Article

The Effects of Aerobic Dancing with Whole Body Electromyostimulation on Body Composition and Biomarkers of Obese Elderly Women

Running title: Whole body electromyostimulation improves body composition and biomarkers

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Abstract: *Background and objective*: Although whole body-electromyostimulation (WB-EMS) has been shown to favorably improve body composition in several research studies, it has not been confirmed how it affects adipose tissue-derived biomarkers and circumferences of the abdomen and thighs. *Materials and Methods*: Twenty participants of obese elderly women were randomly classified into an EMS group (EMSG; n = 10) or a non-EMS group (CON; n = 10). The WB-EMS suits used in this study enabled the simultaneous activation of 8 muscle groups with selectable intensities for each phase. Stimulation frequency was selected at 85 Hz, impulse-width at 350 μ seconds, and impulse-rise as a rectangular application. Impulse duration was 6 seconds with a 4-second break between impulses. The EMS sessions were combined with aerobic dancing 3 times a week for 12 weeks. Both groups received the same program; however, the CON did not receive electrical stimuli. Biomarkers and body composition including circumferences of the abdomen and thighs were measured on Week 0 and Week 12. *Results*: Compared with the CON, 1) a significant effect of the EMS-intervention concerning decreased body weight ($p = 0.032$) and increased basal metabolic rate ($p = 0.029$) were evident. The thigh subcutaneous fat and total fat of EMSG were not significantly changed, but those of CON were significantly increased after 12 weeks. 2) The biomarkers of CON either increased or showed no change, although the interleukin (IL)-6 was significantly ($p = 0.028$) decreased in EMSG. Specifically, C-reactive protein (CRP; $p = 0.005$) and alpha-fetoprotein ($p = 0.050$) of CON were significantly increased after 12 weeks. In addition, the IL-6 ($p = 0.034$), CRP ($p = 0.001$), carcinoembryonic antigen ($p = 0.017$), and low density lipoprotein ($p = 0.005$) of EMSG were lower than those of CON in the end of experiment. 3) *Conclusions*: The results indicate that EMS intervention improved body composition and reduced negative biomarkers, thus highlighting its effectiveness.

Keywords: aerobic dance; electromyostimulation; interleukin-6; C-reactive protein

1. Introduction

Obesity is a medical condition in which excessive amounts of body fat accumulate, resulting in detrimental health effects [1]. The high incidence of female obesity, which may be strongly related to increased health problems, should be given great consideration with respect to the promotion of personal health attitudes and habits [2]. Obesity can get worse with age, and in older people, obesity is likely to cause more serious health complications. In women, obesity aggravates physical conditions and contributes to mental problems [3,4], which are influenced by negative perceptions about body shape [5]. Although the methods for reducing obesity include limited diet, regular exercise, behavior modification, and surgery [6,7], these are not easy for elderly people. In particular, due to the characteristics of the elderly, it may be especially difficult to consistently engage in moderate to high-intensity exercise, thus limiting the amount of fat that can be reduced.

Recently, advanced equipment for reducing obesity and improving body composition has been developed. Electromyostimulation (EMS) devices have the advantage of inducing muscle contractions without direct stimulation to the peripheral muscles by the central nervous system, and providing similar effects of muscle contractions, but without stimulation by weight training exercises such as lifting dumbbells. In other words, EMS is gentle on the joints and reduces the risk of injury due to excessive loading [8]. EMS impulses are transmitted through electrodes on the skin close to the dermis tissue for stimulation and modulate a variety of electrical wave forms resulting in an electrical current that can be used to stimulate innervated muscles [9,10]. In the case of muscle contractions via EMS, the motor units under the control of the larger nerves are activated and muscle fibers with high thresholds are easily mobilized resulting in positive effects on muscle strength [11,12]. Moreover, although voluntary contractions may result in selective motor unit mobilization from slow to fast muscle fibers, non-selective contractions occur when both fibers are mobilized simultaneously during involuntary contractions through EMS. In fact, in the past, a researcher suggested that EMS breaks down the fatty capsule that covers the muscle and also improves blood supply to the muscles thereby helping to gain back lost muscle tone and return to its original size [13]. In other words, it is effective in preventing obesity by reducing fat mass through EMS. Until now, many researchers have reported that EMS is used as an alternative method for controlling pain [14] and edema [15], healing of pressure sores [16], extending range of motion [17], and improving muscular endurance [18] and strength [19,20,21] in human subjects. Recently, whole body (WB)-EMS devices have improved with wireless sensors via Bluetooth technology to enable a wider range of activity that can be adjusted within 40 m [22]. This system allows for more comfort, ease of use, and faster results in rehabilitating patients with musculoskeletal diseases as well as improving body composition as shown in previous studies [19,20-26].

