Research Paper

Effect of Concurrent Training Order With Electromyostimulation on Physical Performance in Young Elderly Women

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ABSTRACT

Objective Aging is one of the stages of life that needs special attention due to the special conditions of this period of life. Inactivity and myasthenia due to aging are important factors in reducing the physical and functional activities in the elderly, which can affect their quality of life. On the other hand, electromyostimulation (EMS) is one of the modern training methods that can be suitable for disabilities in the elderly. Also, the training sequence in concurrent training is one of the variables of training that can affect its adaptations. This study aimed to compare the effect of exercise sequence in concurrent training with EMS on the motor performance of elderly women.

Materials & Methods In this semi-experimental single-blinded study, 50 healthy elderly female volunteers, age range of 60-70 years, were selected by random sampling divided randomly into the following groups (each group of 10 people): Aerobic-resistance training with EMS, resistance-aerobic exercise with EMS, rotational exercise (change of priority periodically in training sessions) with EMS, and rotational and control (without training) groups. The training protocol consisted of twelve weeks of exercise, three sessions per week, and each session three stages of warm-up (10-15 minutes), main exercises (20 minutes) and cooling (10 minutes). The main training program consisted of 20 minutes of parallel combination exercises, which were two 10-minute steps with a 3-5 minute intervals. Aerobic exercises were performed with the intensity of 70%-50% of maximum oxygen consumption and resistance exercises using body weight and elastic bands for different muscle groups. The training schedule was the same for all groups in terms of volume and intensity, with the only difference being in the exercise sequence and EMS presentation. Strength of the upper and lower torso muscles were measured with chest press and seated leg extension, respectively, maximum oxygen consumption (VO_2 max) with a one-mile Rockport walking test, muscular endurance with a 2-minute marching on a spot-test and lower torso strength with a walking test on the slope in two stages before and after the intervention. Statistical analysis was performed using dependent t-tests and Covariance Analysis (ANCOVA) and Bonferroni post hoc test using SPSS software V. 22 and $P \geq 0.05$ was considered statistically significant.

Results Significant increase was observed in all measured dependent variables relative to the baseline values ($P<0.001$). In the study of intergroup changes, a significant increase was observed in VO_2 max level, upper and lower torso strength, and muscular endurance in all of the intervention groups compared to the control group ($P<0.001$), but lower torso strength was significant only in the intervention groups with EMS compared to the control group ($P<0.001$). VO_2 max changes and the lower torso strength in training groups with EMS were significantly higher than the groups without EMS ($P<0.01$). Also, the upper torso strength and the endurance of the lower torso muscles in the group with the priority of resistance training with EMS were higher than the combination group without EMS ($P<0.01$).

Conclusion Based on the results, it can be said that combined concurrent exercises are a useful method in promoting physical fitness and physical performance of elderly women, and the use of EMS can increase the effectiveness of adaptations resulting from exercise, especially lower torso strength in the elderly and can prevent complications associated with myasthenia. On the other hand, the training sequence with the priority of resistance training can be effective in increasing the effect of exercise on the variables of upper torso muscle strength and muscular endurance, but it does not have a significant effect on lower torso strength, cardiorespiratory endurance and lower torso strength.

Keywords:
Elderly, Women, Exercise training, Electromyostimulation, Physical performance

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Extended Abstract

Introduction

Aging is a part of the biological process and one of the acute stages of human life, with particular importance [1]. Due to health-related developments, people's longevity in the community and the number of elderly people is increasing [2]. Due to the synchronicity of sedentary lifestyle and physiological changes, elderly people are more prone to chronic diseases [3], which increases mortality and morbidity in the elderly [4, 5] and indicates the need for special care to prevent diseases. They also increase physical fitness to improve the quality of life [6, 7].

Exercise training can be a preventative measure to reduce chronic diseases and aging complications [10, 11]. Exercise has been reported to reduce mortality by 22 percent in the elderly [12]. One of the most critical public health goals is to reduce age-related disabilities during this period [10, 13]. Recommended physical activity for the elderly is a combination of aerobic exercise to improve cardiovascular capacity and strength training to prevent sarcopenia and improve neuromuscular function [14]. One of the limitations of participating in exercises is training time; some people tend to do combination exercises in one session. Exercise instructions for the elderly emphasize Concurrent training (aerobic-strength) [14, 15]. One of the main variables in simultaneous exercises is the sequence of exercises for which there is limited information about this training variable [16]. The research results regarding the effect of exercise sequence on physiological and functional capacity are also different [16, 22, 23].

