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Effect of Functional Circuit Training Using Electro Muscle Stimulation in Increasing Performance

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Abstract: The main purpose of this study was to analyze the effect of functional circuit training using electro muscle stimulation in improving performance. This type of study is quantitative using quasi-experimental and pre-test post-test control group design. The inclusion criteria for this study were healthy men aged 19-23 years, with a normal BMI and normal blood pressure before exercise. Participants were asked to refrain from consuming coffee and supplements that enhance physical performance. The exclusion criteria for this study were athletes actively participating in sports. A total of 30 students, selected using purposive sampling techniques, participated in this study. The subjects were then divided into two groups. Group 1 was given functional circuit training using electro muscle stimulation and group 2 was given functional circuit training without using electro muscle stimulation. Data was taken from pret-est and post-test arm muscle strength, leg muscle strength, abdominal muscle strength, arm muscle endurance, leg muscle endurance, and abdominal muscle endurance. The functional circuit training was carried out for 8 weeks with a frquency of 3x/week. There were 9 posts of circuit functional training including post 1: jf dumbbell bent over row, post 2: jf resistance bent crunch, post 3: jf suspension side lunges, post 4: jf dumbbell rear deltoids, post 5: jf resistance band glute bridge, post 6: jf suspension hamstring curl, post 7: jf dumbbell biceps curl, post 8: jf resistance bicycle crunch, and post 9: jf suspension mountain climber. The subjects did 3 sets with duration of 20 seconds for each post and 3 minutes rest for each set. Data were analyzed using paired t-test and independent t-test with a significance level of $p<0.05$. The results of this study reported that functional circuit training using electro muscle stimulation and functional training without using electro muscle stimulation both had a significant effect on increasing arm muscle strength, leg muscle strength, abdominal muscle strength, arm muscle endurance, leg muscle endurance, and abdominal muscle endurance. The results of the independent t test reported that there was a significant difference in functional circuit training using electro muscle stimulation and functional training without using electro muscle stimulation ($P <0.05$). We recommend that these exercises be considered when developing a training program.

Keywords: Functional circuit training; electro muscle stimulation; muscle strength; muscular endur-ance; upper body; lower body; exercise physiology

1. Introduction

In the current era of globalization, many physical training models and methods are used to improve physical fitness and performance [1]. Since several decades ago, circuit training has received sufficient attention to improve physical fitness abilities [2]. Circuit training is a physical training models that carried out sequentially by com-

bining several training models in a series of exercises [3]. Circuit training is an effective and efficient physical training method that not only increases cardiovascular endurance but also other physical performance such as strength, flexibility and muscle endurance in important muscle groups [4]. Basically, circuit training is guided by time, not repetition of movements. The repetition of the movement is of course different for each person, but time is determined the same. Circuit training is expected to increase repetitions after several exercises [5].

Circuit training has the characteristics of placing several movements at predetermined posts. Circuit training is an exercise method characterized by high volume, short rest periods and includes several forms of exercise [6]. Circuit training requires 8-10 posts with different movements and forms of physical exercise. Each post can take around 30 seconds to 3 minutes [7]. However, this time requirement can be estimated independently depending on the intensity of the exercise, but keep in mind that circuit training is included moderate intensity exercise. The duration of circuit training can be set between 20 to 30 seconds with a transition period of 30 seconds at each post and ca be done between 3 to 5 sets. The rest transition period from post to post can be adjusted to the athlete's level of ability and can be between 1 to 3 minutes [8]. Circuit training with a high intensity training program is more effective in increasing muscle strength that circuit training with a low intensity [9]. Circuit training can also be carried out between 6 to 10 posts and can be further divided into two parts between 3-4 posts and 4-6 posts, then it can be continued to the next posts [10]. General circuit training consists of a number of exercises with different movements, between 10 to 15 forms of exercise with are ussually called posts. At each circuit training post, individuals perform 15 repetitions in 40 seconds, while the intensity of resistance training does not exceed 60% of 1 maximum repetition, with a short period between exercise [11]. Circuit training and circuit weight training significantly increase muscle strength endurance 4.