Although EMS has been reported to improve body composition, strength and performance, there is a lack of research in obese elderly people. Moreover, few studies have been conducted on changes in blood components related to obesity through EMS. While the degree of visual improvement in obesity is also important, the changes in blood lipids and adipose tissue in the human body are more closely related to health. In particular, the aging process contributes to inflammatory factors, cytokines, and tumor factors generated by various organs, which may lead to health impairments or shorten lifespan. In other words, aging may increase the risk of chronic diseases and develop significant risk factors for cancer [27]. Therefore, the purpose of this study was to investigate the changes in body composition and blood components when EMS was used during the course of providing elderly patients with their favorite aerobic dancing. Having the patients participate in such an intervention program could lead to improved body composition and inflammatory- or adipocyte-related conditions. This study examined a group of patients with obesity in a randomized controlled trial and assessed the physiological effects of EMS intervention.

2. Materials and Methods

2.1. Study Design and Participants

This study took place in a research center from October 12 to December 24, 2018. The first assessment was conducted from October 12 to 13, 2018 and the last assessment from December 23 to 24, 2018. Participants were recruited through the recommendation of social workers. Prior to the study, participants received detailed explanations regarding study procedures and were then asked to complete a questionnaire. The inclusion criteria required that participants were obese in terms of percent fat, could exercise without joint pain before the start of the study, and did not exercise regularly for over six months. Additionally, participants were also included if they had not received treatment or medication for weight loss or anything known to affect body composition, and if they did not have any internal metallic materials.

After excluding one participant (not obese in terms of percent fat) out of twenty-five eligible participants, the remaining twenty-four participants belonged to one of two groups by lot and were randomly allocated to each group as shown in Figure 1. Of the 12 participants in the experimental group who were allocated to the WB-EMS group (EMSG), one did not receive assessment and another was lost in the follow-up phase. Therefore, ten participants of the EMSG were analyzed in our study. Furthermore, of the 12 participants in the control group who were allocated to the non-EMS group (CON), one was lost in the follow-up phase and another underwent arthroscopic surgery in the analysis phase. Therefore, ten participants in CON were analyzed in our study. Exclusion criteria consisted of having a history of impairment of a major organ system or a psychological disorder. Participants with tumors, vascular inflammation, or kidney stones were also excluded.

All participants wore WB-EMS suits that fit their individual size. Although both groups underwent 40-minute WB-EMS sessions combined with aerobic dancing 3 times a week for 12 weeks, the participants of CON did not receive any electrical stimuli. Only EMSG received three types of electrical stimuli, which were classified with different intensities according to maximum tolerance (1MT) as per phase. In other words, EMSG received the same stimulation frequency, impulse-width, and electric current time, however, the impulse intensities were provided differently at 60% of 1MT from baseline to Week 4, 70% of 1MT from Week 5 to Week 8, and 80% of 1MT from Week 9 to Week 12, respectively. Complete subject characteristics are presented in Table 1. As shown in Figure 1, the participants were allocated as follows: EMSG (n = 10) and CON (n = 10). All participants were assigned using random number tables and assigned identification numbers upon recruitment. Participant characteristics, which indicated homogeneity, are presented in Table 1.

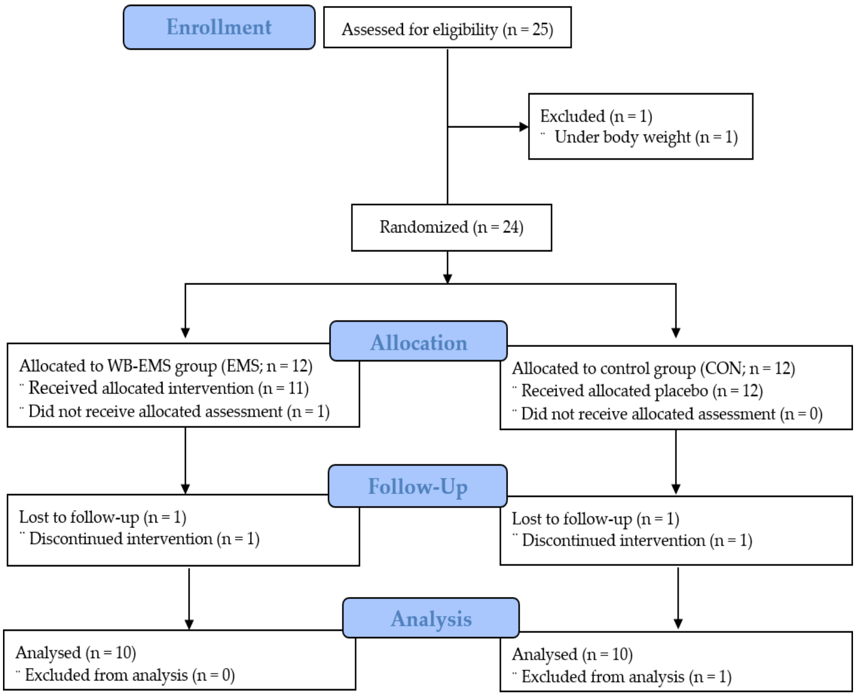

Figure 1. Participant allocation (consolidated standards for reporting of trials flow diagram).

