experimental method because it suited the research problem and objectives. The research population comprised 20 advanced athletes from the Iraqi national Strongest Man team selected intentionally. The research sample included 12 athletes whose body weights ranged between 100 and 105 kg representing 60% of the original population. The remaining 8 athletes were excluded because of their lack of homogeneity in body weight. The research procedures involved identifying the study variables through consultation with experts and specialists in sports training and exercise physiology, selecting appropriate tests, establishing their scientific foundations and conducting a pilot experiment. pre-tests were administered before implementing the proposed training program. The program lasted 8 weeks comprising 3 training sessions per week. Following completion of the intervention post-tests were conducted to evaluate changes in the selected variables. The results revealed that the cross-training exercises positively affected the development of physical abilities among the experimental group, including maximal strength, explosive power and muscular endurance as well as competition achievement. The exercises produced noticeable improvements in the electrical activity of the investigated muscles particularly peak electrical activity. These findings demonstrate the potential effectiveness of structured cross-training programs in enhancing physical performance and neuromuscular function among advanced Strongest Man athletes in the 100–105 kg weight category.

Keywords: Cross-training, physical abilities, electrical activity indicators.

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Introduction

Sports training aims to enhance the various foundations and factors that play an effective role in improving performance across different sports; one such foundation is physical preparation, which is the cornerstone for enhancing the various physical and physiological attributes of players, whether in team or individual sports.

The aim of the training process is to help athletes achieve a high level of performance suitable for entering the world of champions in their specialist sport and for achieving international success in the sporting arena. Among the training methods is the cross-training approach, which the researcher adopted in the methodological procedures for the training module.

Cross-training stimulates auxiliary muscles that are not typically targeted in the training programme for a specific sport, whilst also helping the nervous and muscular systems to improve their coordination, which in turn enhances the athlete's performance.

This approach has a distinct and clear impact on athletes' aerobic and anaerobic endurance through the alternation, combination and variety of exercises used within training sessions. Consequently, this training process is made more engaging; it transfers the effort exerted during exercises and distributes it across different types of muscles and tendons that may not normally be engaged, causing them to work in different ways depending on the type of exercise, whilst also allowing for rest periods between exercises, which serves to reduce the strain on the nervous and muscular systems, and also enhance physical fitness.

Hence the importance of this research lies in developing interval training exercises and determining their effect on strength endurance and certain

indicators of electrical activity in strongman athletes. In his capacity as a certified coach, the researcher observed a lack of available information, or information that was out of date, which ultimately serves to raise the standard of the sport; Therefore, the researcher decided to employ a training method known as cross-training and to investigate its impact on specific physical abilities, performance efficiency and certain indicators of electrical activity in the working muscles, This raises the question of whether cross-training can offer a new training approach that contributes to the development of strength endurance, as strength endurance is one of the qualities required for this discipline, thereby enhancing the ability to perform at a high level despite the difficulty involved, given that athletes handle heavy weights whilst competing in these events Another question is: to what extent might changes occur in the internal physiological environment of the research sample's participants—in terms of muscular aspects and associated functional indicators—as a result of the cross-training approach?

Academic studies are considered a key factor in the development of this modern sport and in helping coaches and players achieve the highest results and accomplishments in domestic and national championships.

Research objectives:

1- To develop interval training exercises to improve strength endurance and certain indicators of electrical activity in strongman athletes

2-To investigate the effect of interval training exercises on strength endurance and certain indicators of electrical activity in strongman athletes

Research Hypotheses:

1. There are statistically significant differences between the pre-test and post-test scores for the control and experimental groups.

2. There are statistically significant differences between the values of the physical ability and achievement indices and the values of the electrical activity of the working muscles between the pre-test and post-test.

Method and Tools

The researcher used the experimental design with two equivalent groups the experimental and control groups as it was appropriate for the research problem The research sample was purposively selected from the 20 players of the Iraqi national strongman team in the advanced category The research sample was selected using a purposive method based on weight, comprising 12 players weighing between 100 and 105 kg, representing 60 per cent of the original population. Eight players were excluded due to inconsistencies in their weight and were divided into two equal groups, one of which was the experimental group to whom the exercises designed by the researcher were applied, whilst the control group followed the exercises previously adopted for their training. The research sample was standardised and the two groups were matched, as shown in Tables 1 and 2.

