Efficacy of Transcutaneous Electrical Stimulation on Body Composition and Lipid Profile in Obese Woman

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ABSTRACT

Background and purpose: Obesity is a chronic metabolic disorder associated with diabetes and cardiovascular disease and increased morbidity and mortality. Transcutaneous electrical stimulation (TES) is a widely used technique to relieve the symptoms of various neuromuscular disorders. It is currently being investigated in the treatment of obesity. The purpose of this study was to investigate the effect of TES with diet control and exercise on body composition including: body weight, waist hip ratio (WHR), body mass index (BMI) and total body fat % and on lipid profile including: levels of the serum total cholesterol, triglyceride, high-density lipoprotein (HDL) cholesterol and low-density lipoprotein (LDL) cholesterol in obese women. **Subjects and procedures:** Forty five women were divided in to three groups of equal number as follows: group (I) Electrical Stimulation Group (ESG) (mean age = 26.73 ± 5.6, and BMI = 35.22 ± 1.3), group (II) Placebo Electrical Stimulation Group (PESG) (mean age = 25.07 ± 5.8, and BMI = 35.09 ± 2) and group (III) Control Group (GC) diet restriction (mean age = 25.67 ± 5.9, and BMI = 36.35 ± 3.4). TES was applied for 90 minutes divided into 3 phase, each phase had 30 minutes. In phase one and two, obese woman received ES on the abdominal muscles around umbilicus by 4 electrodes with a parameter; 35 Hz frequency, 1sec action time, 1sec pause time for phase one and 15 Hz frequency, 2sec action time, 1sec pause time for phase two. In phase three, 4 electrodes were applied on the thigh muscles with a parameter; 50 Hz frequency, 2 sec actions time, 1sec pause time. Three groups were participated in diet restriction program consisted of 1000 Kcal daily and 30 minutes running on treadmill 3 time/ week for 12 weeks. **Results:** Women after 12 weeks electrical stimulation group showed significant lowering of body weight, BMI, WHR and total body fat % than those in PES and CG ($P<0.05$). While no significant difference was found between the groups in the lipid profile parameters ($P\geq0.05$). **Conclusion:** TES with diet control and exercise could be considered as useful therapy for reducing various obesity-related parameters: body weight, body fat %, body mass index and waist hip ratio. This lipolytic effect of TES may reduce obesity by mobilizing the energy stores that results in weight reduction.

Key words: Transcutaneous electrical stimulation; Obesity; Body composition; Lipid profile.

INTRODUCTION

Obesity is an excess of body fat, while overweight is an excess of body weight including all components of body composition (muscle, bone, water and fat)[13]. The prevalence of obesity in developed societies is increasing. It was 15% in 1980 and is now more than double that figure[17]. The reasons for that increase are complex and involve biological, behavioral and environmental factors[18]. The health select committee (HSC) estimates, more than 75% of women older than age 30 now are overweight in countries as diverse as Barbados, Egypt, Malta, Mexico, south Africa, turkey, and the united states. Estimates are similar for men, with over than 75% now overweight in countries as Argentina, Germany, Greece, Kuwait, New Zealand, Samoa, and United Kingdom[42].

Obesity is becoming one of the most common health problems in the world. It is a complex disease of multifaceted etiology, with its own disabling capacities, patho physiologies and co morbidities[7]. Obesity is considered as the consequences of many other medical disorders, such as hypertension, diabetes, cardiovascular disease, dyslipidemia,

and sleep apnea[41]. The psychological consequences are also severe and include body image disparagement, impaired quality of life and depression[5,12].

Obesity should not be considered to be simply a consequence of unhealthy life style, it is a condition in which weight gain has reached the point where it posses significant risks to health[43]. Successful treatment of obesity has an important impact on medical resources utilization, health care costs and patient quality of life [37]. Diet plays a significant role both in development and control of obesity[8]. Exercise was recommended by different studies to reduce body weight[31,38]. Only Orlistat drugs was officially approved by the US Food and Drug Administration for longterm obesity treatment[41]. Since effective treatment remedies are rare, researchers are trying to discover new therapies for obesity, and electrical stimulation is among the most popular alternative approaches.