Table 1. Participant characteristics.

Items	**Groups**		**Z**	***p****
	EMSG (n=10)	**CON (n=10)**		
Age, yr	71.60 ± 2.91	70.90 ± 4.36	-0.343	0.732
Height, cm	150.91 ± 4.05	151.68 ± 3.10	-0.303	0.762
Weight, kg	62.85 ± 9.76	62.01 ± 5.41	-0.038	0.970
Percent fat, %	38.65 ± 1.99	38.59 ± 4.23	-0.341	0.733

All data represents mean ± standard deviation. EMS and CON mean electromyostimulation group and control group. Symbol * was analyzed by Mann-Whitney U test.

2.2. Research Ethics

This study was conducted in accordance with the Declaration of Helsinki and was approved by the IRB at Sahmyook University (2-1040781-AB-N-01-2017083HR). All subjects were recruited through advertisements and a written informed consent was obtained before enrollment. First, all of the participants arrived at the research center to sign an informed consent form and completed a self-reported questionnaire about their health status. After this procedure, all subjects participated in the experiment conducted by an expert.

2.3. Anthropometric Measurements

To measure body composition, all participants were weighed while wearing light clothes and without shoes. The bioelectrical impedance analysis method was employed using BMS 330 and InBody 320 Body Composition Analyzer (Biospace Co., Ltd., Korea), respectively. This analyzer is a segmental impedance device measuring voltage drops in the upper and lower body. Eight tactile electrodes were placed on the surfaces of the hands and feet. The precision of the repeated measurements expressed as coefficient of variation was, on average, 0.6% for percentage of fat mass [28]. The body composition analyzer is a segmental impedance device in which the electrodes are made of stainless steel interfaces. The subjects stood upright by placing their bare feet on the foot electrodes and gripping the hand electrodes. Eight tactile electrodes were attached to the surfaces of both hands and feet: palms, fingers, front soles, and rear soles. Analysis of body composition was measured before dinner and after voiding [29,30].

2.4. Biomarkers Measurements

Blood samples were taken after fasting for 10 hours or longer before assessment and was collected using BD vacutainer tubes (Becton Dickinson, NJ, USA) at 8 am the following day. After the subjects were stabilized for 10-15 minutes, 5 ml of blood was collected from the antecubital vein of the subjects with a disposable syringe by a medical laboratory technologist before and after the experiments. 2 ml from the 5 ml of venous blood was added to an anticoagulant tube (EDTA bottle), shaken, and centrifuged at 3,000 rpm for 5 minutes. The remaining 3 ml was left at room temperature for 1 hour and centrifuged at 1,000 rpm for 15 minutes. Isolated plasma and serum were kept frozen until the test. The samples were taken to the laboratory for analysis as follows.

The carcinoembryonic antigen (CEA) and alpha-fetoprotein (AFP) were measured by the Sandwich principle of quantitative chemiluminescence assay, with a Cobas 8000 e801 (Roche Diagnostics, Mannheim, Germany). For reference, a normal value of CEA is ≦ 3.8 ng / mL for nonsmokers and ≦ 5.5 ng / mL for smokers and a normal value of AFP is ≦ 7.0 ng / mL. High density lipoprotein (HDL) and low density lipoprotein (LDL) cholesterols were measured by the homogeneous enzymatic colorimetric assay, with a Cobas C702 (Roche, Mannheim, Germany). For reference, a normal value of HDL is over 40 mg / dL and a normal range of LDL is < 100 - 129 mg / dL. Tumor necrosis factor-alpha (TNF-a) was analyzed from serum using an enzyme-linked immunospecific assay (ELISA) kit (Cohesion Biosciences, London, UK). The serum was allowed to clot in a serum separator tube at room temperature, centrifuged at approximately 1000 x g for 15 min, and was immediately analyzed. The minimum detectable dose of Human TNF-a is typically less than 7 pg/ml. The Human TNF-a ELISA Kit allows for the detection and quantification of endogenous levels of natural and/or recombinant Human TNF-a proteins within the range of 15.6 pg/ml - 1000 pg/ml. Interleukin-6 (IL-6) was also analyzed from the serum using an ELISA kit (Cohesion Biosciences, London, UK). The minimum detectable dose of Human IL-6 is typically less than 1 pg/ml. The Human IL-6 ELISA Kit allows for the detection and quantification of endogenous levels of natural and/or recombinant Human IL-6 proteins within the range of 3.9 pg/ml - 250 pg/ml. C-reactive protein (CRP) was also analyzed from the serum using an ELISA kit (Cohesion Biosciences, London, UK). The minimum detectable dose of Human CRP is typically less than 10 pg/ml. The Human CRP ELISA Kit allows for the detection and quantification of endogenous levels of natural and/or recombinant Human CRP proteins within the range of 15.6 pg/ml - 1000 pg/ml. Resistin (RSTN), known as adipose tissue-specific secretory factor, was analyzed from the serum using an ELISA kit (Phoenix Pharmaceuticals, London, UK). The analysis method was used as follows. The standard solution and sample for RSTN was added to a microplate coated with a specific RSTN monoclonal antibody and bound to RSTN (#EK-S-028-36) to form immobilized antibodies. Afterwards, unbound material was removed by washing and biotinylated polyclonal antibody specific for biomarkers was added to each well. Unbound antibody-enzyme for biomarkers was removed by washing and Horseradish Peroxidase (HRPs) were added to each well, respectively. A binding substance was developed after the washing process and addition of substrate solution (TMB).