Table1. shows the homogeneity of the research sample in terms of the variables (height, weight, training age, chronological age)

NO	variables	Unit of measurement	mean	SD	Skewness
1	Height	cm	180.91	1.37	0.32
2	Weight	kg	102.58	1.31	0.36
3	Training experience	month	26.16	1.19	0.39
4	Age	year	3.83	0.24	0.81

Table2. shows the arithmetic means, standard deviations, and calculated and tabulated *t*-values for the two study groups (control and experimental) for the research variables

variables	Unit	control group		experimental group		T	SIG
		mean	SD	mean	SD		
Posterior deltoid	Microvolt	583.16	1.47	581.66	1.63	1.67	0.12
Dorsal lumbar	Microvolt	505.83	1.16	505.16	0.75	1.17	0.26
Triceps	Microvolt	575.0	0.89	574.33	1.21	1.08	0.304
Attachment of the arms to the shoulder joint	Number	6.33	0.51	6.66	0.52	1.11	0.29

Not statistically significant at the 0.05 significance level with 10 df.

Field Research Procedures

Identification of indicators of electrical activity

The views of a number of experts and specialists in the field were sought, resulting in the selection of 12 muscle-related variables, which were presented in a questionnaire to a group of nine experts in physiology. The variables were selected through direct observation via a video presentation of the technical performance.

Based on the above, the researcher adopted the variables that achieved a percentage of 75 per cent or higher, in accordance with the views of (Benjamin, 1983; Hassanein, 2004), who emphasise that ‘the researcher must obtain a percentage of agreement of 75 per cent or more to accept the phenomenon, as shown in the tables below (3) (4), the researcher is also entitled to select variables they deem appropriate provided that the percentage is not less than 25 per cent as a percentage of 25 per cent does not constitute a significant contribution to the overall variation of the measured phenomenon. (Jassim, 2014)

Table 3. shows the relative importance of the muscles studied, according to the opinion of (9) experts

NO	variables	Relative Importance	Accepted variables	Unacceptable variables
1	Ulnar wrist extensor	68.8		✓
2	Humeroulnar	73.3		✓
3	Posterior deltoid	95.5	✓	
4	Lumbar dorsal	86.6	✓	
5	Triceps brachii	91	✓	
7	Coracobrachialis	46.6		✓



8	Ulnar brachialis	44.4	✓
9	Brachialis	73.3	✓
10	Ulnar wrist extensor	49	✓
11	Ulnar wrist stabiliser	44	✓
12	Lateral vastus ulnaris	47	✓

Tests used

Electromyography (EMG)

Test name: Electromyography (EMG).

Purpose of the test: To measure the amplitude and peak of the waveform of the working muscles. Equipment and instruments used: An electromyography (EMG) device (Samsung) that receives and transmits signals via Bluetooth and is rechargeable, weighing 250 g; connecting cables between the electrodes and the device; four surface electrodes per muscle a remote signal receiver tuned to the transmitter's frequency, software for the device supported by the manufacturer medical cotton wool, Aspiro, a shaving stand, a Sony camera, and a Lenovo computer Procedure: Steps for operating the EMG device: Before starting the EMG programme, the area over the muscle must be shaved to remove hair, and then cleaned with an alcohol solution. It is important to emphasise here the importance of cleaning the area to remove the thin layer of dirt that affects the electrical signal. We place surface electrodes to record electrical activity; the electrode closest to the stimulated motor unit records a larger EMG signal, whilst a smaller signal is recorded when the stimulated motor unit is further away from the electrode. Surface electrodes are the most commonly used in the analysis of human movements; in addition to recording signals that pass beneath the surface of the electrode, they also record electrical signals. A surface electrode consists of a small metal disc with a diameter of 1 cm; it can be even smaller if small muscles are to be tested. The electrode is made of silver chloride and is highly sensitive to the electrical signals emitted by muscles close to the skin. These electrodes record the signal indicating the rate of electrical activity. As for the surface electrodes, which are attached to the upper and middle parts of the muscles after we have asked the laboratory to contract the muscle, their function is to detect the electrical current in the activated muscles and transmit it to a computer screen to display the strength and shape of the signal via a software programme, which analyses the stored data and provides useful reports on muscle activity. Two electrodes have been placed on each muscle.