Transcutaneous electrical stimulation (TES) is a widely used technique in physical therapy. It has several clinical applications including, restoration/improvement of muscle function (eg, in neurorehabilitation)[33] and pain management[28,35]. Depending on treatment objectives, electrical stimulation can be applied with a variety of protocols and parameters. TES is currently being investigated in the treatment of obesity to physically enable and encourage increased levels of voluntary exercise[11]. Yongjun et al., (2008)[44] and Liping et al., (2008)[26] found that twelve week training with neuromuscular electrical stimulation on the rectus-abdominis muscle was a potent visceral fat losing method for the women suffered from simple ventral obesity. Tian et al., (2003)[39] anticipated that a better effect can be achieved if the treatment of obesity by transcutaneous electrical nerve stimulation (TENS) was accompanied with diet control and appropriate exercise. The purpose of this study was to investigate the effect of TES with diet control and exercise on body composition and lipid profile in obese women.

MATERIALS AND METHODS

Subjects

Forty five young, healthy, sedentary females subjects participated in this study. They were selected randomly from El Kasr EL Einy Hospital out clinic, Faculty of Medicine, Cairo University and were randomly allocated to three equal group numbers of 15; group (I) Electrical Stimulation Group (ESG), group (II) Placebo Electrical Stimulation Group (PESG) and group (III) Control Group (GC). Inclusion criteria for the participated women were as follows: (1) age ranged from 18-35 years; (2) body mass index (BMI) >30 kg/m^2; (3) waist hip ratio (WHR) >0.8); (4) no involvement in structured physical activity (i.e., regular activity more than 60 min/week) in the 8 months previous to the study; (5) absence of overt uncompensated diabetes; (6) absence of signs or symptoms related to any major cardiovascular, respiratory, hormonal disturbances or orthopaedic disease that significantly interfering with the performance of the motor activities employed in the study; (7) they have not any medications that may affect the lipid profile or suppress the appetite. Permission for this study was obtained from the Institutional Ethics Board of Faculty of Physical Therapy, Cairo University and all subjects gave their written informed consent before the measurements. The physical characteristics of all subjects are shown in Table 1.

Measurements

Before and after 12 weeks of treatment intervention obese women were tested for the following variables:

1- Body composition:

Height; was measured to the nearest 0.1 cm using a stadiometer (Holtain Ltd., UK) as the distance from the top of head to the bottom of the feet with no shoes.

Weight; was measured to the nearest 0.1 kg on a digital balance scale (Seca, max. 200 kg, Germany) in light clothing with no shoes after empting the bladder.

BMI; was calculated from weight and height, as weight (kg) divided by height in meter squared (m^2)[21].

Waist Hip Ratio (WHR): Waist circumference (cm) was taken with a tape measure a the point midway between the costal margin and iliac crest in the mid- axillary line, with the subject standing and breathing normally. Hip circumference (cm) was measured at the widest point around the greater trochanter. The waist to hip ratio was calculated as the waist measurement divided by the hip measurement[6].

BMI and WHR were measured 3 times by the researcher and other two therapists to insure reliability and accuracy of measurements before and after the treatment.

Body fat analysis; Total Body Fat % was assessed by bioelectric impedance analysis (BIA) that performed in the early morning after an overnight fast, according to a conventional standard technique[27]. Whole-body resistance to an applied current (50 kHz, 0.8 mA) was measured with a Body fat analyzer device (Model BT-905/ made in Taiwan) whose electrodes were placed on the right wrist and ankle as subjects lying comfortably in bed with the limbs abducted from the body. Room temperature and humidity were maintained within the same narrow range during the measurements in all subjects (20–24˚C). Total fat % was calculated automatically by the device[15].

2- Lipid profile:

Venous blood was drawn after over-night fasting. Samples were kept at -70˚C for subsequent assay. Serum concentrations of total cholesterol, triglycerides, high density lipoprotein-cholesterol (HDL-C), low density lipoprotein-cholesterol (LDLC) were evaluated. HDL-C was calculated from the equation; total cholesterol - HDL-C.