2.5. Measurement of Abdomen and Thigh Circumferences using by CT

Participants of the study visited Songdo Hospital in Seoul, Korea. The subjects lied horizontally with the face and torso facing up and both arms raised overhead. A radiologist performed a computer tomography (CT) scan of the abdomen and thighs before and after the experiment. The CT scan (Toshiba Scanner Aquilion Prime Model TSX-303A, Toshiba Medical Systems Corporation, Tokyo, Japan) was performed on the umbilical part of abdomen and on the thickest part of both thighs. Visceral fat (Vf) and total fat (Tf) of both the abdomen and thighs were estimated by delineating the regions and calculating an attenuation range of -190 to -30 Hounsfield units. Subcutaneous fat (Sf) area was calculated by subtracting the Vf area from the Tf value. In the case of the abdomen, the average of a single value was recorded, whereas in the case of the thighs, the values of the left and right were combined and averaged. The unit of all area values was cm^2. Moreover, this study attempted to secure the safety of the subjects by measuring the circumferences in the shortest amount of time while minimizing radiation exposure from the CT scans [31,32]. In other words, it was considered that the level of radiation exposure that the subjects received was not dangerous to their health [23].

2.6. Aerobic Dance Program with EMS Administration

Participants completed a supervised progressive program for 12 weeks (Table 2). All participants wore WB-EMS suits (Miracle®, Seoul, Korea; Figure 2) that fit their individual size. Their garments were composed of a silicone conductive pad and wireless materials. The electrical strength of the suit was controlled via Bluetooth. The WB-EMS suits used in this study enabled the simultaneous activation of eight muscle groups (both upper legs, both upper arms, buttocks, abdomen, chest, lower back, upper back, and latissimus dorsi) with selectable intensities for each region. Based on recommendations from available literature, the stimulation frequency was selected at 85 Hz, the impulse-width at 350 microseconds, the impulse-rise as a rectangular application, and variable electrostimulation intensities relative to the maximum peak voltage (160V). Impulse duration was 6 seconds with a 4-second break between impulses [8,23,24,33-35]. For EMSG, a qualified instructor conducted EMS sessions 3 times a week on two non-consecutive days to allow for a rest interval of 48 hours between each session. In order to provide effective muscular contractions, the aerobic dance movements were composed of clapping and tapping, bending and rotating, aerobic and anaerobic exercises, and stretching exercises which were performed according to the instructor's directions.

This study used 1MT as the maximum peak voltage, similar to calculating the maximal voluntary contraction (MVC) as one maximal repetition. A research study reported that the maximal toleration, expressed in this study as the corresponding incomplete muscle activation, is the inability to produce an electrically-evoked force equal to 100% of MVC [12]. 1MT was determined by progressively administering electrical intensity until the subjects expressed their maximum tolerance [22,36]. Several researchers have described exercise intensity based on the concept of MVC in the recommendation for resistance exercise in which less than 50% of MVC is considered light intensity, 60% as moderate intensity, and over 80% as vigorous intensity [37,38]. In this study, 1MT was measured as follows. Each participant in the EMSG stood still while wearing WB-EMS suits. Starting from 10% of 1MT, the intensity was gradually increased according to the response of the participant and the electric stimulation was stopped at the request of the participant when reaching an unbearable level, at which point the intensity was set as 1MT. The participants of EMSG were assigned to 60% (≈ 96 V) of 1MT from baseline to Week 4, 70% (≈ 112 V) of 1MT from Week 5 to Week 8, and 80% (≈ 128 V) of 1MT from Week 9 to Week 12, respectively. Although the subjects in CON performed aerobic dancing while wearing WB-EMS suits 3 times a week for 12 weeks, they did not receive any electrical stimuli.

Table 2. Aerobic dance program for EMSG and CON.