Method of recording: The peak values and areas of the waveforms for certain active muscles that have been measured will be calculated using the analysis software linked to the computer-connected EMG device.

The results of this test will be recorded alongside the results of the muscle strength tests for the muscles involved in the activity; these muscles are the posterior deltoid, the triceps brachii and the lumbar back muscles.

Strength Endurance Test

Test name: Pull-ups (Hazaa, 1413 AH) Source

Purpose of the test: To measure the strength endurance of the arm muscles.

Equipment used: Pull-up bar

Description of the test: The test subject stands beneath the horizontal bar; upon the start signal, they begin to pull themselves up with their arms until their chin is above the bar, then lower themselves until their arms are fully extended as in the starting position, and repeat this movement as many times as possible without stopping.

Scoring: Each contraction is counted as valid and complete if the participant's chin reaches above the bar.

Results

Table4.Shows the arithmetic means, standard deviations and calculated *t*-values for the pre- and post-test results of the research variables for the experimental group

variables	Pre-tests		Post-tests		fm	ES	T	SIG
	mean	SD	mean	SD				
Posterior deltoid	581.66	1.63	653.6	2.73	72	1.12	63.97	0.000
Dorsal lumbar	505.16	0.75	544.3	1.96	39.16	0.94	41.41	0.000
Triceps	574.33	1.21	633.3	2.80	59	1.31	44.81	0.000
Attachment of the arms to the shoulder joint	6.66	0.51	10.83	0.75	4.16	0.40	10.38	0.000

significant at the 0.05 significance level with 5 df.

Table5.Shows the arithmetic means, standard deviations and calculated *t*-values for the pre- and post-test results of the research variables for the control group

variables	Pre-tests		Post-tests		fm	ES	T	SIG
	mean	SD	mean	SD				
Posterior deltoid	583.1	1.47	622.5	1.87	39.33	0.49	79.55	0.000
Dorsal lumbar	505.83	1.16	524.5	1.87	18.66	0.84	22.13	0.000
Triceps	575.0	0.89	603.1	1.94	28.16	0.74	37.60	0.000
Attachment of the arms to the shoulder joint	6.33	0.51	8.50	0.54	2.16	0.40	5.39	0.003

significant at the 0.05 significance level with 5 df.

Table6. Shows the arithmetic means, standard deviations and calculated *t*-values for the results of the dimensional tests for the research variables in the control and experimental groups

variables	Unit	control group		experimental group		T	SIG
		mean	SD	mean	SD		



Posterior deltoid	Microvolt	622.50	1.87	653.6	2.73	23.05	0.000
Dorsal lumbar	Microvolt	524.50	1.87	544.3	1.96	17.89	0.000
Triceps	Microvolt	603.16	1.4	633.3	2.80	21.65	0.000
Attachment of the arms to the shoulder joint	Number	8.50	0.54	10.83	0.75	6.13	0.000

Discussion

The results in Tables (4) and (5), relating to the pre- and post-tests for the experimental and control groups, showed statistically significant differences between the pre- and post-tests, with the post-tests yielding better results. The results showed improvement in both groups with the experimental group performing better in these tests the researcher attributes this to the cross-training exercises he designed and their clear impact on the sample.

The researcher sought to develop the variables under study through scientifically and carefully designed exercises, which were undoubtedly aimed at improving the players' performance in accordance with the scientific principles and foundations of proven training programmes, based on the coach's experience and logical analysis, which focused on the variables under study; What distinguishes the exercises used by the experimental group is their specialised nature, which is evident from the extent of the differences shown in Table 4-1. His aim is to optimise and develop the variables under study to the greatest possible extent, in order to achieve the maximum possible strength in the shortest possible time, The specific exercises used by the researcher were characterised by their effect on rapid muscle responses, achieved by exerting maximum force in the shortest possible time, which has a positive effect on the development of physical capabilities and electromyographic activity (EMG). These exercises had a positive impact on strength gains, which were evident from the electromyographic readings of the muscles involved, as confirmed by (Abda Al-Aziz Al-Nimr and Nariman Al-Khatib, 2017) Increasing the range of motion in the joints and the muscles acting upon them enables these muscles to generate greater force throughout the range of motion, as muscles that are stretched perform their function with high efficiency and generate a certain amount of force as a result of the storage of elastic energy in the muscle tissue during the stretching phase and its release during the subsequent shortening phase (Al-Khatib, 2017, p. 305) The researcher also attributes the changes in electrical activity to the moment when players exert maximum force to achieve a feat; this requires a very high degree of coordination between the various forces exerted across several areas of the body that are actively involved in the specific execution of the skill, in order to achieve