Functional training is an exercise that involves a group of muscles carried out in one or more movements at the same time, where the implementation involves the core muscle group. The specificity principle of functional training that promote physical abilities with a similar pattern of daily living of activities [12]. There are several exercise models that can be done for functional training, including TRX, Bosu, Kettlebell, Medicine Ball, and Dumbbell.

EMS is a technology that can be applied to physical activity, recovery and physiotherapy [13]. The advantage of using EMS during physical exercise, recovery and physiotherapy is that the time can be shorter, where there are conductive panels attached to several parts of the body to stimulate muscles. Training using EMS can increase muscle mass, muscle strength, cardiopulmonary function, and balance, as well as reduce body circumference [14]. Physiologically, EMS affects how motor units are activated and work, but it does not directly increase the number of motor units as muscle growth does. Instead, EMS can alter motor unit recruitment patterns, for example, encouraging a shift from fast-twitch to slow-twitch units to increase endurance. Furthermore, EMS has the potential to improve the coordination and efficiency of existing motor units by stimulating larger fibers and bypassing the nervous system's natural recruitment sequence [15]. The results of previous research shsowed that there was a significant difference in training using EMS on knee flexor isokinetic muscle function and balance function [13].

Strength is a component of physical condition which has an important role in supporting the performance of elite athletes [16]. Muscle strength is the ability to use muscles to receive loads within a certain time [17]. Systematic exercise can produce structural and functional changes, or adaptations in the body. This level of adaptation is evidenced by muscle size and strength. The amount of adaptation is directly proportional to the demands placed on the body by volume, frequency and intensity of training. Core strength has a significant influence on the athlete's ability to create and

transfer force to the extremities and angular momentum between the lower and upper extremities, which is important for certain sporting activities [18].

Therefore, the aim of this study is to analyze the effect of functional circuit training using electro muscle stimulation on arm muscle strength, leg muscle strength, abdominal muscle strength, arm muscle endurance, leg muscle endurance, and abdominal muscle endurance.

2. Materials and methods

2.1.1. *Study Design*

The type of this study is quantitave research using quasi-experimental with pretest and posttest control group design.

2.1.2. *Subjects*

This study was conducted on male college students aged 19 to 23 years. The inclusion criteria for this study were healthy men aged 19-23 years, with a normal BMI and normal blood pressure before exercise. Participants were asked to refrain from consuming coffee and supplements that enhance physical performance. The exclusion criteria for this study were athletes actively participating in sports. A total of 30 students, selected using purposive sampling techniques, participated in this study. The subjects were then divided into two groups. All students volunteered to be research subject by filling out Informed Consent. Ethical clearance was approved by the local university referring to the 2016 CIOMS guidelines.

2.1.3. *Procedure*

The independent variable in this research is functional circuit training. The dependent variable is performance including arm muscle strength, leg muscle strength, abdominal muscle strength, arm muscle endurance, leg muscle endurance, and abdominal muscle endurance. The control variable is training using electro muscle stimulation. Group 1 was given functional circuit training using electro muscle stimulation and group 2 was given functional circuit training without using electro muscle stimulation. Data was taken from pretest and posttest of arm muscle strength test using 30 seconds push-up, leg muscle strength test using leg dynamometer, abdominal muscle strength test using 30 seconds sit ups, arm muscle endurance test using 60 seconds push-ups, leg muscle endurance test using squat, and abdominal muscle endurance test using 60 seconds of sit ups.

The training was carried out for 8 weeks with a frquency of 3x/week. Functional circuit training using 9 posts including post 1: jf dumbbell bent over row, post 2: jf resintance bent crunch, post 3: jf suspension side lunges, post 4: jf dumbbell rear deltoids, post 5: jf resitance band glute bridge, post 6: jf dumbbell biceps curls, post 8: jf resistance band bicycle crunch, post 9: jf suspension mountain climber. The subject did 3 sets with an exercise duration of 20 seconds for each post and 3 minutes rest for each set.