Type		**Program types**	**Intensity (RPE) / Time (min)**
Warm-up		Walking in place	9-11 / 5
		Upper and lower leg stretching	9-11 / 5
Work out	Clapping and tapping with dance (8 min)	Clapping	9 / 1
		Tapping the head	9-11 / 1
		Tapping the shoulders	9-11 / 2
		Tapping the trunk	9-11 / 2
		Tapping the back and legs	9-11 / 2
	Bending and rotating with dance (12 min)	Kneeling then standing	11-13 / 2
		Standing on toes	11-13 / 2
		Waving arms	11-13 / 2
		Lifting legs	11-13 / 2
		Bending waist upward	11-13 / 2
		Rotating shoulders	11-13 / 2
	Aerobic and anaerobic exercises with dance (10 min)	Basic step movements	9 / 1
		Walking in place	11 / 1
		Stepping forward, sideways, backward	13-15 / 2
		Heel raises	11-13 / 2
		Lifting knees	13-15 / 1
		Curling legs	11-13 / 1
		Front lunges	13-15 / 1
		Cross lunges	13-15 / 1
	Stretching exercises with dance (10 min)	Clapping, drawing an X-shape	11 / 1
		Rotating arms	11 / 1
		Stretching arms	11-13 / 1
		Rotating wrists	11-15 / 1
		Shaking wrists	11 / 2
		Bowing	13-15 / 2
		Rotating shoulders	11-13 / 2
Cool-down		Upper body stretching	7-9 / 5
		Lower body stretching	7-9 / 5

EMS, CON, and RPE mean electromyostimulation group, control group, and ratings of perceived exertion or Borg’s scale.

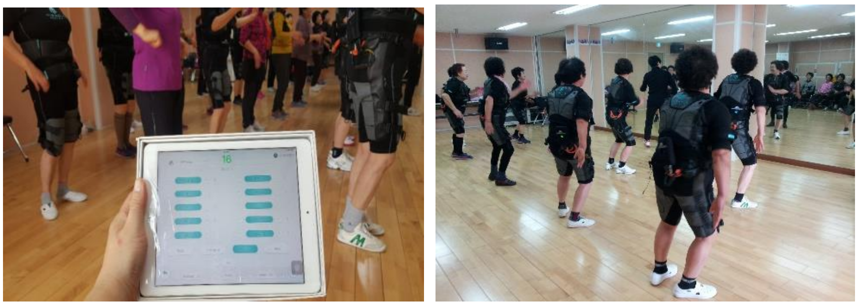

Figure 2. Aerobic dancing while wearing WB-EMS suits controlled via Bluetooth.

2.7. Data Analysis

All data are reported as mean (SD). The sample size was determined using G*Power v 3.1.3, considering an *a priori* effect size of $f^2(V) = .35$ (medium size effect), α error probability of .05, and power ($1 - \beta$ error probability) of .95. Although a sample size of 30 was recommended, the current sample included 20 participants. Based on the results of the Kolmogorov-Smirnov test, the non-parametric Mann-Whitney U test and Wilcoxon rank test were used to examine the differences of variables between groups and to examine the changes of variables between times. A significance of $p < .05$. SPSS 18.0 (SPSS Inc., Chicago, IL, USA) was used for all analyses.

3. Results

3.1. Effect of EMS on Body Composition

The aerobic dance program with EMS that was applied in this study improved the anthropometric measures in EMSG. As shown in Table 3, although there was no significant change in the body weight of CON between times, that of EMSG significantly decreased after 12 weeks. Moreover, the remaining variables in EMSG showed positive changes, although not significant. Specifically, the basal metabolic rate (BMR) of EMSG significantly increased, whereas that of CON significantly decreased by the end of the experiment. This result showed a significant difference between groups at post-value. In other words, a significant effect from EMS intervention concerning body weight and BMR were evident.

Table 3. Differences and changes in body composition.

Items		**Groups**		
		EMSG (n = 10)	**CON (n = 10)**	**Z (*p*)***
Body weight, kg	Pre	62.85 ± 9.76	62.01 ± 5.41	-0.038 (0.970)
	Post	61.33 ± 8.81	62.94 ± 5.47	-0.492 (0.623)
	Z (*p*)**	-2.142 (0.032)	-1.735 (0.083)	
Skeletal muscle, kg	Pre	20.29 ± 2.26	20.03 ± 1.49	-0.605 (0.545)
	Post	21.21 ± 2.37	19.83 ± 1.45	-0.832 (0.405)
	Z (*p*)**	-1.581 (0.114)	-.178 (0.858)	
Fat mass, kg	Pre	24.79 ± 5.78	24.85 ± 4.09	-0.076 (0.940)
	Post	23.17 ± 5.19	25.00 ± 3.73	-0.945 (0.345)
	Z (*p*)**	-1.734 (0.083)	-.306 (0.760)	
Percent fat, %	Pre	38.65 ± 1.99	38.59 ± 4.23	-0.341 (0.733)
	Post	36.12 ± 4.30	39.69 ± 3.09	-1.853 (0.064)
	Z (*p*)**	-1.377 (0.169)	-1.125 (0.260)	
BMR, kcal	Pre	1177.80 ± 68.59	1194.10 ± 41.74	-0.492 (0.623)

	Post	1225.70 ± 71.77	1123.50 ± 54.53	-2.760 (0.006)
	Z (*p*)**	-2.186 (0.029)	-2.601 (0.009)	

All data represents mean ± standard deviation. EMS, CON, and BMR mean electromyostimulation group, control group, and basal metabolic rate, respectively. Symbols * and ** were analyzed by Mann-Whitney U test and Wilcoxon rank test, respectively.