Treatment

After initial evaluation, obese women in three groups received low calorie diet (1000 Kcal ⁄ day) and 30 minutes running on treadmill after treatment intervention session that applied 3 time/ week for 12 weeks[16,31]. The women were treated individually to avoid influencing one another.

Fig. (1): Application of electrodes in phase one and two in electrical stimulation and placebo groups.

Electrical Stimulation: EST 12 plus (eight sequential outlets, Vida elettronica via Vittorio Locchi 5/b 47100 Forli) was used to deliver electrical stimulation. The instrument had prestored program for lipolysis. This program delivered 90 minutes of electrical stimulation to patient that divided into 3 phase, each phase has 30 minutes. In phase one and two, each woman was lying in comfortable lying position and 10x6 cm electrode was placed10 cm above and below umbilicus on both side with a parameter; 35 Hz frequency, 1sec action time, 1sec pause time for phase one and 15 Hz frequency, 2sec action time, 1sec pause time for phase two. In phase three, 4 electrodes were applied on the lower limbs muscles on the anterior and posterior aspects of the thigh with a parameter; 50 Hz frequency, 2 sec actions time, 1sec pause time, (Fig. 1). The intensity of electrical stimulation was adjusted to the tolerance of each woman, which was kept at the intensity of muscle contraction felt and observed on the abdominal and thigh muscles.

Placebo electrical stimulation: Women in this group received no current output from the electrical stimulation device using the same electrotherapy machine. This was achieved using a circuit that prevented currents from reaching subjects in the placebo group but that allowed currents to reach women in the active electrical stimulation group without altering the electrical characteristics (Fig. 1). The output from the electrotherapy device was displayed on a cathode ray oscilloscope during the treatment cycles for both the active treatment groups and the placebo group to give the impression to woman that electrical currents were being delivered to the electrodes. Women in the placebo group also were told that "the electrotherapeutic device may have effects at subthreshold levels, which

you may not be able to feel" and "this means that you may or may not feel a slight tingling sensation beneath the electrodes". No subject questioned this procedure, and their responses to a posttest revealed that all subjects in the placebo electrical stimulation group believed that they were receiving currents[10,29].

Control group: women in this group received low calorie diet (1000 Kcal ⁄ day) and 30 minutes running on treadmill[16,38].

Treadmill exercise: MFI model (MB 618 RH) with motor 2.7 HP was used for running exercise. Each subject in all groups started each session with 5 minutes warming up exercise on treadmill in the form of slow progressive exercise, then the speed of the treadmill was increased to achieve at least 60 % and not more than 70% of maximal heart rate for 20 min.[4]. Finally each exercise session terminated with 5 minutes as cooling down. The speed of treadmill was gradually reduced until the heart rate returned nearly to the ting level.

Statistical analysis

Data are given as arithmetic mean ± SD. Changes in the body composition parameters and lipid profile within groups were evaluated by using a paired t test; differences between groups were evaluated by use of one -way analysis of variance (ANOVA). A Bonferroni's post hoc test was used to determine the differences between pair wise comparisons. Values of $P < 0.05$ were considered significant. Statistical Package for GragPad software (version 3) program was used for all analyses on personal computer.

RESULTS

At baseline, there were no significant differences between the groups in age, weight, height, BMI, waist-hip ratio, total fat % and lipid profile, as shown in Table 1.

Table (1): Baseline characteristics of women participated in the study.

Items	PESG Mean ±SD N=15	CG Mean ±SD N=15	F	P-value
Age (yrs)	25.06 ± 5.8	25.67 ± 5.9	0.3222	0.7#
Weight (Kg)	88 ± 8.9	94.4 ± 8.8	2.497	0.09#
Height (cm)	161.67 ± 7.2	164 ± 8.8	1.412	0.2 #
Body mass index	35.09 ± 2	36.35 ± 3.4	1.210	0.3#
Waist hip ratio	0.92 ± 0.06	0.92 ± 0.08	0.01849	0.9#
Total fat %	56.2 ± 3.7	54.9 ± 3.3	0.5089	0.6#
Total cholesterol (mg/dl)	175.07 ± 21.8	178.53 ± 28.9	0.8620	0.4#
Triglycerides (mg/dl)	163.73 ± 25.8	155.67 ± 35.1	0.980	0.3#
HDL-C(mg/dl)	37.2 ± 4.8	40.4 ± 4.9	2.523	0.09#
LDL-C(mg/dl)	142.2 ± 26.8	141.07 ± 21.7	1.089	0.3#