2.1.3. Statistical analysis

Data was analyzed using paired t-test and independent t-test with a significance level $p<0.05$.

3. Results

Results data analysis for physical performance of group 1 and group 2 is presented in Table 1.

Table 1. Data Analysis of Physical Performance group 1 and group 2

No.	Variables	Pre-test		Post-test	
		x̄±SD		x̄±SD	
		Group 1	Group 2	Group 1	Group 2
1.	Arm muscle strength	26.78±6.39	25.16±5.22	35.57±4.38	30.24±4.73
2.	Leg muscle strength	87.63±5.12	86.73±9.74	128.91±5.26	106.57±13.29
3.	Abdominal muscle strength	24.28±3.76	24.38±4.92	31.44±3.61	29.71±5.18
4.	Arm muscle endurance	43.49±7.33	44.61±5.88	52.38±5.24	48.96±4.48
5.	Leg muscle endurance	28.17±5.68	27.36±4.34	35.25±4.28	31.84±3.85
6.	Abdominal muscle endurance	37.85±6.28	36.17±5.82	41.25±4.78	39.81±3.22

Table 1 shows that after being given functional circuit training using electro muscle stimulation for Group 1, there was an increase in arm muscle strength from 26.78±6.39 to 35.57±4.38. There was also an increase in leg muscle strength from 87.63±5.12 to 128.91±5.26. In addition, there was an increase in abdominal muscle strength from 24.28±3.76 to 31.44±3.61. Furthermore, there was an increase in arm muscle endurance from 43.49±7.33 to 52.38±5.24. Then, there was an increase in leg muscle endurance from 28.17±5.68 to 35.25±4.28. There was also an increase in abdominal muscle endurance from 37.85±6.28 to 41.25±4.78.

Group 2 showed that after being given functional circuit training without using electro muscle stimulation, there was an increase in arm muscle strength from 25.16±5.22 to 30.24±4.73. Then therwe was an increase in leg muscle strength from 86.73±9.74 to 106.57±13.29. In addition, there was an increase in abdominal muscle strength from 24.38±4.92 to 29.71±5.18. Furthermore, there was an increase in arm muscle endurance from 44.61±5.88 to 48.96±4.48. Then, there was an increase in leg muscle endurance from 27.36±4.34 to 31.84±3.85. There was also an increase in abdominal muscle endurance from 36.17±5.82 to 39.81±3.22.

Results analysis data for normality test in Group 1 and Group 2 using Shapiro-Wilk is presented in Table 2.

Table 2. Data analysis of normality test at group 1 and group 2

No.	Pre-test and Post-test	Group	P-Value
1.	Pre-test arm muscle strength	Group 1 EMS	0.261
		Group 2 non-EMS	0.317
2.	Post-test arm muscle strength	Group 1 EMS	0.484
		Group 2 non-EMS	0.326
3.	Pre-test leg muscle strength	Group 1 EMS	0.319
		Group 2 non-EMS	0.328
4.	Post-test leg muscle strength	Group 1 EMS	0.402
		Group 2 non-EMS	0.337
5.	Pre-test abdominal muscle strength	Group 1 EMS	0.163
		Group 2 non-EMS	0.147
6.	Post-test abdominal muscle strength	Group 1 EMS	0.273
		Group 2 non-EMS	0.189
		Group 1 EMS	0.254

7.	Pre-test arm muscle endurance	Group 2 non-EMS	0.273
8.	Post-test arm muscle endurance	Group 1 EMS	0.311
		Group 2 non-EMS	0.285
9.	Pre-test leg muscle endurance	Group 1 EMS	0.471
		Group 2 non-EMS	0.392
10.	Post-test leg muscle endurance	Group 1 EMS	0.116
		Group 2 non-EMS	0.218
11.	Pre-test abdominal muscle endurance	Group 1 EMS	0.264
		Group 2 non-EMS	0.319
12.	Post-test abdominal muscle endurance	Group 1 EMS	0.281
		Group 2 non-EMS	0.199

$p > 0.05$ = data is normally distributed

Results data analysis of physical performance at Group 1 and Group 2 using paired t-test is presented in Table 3.