3.2. Effect of EMS on Circumferences of Abdomen and Thighs

As shown in Table 4, there were no significant changes in abdomen circumferences involving Vf, Sf, and Tf in both groups from baseline to Week 12, although a decreasing tendency was shown in EMSG. There were also no differences between groups after 12 weeks. Thigh Vfs in both groups showed no significant change by the end of experiment. There was no significant change in thigh Sf and Tf in EMSG, but those of CON significantly increased after 12 weeks. In other words, a significant effect from EMS intervention was found concerning circumference variables in obese elderly women.

Table 4. Differences and changes in abdomen and thigh circumferences.

Items (units)		**Groups**		
		EMSG (n = 10)	**CON (n = 10)**	**Z (*p*)***
Abdomen Vf, cm^2	Pre	16.53 ± 4.32	16.15 ± 3.38	-0.076 (0.940)
	Post	14.40 ± 5.38	16.25 ± 2.45	-0.680 (0.496)
	Z (*p*)**	-1.274 (0.203)	-0.153 (0.878)	
Abdomen Sf, cm^2	Pre	20.06 ± 7.58	18.99 ± 7.36	-0.076 (0.940)
	Post	21.25 ± 10.67	20.24 ± 4.19	-0.605 (0.545)
	Z (*p*)**	-0.255 (0.799)	-0.866 (0.386)	
Abdomen Tf, cm^2	Pre	36.59 ± 8.87	35.14 ± 9.07	-0.151 (0.880)
	Post	35.65 ± 8.35	36.50 ± 4.61	-0.076 (0.940)
	Z (*p*)**	-0.663 (0.508)	-0.968 (0.333)	
Thigh Vf, cm^2	Pre	11.53 ± 0.33	11.47 ± 0.36	-0.406 (0.698)
	Post	10.65 ± 0.35	11.47 ± 0.33	-0.784 (0.445)
	Z (*p*)**	-1.829 (0.067)	-0.037 (0.970)	
Thigh Sf, cm^2	Pre	10.55 ± 1.98	10.07 ± 1.77	-1.163 (0.253)
	Post	10.36 ± 1.79	11.10 ± 2.19	-0.595 (0.565)
	Z (*p*)**	-0.933 (0.351)	-3.360 (0.001)	
Thigh Tf, cm^2	Pre	11.71 ± 2.04	11.28 ± 2.06	-1.190 (0.242)
	Post	11.43 ± 1.95	12.25 ± 2.42	-0.379 (0.718)
	Z (*p*)**	-1.531 (0.126)	-3.359 (0.001)	

All data represents mean ± standard deviation. EMSG, CON, Vf, Sf, and Tf mean electromyostimulation group, control group, visceral fat, subcutaneous fat, and total fat, respectively. Symbols * and ** were analyzed by Mann-Whitney U test and Wilcoxon rank test, respectively.

3.3. Effect of EMS on Biomarkers

Aerobic dancing with EMS improved biomarker measurements in EMSG. As shown in Table 5, IL-6 significantly changed in EMSG, whereas a significant change in CON did not result from baseline to the end of the experiment. According to the results, there was a significant difference between groups. Although CRP, CEA, and LDL in EMSG did not show a significant change, those in CON changed significantly after 12 weeks. In other words, a significant effect due to EMS intervention was found concerning biomarker variables in obese elderly women.

Table 5. Differences and changes in biomarkers.

Items (units)		Groups		
		EMSG (n = 10)	**CON (n = 10)**	**Z (*p*)***
IL-6, pg/ml	Pre	13.68 ± 6.77	13.42 ± 6.48	-0.151 (0.880)
	Post	9.91 ± 6.46	15.71 ± 3.18	-2.117 (0.034)
	Z (*p*)**	-2.191 (0.028)	-1.784 (0.074)	
TNF-a, pg/ml	Pre	27.35 ± 21.34	27.99 ± 11.81	-0.416 (0.677)
	Post	23.45 ± 15.48	36.60 ± 17.35	-1.588 (0.112)
	Z (*p*)**	-1.376 (0.169)	-1.682 (0.093)	
CRP, pg/ml	Pre	34.35 ± 10.17	32.94 ± 14.38	-0.680 (0.496)
	Post	29.95 ± 6.16	64.63 ± 20.04	-3.628 (0.001)
	Z (*p*)**	-1.376 (0.169)	-2.803 (0.005)	
RSTN, ng/ml	Pre	5.19 ± 2.56	5.09 ± 2.47	-0.302 (0.762)
	Post	3.96 ± 1.85	6.57 ± 4.21	-1.587 (0.112)
	Z (*p*)**	-1.784 (0.074)	-0.866 (0.386)	
AFP, ng/ml	Pre	3.17 ± 1.93	3.22 ± 1.85	-0.151 (0.880)
	Post	2.67 ± 1.28	3.91 ± 1.95	-1.664 (0.096)
	Z (*p*)**	-1.123 (0.262)	-1.956 (0.050)	
CEA, ng/ml	Pre	2.27 ± 0.60	2.28 ± 1.36	-0.265 (0.791)
	Post	1.93 ± 0.53	2.92 ± 1.04	-2.390 (0.017)
	Z (*p*)**	-1.251 (0.211)	-1.837 (0.066)	
HDL, mg/dl	Pre	49.10 ± 9.77	49.80 ± 10.66	-0.456 (0.649)
	Post	54.30 ± 14.58	45.70 ± 9.25	-1.362 (0.173)
	Z (*p*)**	-0.919 (0.358)	-1.943 (0.052)	
LDL, mg/dl	Pre	138.00 ± 38.81	138.90 ± 46.45	-0.076 (0.940)
	Post	89.30 ± 31.43	138.90 ± 34.34	-2.797 (0.005)
	Z (*p*)**	-1.784 (0.074)	-0.153 (0.878)	