The elderly are usually reluctant to exercise at high intensities, and there may also be a risk of injury at high intensities for them [15]. Therefore, complementary training methods such as Electromyostimulation (EMS) can achieve high training intensities [25]. Due to limitations such as low physical fitness and aging complications such as musculoskeletal pain, this type of exercise can help the elderly [13]. EMS training has been reported to increase muscle mass, decrease body fat percentage, and improve functional capacity in the elderly [26]. Also, the results of research by Robles-Gonzalez et al. [31] and Schenk et al. [32] indicate the effectiveness of EMS training in improving cardiovascular function in healthy and sick individuals.

Although research shows that EMS training is essential for improving physical function in the elderly, the need for this study is justified due to the lack of information and inconsistent results on the effect of exercise sequence on physical performance and also the lack of research that specifically examines the effect of exercise sequence in Concurrent training with EMS. According to the above, the present study was designed to investigate the effect of concurrent training sequence with EMS on young, older women's physical performance.

Materials and Methods

In the present semi-experimental study, 50 older women aged 60-70 were selected by random sampling method and randomly divided into 5 groups of 10 people. The study's inclusion criteria included being in the low-risk category based on the Physical Activity Readiness Questionnaire (PAR-Q), not taking any medications or supplements, no specific diseases, and sedentary lifestyle. The exclusion criteria also include dissatisfaction to continue the research, non-compliance with the training intervention program and absence in training sessions, and the occurrence of any disease or complication that leads to forbid exercise according to the physician supervisor.

Weight and body mass index were measured using a body composition device, and height was measured using a stadiometer without shoes.The upper limb and lower limb strength were measured by the bench press and seated leg extension machine. Maximum oxygen consumption by Rockport one-mile walk test [36], muscular endurance by Two-minute Step Test [37], and lower limb power by Ramp Power Test [38] were measured.

The training program consisted of twelve weeks of training with 2 Concurrent training sessions per week, including two 10-minute steps with a break between them for 3-5 minutes. The strength-aerobic with EMS group (SAT+EMS) performed resistance exercises, but the aerobic-strength with EMS group (AST+EMS) performed aerobic exercises in the first half of season training. In the circular with the EMS group (CT+EMS), the exercise priority was variable in each session [24]. In the circular without EMS group (CT), the order of exercises was rotational, but the electrical stimulation intervention was not performed.

Aerobic training was performed at 50-70% of the subjects' maximum oxygen consumption. Strength training included static and dynamic training for various muscle groups, including chest, shoulders, latissimus dorsi, arm, quadriceps and hamstrings, calf, abdomen, and back by the bodyweight, weights, and available equipment, TRX, and elastic bands.

In the present study, a frequency of 15-33 Hz was used for aerobic training. Also, in the strength part, a frequency with

Table 1. Demographic variables

Groups	No.	Steps	Mean±SD			
			Age (y)	Height (cm)	Weight (kg)	BMI (kg/m²)
AST+EMS	10	Pre-test	64.40±3.37	158.88±4.92	70.43±3.59	27.90±0.86
		Post-test	-	-	66.80±4.50*	26.45±1.09*
SAT+EMS	10	Pre-test	65.70±3.06	156.10±4.43	69.15±3.28	28.38±0.78
		Post-test	-	-	66.93±3.16*	27.48±0.97*
CT+EMS	10	Pre test	63.30±2.98	156.92±3.37	69.60±3.18	28.27±1.16
		Post-test	-	-	65.98±4.52*	26.87±1.41*
CT	10	Pre-test	64.40±3.13	162.09±3.97	72.47±4.58	27.56±0.91
		Post-test	-	-	70.26±4.97*	26.72±1.16*
Control	10	Pre-test	66.30±2.31	159.82±3.13	72.67±4.01	28.44±0.99
		Post-test	-	-	73.82±4.10*	28.68±1.00*

Archives of Rehabilitation

AST: Aerobic-strength training; SAT: Strength-aerobic training; CT: Circular training; EMS: Electromyostimulation; BMI: Body Mass Index; *P<0.05.

a range of 75-35 Hz was used [33, 42]. Impulse intensity in the present study was 80-100 mA which was individually assigned according to the participants for values of Rate of Perceived Exertion (RPE) and the Berg scale from 5 to 9 [26, 33, 43].

Impulse Width was adjusted between 200 and 400 µsec in different exercise parts [33, 42]. Cycle Duty was planned 50-67% in the strength training section and 99% for the Cycle Duty in aerobic training [13, 33, 44]. The one-way ANOVA was used to examine the differences between groups. Statistical analysis was performed using SPSS V. 22, and a significance level (P≤0.05).