the correct dynamics of the movement, which enables the optimal economy of force and time required to maximise the force output. Scientific sources have also pointed out that “proper training results in an increase in an individual’s capabilities due to the performance of physical exercises over several days, weeks and months, as the body’s systems and muscles adapt to the optimal performance of those exercises; In other words, the effect of physical exercise, as noted by the researcher, stimulates muscle cells to adapt, making them more efficient in performing high-intensity work (Edington, pp. 8–10).”

This improvement was confirmed by measuring the electrical activity of the target muscles under study; the researcher attributes the increase in electrical activity observed in the post-test of the experimental group to the effect of the exercise programme he devised, as the training led to an increase in electrical activity, making it more regular and less random; this is because muscle signals are elevated when the muscles are subjected to sustained high exertion and a prolonged period of training in order to achieve the goal of reaching the stage of adaptation and muscle plasticity. Consequently, there is an increase in the peak index (i.e. the amplitude of the electrical activity of the working muscles), and (Komi, 1992) confirmed that” “Muscle adaptation requires more time, which may extend to several months depending on the type and volume of training. We therefore observe an improvement in muscle strength within a short period; this performance gain resulted from the coordination of the working muscles due to the neural adaptations that occurred initially through an increase in the number of nerve impulses” (Komi, 1992, p. 38)

Table 6 presents the results of the post-test analyses for the experimental and control groups regarding the research variables under study. It shows that there were statistically significant differences between the experimental and control groups, in favour of the experimental group for the variables under study The results of the electrical activity of the muscles under study revealed differences in favour of the post-tests, as the results presented in the aforementioned table This means that the exercises designed by the researcher led to neuromuscular adaptation as a result of strength training and neuromuscular stretching of the sensory receptors, The researcher also attributes this development—the increase in electrical activity in the working muscles—to the nature of the exercises included in the training units, which focused on engaging the required muscles in a specific and fluid manner whilst avoiding excessive movements This helped the players to focus on their motor performance resulting in highly fluid movement without any interruptions and with minimal exertion; when one muscle has completed its task, it returns to a state of relaxation (inactivity) and the next muscle begins its electrical



activity, which in turn leads to efficiency in the muscular effort expended, resulting in fluidity and coordination in muscular function, “The more streamlined the path of the forces, the more streamlined the motion; this is what is referred to as ‘dynamic configuration’, meaning the path of the force over time for this motion” (Al-Madamga, M., 2017, p. 650) Another important point to note, which explains the development of the electrical activity indicators for both peak and average values, is that ‘using low intensity during training results in the recruitment of fewer motor units, most, if not all, of which are red; whilst the white fibres will not be activated; however, when using loads close to or at maximum intensity, the muscle groups will recruit both types of fibres.”Consequently, white muscle fibres have a greater opportunity to be activated, and thus the muscle’s explosive strength will develop more effectively owing to the characteristics of white muscle fibres in force production (Al-Dalawi, 2011, p. 265), Here, the researcher explains that the high-intensity, repetitive exercises used contributed significantly to the recruitment of both types of muscle fibres as a result of working at high intensity for short periods, in accordance with the circuit-based exercises (stretching and shortening) In other words, the principle of maximising muscle contraction in the shortest possible time, which led to an increase in muscle capacity and had a positive effect on indicators of electrical activity, as confirmed by Paxinos (2004) “The recruitment of motor units follows the size principle; that is, the size of the recruited motor unit increases as the level of tension increases. This leads us to conclude that, initially, smaller motor units are recruited, whilst larger ones are recruited later; this system enables movements to be performed in gradual stages.” ‘This is reflected in movements that require high force; when maximum contraction is required, all motor units work together at the highest level of excitation’ (Thrasivoulos Paxinos, 2004, p. 82) In addition to the adaptation resulting in a reduction in muscle contraction time and a high degree of coordination between the neuromuscular system during contractions, achieved through the improvement of neural responses brought about by exercise This has been confirmed by some scientists: during strength training, neurological changes occur that reduce the time required to recruit motor units and increase the tolerance of motor neurons to high nerve impulses (Komi, 1992, p. 102). The researcher therefore considers that the results observed in the electrical activity indices reflect the extent to which the nervous and muscular systems have developed and adapted in response to the exercises used This led to an increase in peak muscle strength and an improvement in the rate of force production, on the one hand through greater recruitment of motor units, and on the other hand through improved contraction time and muscle contraction speed; consequently, the muscles under investigation demonstrated their efficiency in force