Table 3. Data analysis of physical performance at group 1 and group 2 using paired t-test

No.	Variables	P-value	
		Group 1	Group 2
1.	Pre-test arm muscle strength – Post-test arm muscle strength	0.004	0.028
2.	Pre-test leg muscle strength – Post-test leg muscle strength	0.025	0.016
3.	Pre-test abdominal muscle strength – Post-test abdominal muscle strength	0.013	0.001
4.	Pre-test arm muscle endurance – Post-test arm muscle endurance	0.000	0.032
5.	Pre-test leg muscle endurance – Post-test leg muscle endurance	0.017	0.000
6.	Pre-test abdominal muscle endurance – Post-test abdominal muscle endurance	0.028	0.024

* There is a significant difference in the paired t-test ($p < 0.05$).

Table 4. Data analysis of comparisson between group 1 and group 2 using independent t-test

No.	Variable	Groups	P-value
1.	Arm muscle strength	Group 1 EMS Group 2 Non-EMS	0.016
2.	Leg muscle strength	Group 1 EMS Group 2 Non-EMS	0.023
3.	Abdominal muscle strength	Group 1 EMS Group 2 Non-EMS	0.035
4.	Arm muscle endurance	Group 1 EMS Group 2 Non-EMS	0.021
5.	Leg muscle endurance	Group 1 EMS Group 2 Non-EMS	0.034
6.	Abdominal muscle endurance	Group 1 EMS Group 2 Non-EMS	0.019

* There is a significant difference in the Independent t-test ($p < 0.05$).

4. Discussion

The results of this study reported that functional circuit training using electro muscle stimulation and functional training without using electro muscle stimulation both had a significant effect in increasing arm muscle strength, leg muscle strength,

abdominal muscle strength, arm muscle endurance, leg muscle endurance, and abdominal muscle endurance.

Previous research has shown that circuit training can improve not only cardiovascular endurance but also physical performance such as strength, flexibility, and muscular endurance. Functional training in the form of circuit training can improve arm muscle strength, leg muscle strength, abdominal muscle strength, arm muscle endurance, leg muscle endurance, and abdominal muscle endurance. Furthermore, a study reported that high-intensity circuit training for 8 weeks can increase muscle mass and lower-extremity muscle performance in sedentary workers [19]. Additionally, previous research has shown that circuit training results in neuromuscular, cardiorespiratory, and body composition (fat-free mass and bone mineral density) improvements in older adults [11]. Furthermore, functional circuit training using electromuscle stimulation can improve physical performance. Previous research also suggests that physical training using electromuscle stimulation can increase muscle mass [20]. In addition, a study was conducted by (Zampieri et al, 2025), Sedentary older adults with normal lifestyles were recruited and randomized to undergo leg press and EMS training for 9 weeks. Before and at the end of both training periods, mobility function tests were performed, and muscle biopsies from the vastus lateralis muscle were taken. Overall, the results showed that EMS improved functional performance more effectively than voluntary exercise and counteracted fast-tissue muscle fiber atrophy, which is typically associated with sarcopenia [21].

The findings of this study indicate that functional circuit training without electrostimulation can also improve arm muscle strength, leg muscle strength, abdominal muscle strength, arm muscle endurance, leg muscle endurance, and abdominal muscle endurance. However, functional circuit training with electrostimulation improves physical performance to a greater extent than functional circuit training without electrostimulation.

5. Conclusions

Functional circuit training using electromuscle stimulation significantly improved arm strength, leg strength, abdominal strength, arm endurance, leg endurance, and abdominal endurance. We recommend considering these exercises when developing a training program. However, a limitation of this study is the small number of subjects.

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