Results

The Shapiro-Wilk and Leven tests showed that data distribution was normal, and there was also a precondition for variance homogeneity between research groups. The table is related to the subjects' demographic variables, including age, weight, height, and body mass index for pre-test and post-test in the research groups.

After the training period, a significant reduction in weight and body mass index in the groups of aerobic-strength training with EMS (P=0.004), strength-aerobic training with EMS (P=0.010), circular training with EMS (P<0.001), and circular training without EMS (P=0.002) were observed compared to baseline values; Also, a significant increase in weight and body mass index of subjects in the control group without exercise (P=0.010) was observed compared to baseline values (Table 1).

The results of the dependent t-test (Table 2) showed that after twelve weeks of intervention, there was a significant increase in VO_2max, upper limb strength, lower limb strength, muscular endurance, and lower limb power in aerobic-strength training with the EMS group (P<0.001), strength-aerobic training with EMS group (respectively: P<0.001, P<0.001, P<0.001, P=0.003), Circular order training with EMS group (P<0.001) and Circular order training without EMS group (respectively: P<0.001, P<0.001, P<0.001, P=0.010) were observed. No significant difference was observed in any studied variables in the control group (P>0.05). The results of the analysis of covariance (Table 3) showed that there was a significant difference in the variables of VO-2max, upper limb strength, lower limb strength, muscle endurance, and lower limb power between the research groups (P<0.001). Bonferroni post hoc test (Table 4) was used for further investigation and location of differences.

Discussion and Conclusion

After twelve weeks, a significant increase was observed in older women's physical performance in all groups' intervention compared to the control group. Investigating the

Table 2. Variables examined in pre-test and post-test

Steps	Variables	Mean±SD				
		AST+EMS	SAT+EMS	CT+EMS	CT	Control
Pre-test	VO_2max (ml/kg/min)	19.16±2.19	18.84±1.60	19.19±2.42	19.46±1.90	20.30±2.05
	Upper limb strength(kg)	32.55±4.80	30.38±4.54	35.01±5.30	23.28±5.13	32.73±5.59
	Lower limb strength (kg)	45.20±7.14	44.18±7.17	46.57±7.42	46.26±8.00	46.32±7.34
	Muscular endurance (n/2min)	78.90±12.41	79.10±12.39	80.60±11.44	77.00±11.31	77.90±13.94
	Lower limb Power (W)	116.91±16.41	103.86±16.06	111.28±13.62	113.85±17.86	122.05±18.95
Post-test	VO_2max (ml/kg/min)	25.80±2.27*	25.37±1.70*	25.48±2.06*	22.72±1.75*	20.12±2.10
	Upper limb strength (kg)	41.74±5.30*	41.96±7.39*	45.04±7.26*	40.50±6.73*	32.53±5.48
	Lower limb strength (kg)	62.64±8.80*	63.94±12.25*	64.86±11.43*	56.02±7.67*	46.07±8.35
	Muscular endurance (n/2min)	101.10±11.81*	104.10±14.15*	103.20±12.14*	95.00±10.47*	78.30±12.28
	Lower limb Power (W)	150.75±31.65*	136.94±31.74*	145.18±32.73*	134.89±12.84*	123.65±18.88

Archives of Rehabilitation

AST: Aerobic-strength training; SAT: Strength-aerobic training; CT: Circular training; EMS: Electromyostimulation; BMI: Body Mass Index; VO_2Max: Maximum oxygen consumption; *P<0.05.

effect of sequence on aerobic capacity in training with EMS groups was significantly higher than the training without EMS group, but no difference was observed between EMS training groups. The results of research by Robles-Gonzalez et al. [31], Schenk et al. [32] also showed the effect of EMS training on improving VO_2max. Karatrantou et al. also stated that the sequence of exercise did not significantly affect changes in VO_2max of middle-aged women [45], which is consistent with the results of the present study.

Checking muscle strength was observed that changes in upper limb strength in the Strength-aerobic training with

Table 3. ANCOVA results

Variables	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
VO_2max (ml/kg/min)	Contrast	291.133	4	72.783	41.924	<0.001*	0.792
	Error	76.382	44	1.736	-	-	-
Upper limb strength (kg)	Contrast	868.024	4	217.006	41.322	<0.001*	0.790
	Error	231.071	44	5.252	-	-	-
Lower limb strength (kg)	Contrast	2600.851	4	650.213	40.491	<0.001*	0.786
	Error	706.564	44	16.058	-	-	-
Muscular endurance (n/2min)	Contrast	3994.904	4	998.726	56.424	<0.001*	0.837
	Error	774.812	44	17.700	-	-	-
Lower limb Power (W)	Contrast	9775.202	4	2443.800	7.143	<0.001*	0.394
	Error	5052.690	44	342.107	-	-	-

*P<0.05.