All data represents mean ± standard deviation. EMSG, CON, IL-6, TNF, CRP, RSTN, AFP, CEA, HDL and LDL mean electromyostimulation group, control group, interleukin-6, tumor necrosis factor, C-reactive protein, resistin, alpha-fetoprotein, carcinoembryonic antigen, high density lipoprotein cholesterol, and low density lipoprotein cholesterol, respectively. Symbols * and ** were analyzed by Mann-Whitney U test and Wilcoxon rank test, respectively.

4. Discussion

This study found some evidence that aerobic dancing combined with progressive EMS intervention improved body weight and BMR. Thigh fat (Sf and Tf) in EMSG did not significantly change, but that in CON increased significantly. All biomarkers in CON either showed an increasing tendency or no change after 12 weeks, although IL-6 significantly decreased in EMSG. Specifically, CRP and AFP in CON significantly increased after 12 weeks. In addition, IL-6, CRP, CEA, and LDL-C in EMSG were lower than those in CON by the end of experiment. The results of this study showed that the oxidative effect of aerobic dancing combined with the muscle contractions provided by EMS had a beneficial effect. In fact, it is difficult to expect positive changes if elderly women solely engage in aerobic dancing without the stimulation of EMS. The results of this study are thought to be similar to those of several research studies. According to the results of an 8-week study by Anderson et al. [39], the improvement in anthropometric measures was greater for walking + EMSG compared with walking only and CON in sedentary adult women. They also suggested that the combined effects of walking + EMS resulted in significantly greater reductions in hip and thigh circumferences. This finding provides additional support to another research study conducted by Porcari et al. [40] that showed significant reduction in body fat when exercise was combined with EMS.

Aerobic dancing is a type of oxidative training that can be enjoyed while listening to music. It can also develop cardiopulmonary function as well as muscular strength and endurance. The aerobic dance movements used in this study was designed to avoid using full ROM to prevent joint complications in elderly women. For this reason, the body composition in CON, which only consisted of aerobic dancing, did not change much. In particular, the biomarkers (CRP and AFP) in CON showed significant increases, despite participating in aerobic dancing. Specifically, the CRP and AFP in CON significantly increased after 12 weeks. In addition, IL-6, CRP, CEA, and LDL in CON were higher than those in EMSG by the end of experiment. Increasing CEA levels in which aging is a major contributing factor, along with AFP, showed an increasing tendency in CON over the course of the 12-week program. On the other hand, CEA levels in the elderly women significantly decreased by the end of the 12-week exercise program. Lee et al. [41] reported that CEA concentrations could be associated with metabolic disturbances and cardiovascular disease, as well as cancer. Several types of diseases are linked to higher levels of the above blood components for the following reasons [42-45].

IL-6 has many roles essential to the regulation of the immune response, hematopoiesis, and bone resorption. It is involved not only in the hepatic acute phase response, but also in adipose tissue metabolism and lipoprotein lipase activity [46]. Overproduction of IL-6, a pro-inflammatory cytokine, is associated with a spectrum of age-related conditions including cardiovascular disease, osteoporosis, arthritis, type 2 diabetes, certain cancers, periodontal disease, frailty, and functional decline [47]. Meanwhile, CRP is a major acute phase reactant synthesized primarily in the liver hepatocytes. It is composed of 5 identical, 21,500-molecular weight subunits. CRP mediates activities associated with pre-immune nonspecific host resistance. CRP shows the strongest association with cardiovascular events. When screening any cancer, the biomarkers in the blood that are widely investigated are also CEA and AFP [48-50]. CEA, an oncofetal glycoprotein, is overexpressed in adenocarcinomas, and thus it is widely used as a tumor marker. CEA may be involved in the release of pro-inflammatory cytokines, probably by stimulating monocytes and macrophages [48] and in the release of endothelial adhesion molecules [49]. Thus, CEA may contribute to the development of cancer. In addition, this action of CEA may also cause atherosclerosis and cardiovascular disease, as well as the metastasis of malignant cells [42,43]. AFP is another tumor marker related to the liver [44], and serum AFP levels were increased in all patients who had cancer cells [45]. In other words, it is no exaggeration to say that most of the diseases associated with the aging process and obesity or caused by both processes are associated with vascular disease, cardiovascular disease, and tumorigenic diseases. Such chronic degenerative diseases can be prevented and cared by medication, surgery, and healthy lifestyles, but above all, it has been reported that exercise habits and the application of effective exercise are more necessary [27].