production. Furthermore, the balance in the work between the agonist and antagonist muscles led to an increase in force production. Since the muscular force resulting from the net interaction between the antagonist and agonist muscles during the effort exerted by the player at the moment of push-off and strike must be of a high magnitude, as it represents the final outcome of the body's muscles acting on the joints involved in performance (Al-Kilani, 2000, p. 179). This was a distinguishing feature of the members of the experimental group, as neuromuscular facilitation exercises for the receptors had a significant effect on increasing muscular balance, as confirmed by (Abdulaziz Al-Nimr and Neriman Al-Khatib) As the inhibitory process that hinders maximum muscle activity can be eliminated, these exercises should be performed correctly and regularly to restore the natural length of shortened muscles and to achieve and maintain muscular balance, This improves the functional efficiency of the muscles, which manifests as enhanced physical and technical performance, thereby enabling the athlete to perform movements with a wide range of motion and with optimal production of strength and speed (Al-Khatib, 2017, p. 305), which represents the high degree of coordination and harmony between the agonist and antagonist muscle groups at work during the process of generating the energy required for muscle force production. As regards the results of the strength endurance test (grip strength), there are differences in favour of the distance tests, as the results presented in Table 6 show an improvement in the distance tests for the experimental group. The researcher attributes this improvement to the exercises used, which were selected and guided in a scientific manner and designed to simulate the player's performance Through the involvement of the major joints and muscles involved in performance, and the resulting physical benefits and increased strength as an inevitable consequence of regularly practising exercises designed to achieve the best possible results in order to reach the desired goal, as (Risan Kharib and Ali Turki) state that "muscle strength holds a special place within the training programmes for all sporting activities, as it is one of the key factors in performance; the majority of training theories emphasise the need for muscle strength to be developed through specific training, Through exercises that approximate the actual nature of the technical performance of the specialised event. (Turki, 2002, p. 35)

Conclusions

- 1- The study revealed functional measurements within the normal range and no critical functional measurements were recorded.
- 2-The exercises had a positive effect on the development of strength endurance.



3-The exercises used had a noticeable effect on improving the electrical activity of the muscles under study in the ‘peak’ variable among members of the training group.

Appendices

Schedule of exercises for the training unit in the CrossFit hall

Objective: Endurance

Duration: 31 minutes

NO	exercises	Intensity of the exercise	Repetitions	time	Rest between repetitions	The rest between the sets	Total performance time
1	25 kg dumbbell bench press (facing each other)	%89	2	25 Second	100Second	60Second	335Second
2	100 kg front squat with barbell	%89	2	30 Second	120Second	60Second	390Second
3	20 kg dumbbell jump	%84	2	30 Second	120Second	60Second	390Second
4	Clean with blocks plus shoulder press	%89	2	30 Second	120Second	60Second	330Second
5	Lying abdominal crunches holding a 10 kg disc	%89	3	25 Second	100Second	60Second	335Second
6	Incline dumbbell flies + pull-ups	%89	3	30 Second	120Second	60Second	390Second
7	Barbell pull-ups to the neck	%84	3	30 Second	120Second	60Second	390Second
8	5 kg dumbbell lateral raises, front	%89	3	30 Second	120Second	60Second	330Second



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