Archives of Rehabilitation

Table 4. Bonferroni test results

Group 1	Group 2	VO_2max	Upper Limb Strength	Lower Limb Strength	Muscular Endurance	Lower Limb Power
AST+EMS	SAT+EMS	1.000	0.104	1.000	1.000	1.000
	CT+EMS	1.000	1.000	1.000	1.000	1.000
	CT	<0.001*	0.469	<0.001*	0.264	0.102
	Control	<0.001*	<0.001*	<0.001*	<0.001*	0.002*
SAT+EMS	CT+EMS	1.000	0.325	0.074	1.000	1.000
	CT	<0.001*	<0.001*	<0.001*	0.005*	0.070
	Control	<0.001*	<0.001*	<0.001*	<0.001*	0.003*
CT+EMS	CT	0.002*	0.192	0.032*	0.139	0.073
	Control	<0.001*	<0.001*	<0.001*	<0.001*	0.003*
CT	Control	<0.001*	<0.001*	<0.001*	<0.001*	1.000

*P<0.05.

Archives of Rehabilitation

EMS group were significantly more significant than the circular training without EMS group, which indicates the priority role of sequence for upper body strength training at the beginning of training, which is consistent with results if research by Shiatsu et al. [46]. An increase in lower torso strength was more significant in the groups with EMS than the group without EMS. However, no difference was observed between the training with EMS groups, which indicates that the sequence of exercise in EMS training did not affect lower muscles. Murlasits et al. in a meta-analysis, stated that 1RM of lower limbs in strength- endurance sequence training was more than the endurance-strength sequence, which is not consistent with the results of the present study [22]. Although the increase in strength was more significant in the training group with the priority of strength training in the EMS group, this difference was not significant compared to other EMS groups. Probably the reason for the difference in results is due to the difference in the type of exercise and using EMS along with voluntary exercises, which leads to maximum recall in the motor units, and as a result, there is a more significant increase in strength than usual exercises.

The results obtained in the strength-aerobic training with the EMS group were significantly higher than the training without the EMS group. The results of the study of Karatrantou et al. after eight weeks of training showed no significant difference in muscle endurance between the two groups with different training sequences [45], which was somewhat consistent with the results of the present study. In the present study, although no difference was observed between two groups of aerobic-strength training with the EMS group and strength-aerobic training with the EMS group, compared with the circular training without EMS group, the results indicate the effectiveness of resistance training at the beginning of the concurrent training.

After concurrent training with EMS, a significant increase in Lower limb power in older women was observed compared to the control group, but in the concurrent training without EMS group, no significant difference was observed compared to the control group. Wilhelm et al. did not report a significant difference between the two groups of concurrent training (aerobic and power-like strength training) after 12 weeks [19]. In the present study, in the concurrent training without EMS group, there was no difference in muscle power impaired to control group; however, in the concurrent training with EMS group, although the training time was shorter than Wilhelm's study, an increase in lower torso power was observed which indicates EMS training was more effective on muscle power than conventional concurrent training. Also, Chtara et al. reported that the sequence of exercise did not significantly affect muscle strength [48], which is consistent with the results of the present study.

Overall, the present study results showed that EMS, along with concurrent training, made better effective. Studying the effect of training sequence showed that although there was no significant difference between the concurrent with EMS groups, the sequence of EMS training with the priority of resistance training had a better effect on the maximum strength of upper body muscles and muscle endurance.

EMS interventions along with combined exercises are also needed to improve lower limb power. Considering the present study results indicate an increase in motor function and muscle power in older women, this EMS training style can increase muscle power and reduce age-related disabilities in older women.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the Shahid Chamran University of Ahvaz (Code: EE/98.24.3.60529/ssu.ac.ir). All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them.

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Authors' contributions

Validation, conceptualization, case management: Mehri Derakhshan Nejad, Masoud Nikbakht, Ghanbarzadeh, Rouhollah Ranjbar; Methodology, editing, investigation and finalization: Mehri Derakhshan Nejad, Masoud Nikbakht; Drafting: Mehri Derakhshan Nejad.

Conflict of interest

The authors declared no conflict of interest.

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