Regular physical activity for elderly people can help to maintain a healthy body weight, enhance muscle mass, and strengthen the immune system. According to the above theories, Rogers et al. [51] and McTiernan [52] showed that the modulation of energy balance by increasing physical activity has contributed to the reduction of cancer risks through numerous epidemiological reviews. Kobayashi et al. [53] also suggested that high levels of moderate and vigorous physical activity during adolescence may contribute to a lower risk of breast cancer in both pre- and post-menopausal women. Thus, an emerging body of evidence suggests a strong inverse association between higher levels of fitness, or greater amounts of exercise, and cancer occurrence, or mortality [54]. However, there are some discrepancies regarding exercise volume (intensity, time, and frequency) for the prevention of cancer. With reduction of CEA, a 12-week exercise significantly improved body composition in elderly women [27]. In summary, many studies have reported that exercise can inhibit cancer development through enhancement of immunity, or promote cancer through suppression of immunity [55,56]. Banerjee et al. suggested that EMS was capable of eliciting a cardiovascular exercise response without loading the limbs or joints and inducing rhythmical contractions in the leg muscles [57]. According to their results, they demonstrated significant improvements in peak oxygen consumption, walking distance, and quadriceps strength, except for BMI, after 6 weeks. In these findings, the EMS device was attached only to specific parts of the body and the tolerance strength was only about 50%, suggesting that there was no change in BMI. In other words, most subjects in their study selected an impulse intensity that was consistent with the lower end of the training intensity zone [57]. This indicates that because the EMS patch was attached only to the legs, it not only limited overall muscle contraction, but also resulted in a limited effect on BMI due to the low impulse intensity of 50%. It is important that exercise intensity be high enough in order to improve body composition and to receive the benefits of metabolism-related exercises [58,59].

This study combined aerobic dancing with EMS, which used progressive impulse intensities. The use of EMS has been reported as an effective complementary method to conventional exercise programs [12,60-62]. Although the favorable effects of EMS on neuromuscular parameters have been previously shown in elderly subjects [61-64], the effects of EMS on body composition and blood contents in elderly obese women are confirmed by the results of this study. Several studies have found that although the various impulse intensities of EMS showed improved tendencies in adipokine profiles, there was increased effectiveness when using higher electrical impulse intensities [23,65,66]. Jee [23] reported that adipokines fluctuated irregularly when low and moderate EMS impulse intensities were applied during the experimental period. However, resistin decreased regularly and sequentially for 6 weeks when a high EMS impulse intensity was applied. The results of other research studies also show an increase in adiponectin and a decrease in resistin due to exercise [67-71]. In other words, the stimulation that was applied in this study with impulses greater than moderate intensity can be regarded as an exercise stimulus that activates lipid metabolism reported by other researchers [72,73]. Previous researchers have reported that a higher level of physical activity is associated with improved lipoprotein profile and increased fat oxidation [73]. Considering the results of this study, the effects of EMS with aerobic dancing performed for 40 minutes per session with low to high impulse intensities provided benefits similar to engaging in aerobic dancing.

In summary, EMS significantly increases the oxidative effect through aerobic dancing and resistance stimulation. Furthermore, this study concluded that EMS combined with aerobic dancing may be an effective alternative to conventional exercise for increasing BMR, decreasing body weight, and improving vascular conditions for obese elderly women. The effects of the progressive application of EMS intensities in this study were similar to the results of a research [74] published in endurance exercise training that showed increased lipid oxidation leading to positive effects on adipokines, inflammatory substances, and metabolic indicators as well as body composition in obese women. Although this study did not observe significant decreases in the circumferences of the abdomen and thighs, significant increases of Vf and Sf were evidenced in CON. The 12-week program of aerobic dancing combined with EMS that was applied in this study not only prevented the accumulation of thigh fat, but also improved the anthropometric and biomarker measures in obese elderly women.

5. Conclusions

In order to increase effective muscular contraction, this study combined EMS with aerobic dancing during the impulse phase [22,75,76]. Ultimately, based on the confirmed homogeneity of this study, the results suggest that the progressive electrical impulse of EMS for 12 weeks can improve body composition and inflammation-related blood profiles in elderly obese women.

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