ESG: electrical stimulation group, PESG: placebo electrical stimulation group, CG: control group, M: mean, SD: stander deviation, n: number, #: non significant.

Body composition; Collectively, our data demonstrated that after 12 weeks of treatment intervention, there were significant decrease of weight, BMI, waist-hip ratio and total body fat% in the three groups ($P<0.05$). The mean value of body composition parameters was significantly differ between the groups in favored of ESG ($P<0.05$), as shown in Table 2. The results of Bonferroni's post hoc test that was applied as posttest to determine level of significant difference between pair wise group showed that there were significant difference between ESG and PESG and between ESG and CG in all parameters except waist-hip ratio, with no significant difference between placebo and control groups, as shown in Table 3.

Table (2): The mean values ± SD of body compositions parameters in the three groups and comparison within and between the groups.

VARIABLES	GROUPS		PRE M ±SD	POST M±SD	T	P-VALUE
Weight (kg)	**ESG**		90 ± 6	76.03 ± 5.9	64.156	0.0001*
	PESG		88 ± 8.9	83.87 ± 8.7	25	0.0001*
	CG		94.4 ± 8.8	87.83 ± 9.5	6.623	0.0001*
	F	**Pre**	2.497			
		Post	8.071			
Waist Hip Ratio	**ESG**		0.92 ± 0.02	0.86 ± 0.02	16.432	0.0001*
	PESG		0.92 ± 0.06	0.91 ± 0.06	2.870	0.01 *
	CG		0.92 ± 0.08	0.909 ± 0.74	5.292	0.0001*
	F	**Pre**	0.01849			
		Post	3.536			
Body Mass Index	**ESG**		35.22 ± 1.3	29.73 ± 1.4	58.986	0.0001*
	PESG		35.09 ± 2	32.39 ± 1.9	13.274	0.0001*
	CG		36.35 ± 3.4	33.67 ± 3.2	10.192	0.0001*
	F	**Pre**	1.210			
		Post	11.417			
Total Fat %	**ESG**		55.67 ± 3.4	34.33	36.101	0.0001*
	PESG		56.2 ± 3.7	52.4 ± 4.06	9.127	0.0001*
	CG		54.9 ± 3.3	51.4 ± 3.11	8.123	0.0001*
	F	**Pre**	0.5089			
		Post	130.83			

ESG: electrical stimulation group, PESG: placebo electrical stimulation group, CG: control group, M: mean, SD: stander deviation, #: non significant, *: significant.

Table (3): Comparison between body composition results in all groups

VARIABLES	GROUPS COMPARISON	MD	T	P-VALUE
Weight (kg)	ESG vs. PESG	-7.83	2.621	< 0.05 *
	ESG vs. CG	-11.8	4.131	< 0.001*
	PFSG vs. CG	-3.967	1.327	> 0.05 #
Waist Hip Ratio	ESG vs. PESG	-0.05	2.364	> 0.05 #
	ESG vs. CG	0.47	2.237	> 0.05 #
	PFSG vs. CG	0.0003	0.1261	> 0.05 #
Body Mass Index	ESG vs. PESG	-2.663	3.163	<0.01*
	ESG vs. CG	-3.943	4.683	< 0.001*
	PFSG vs. CG	-1.280	1.521	>0.05#
Total Fat %	ESG vs. PESG	-18.067	14.39	< 0.001*
	ESG vs. CG	-17.067	13.593	< 0.001*
	PFSG vs. CG	1	0.7965	> 0.05 #

ESG: electrical stimulation group, PESG: placebo electrical stimulation group, CG: control group, M: mean, SD: stander deviation, #: non significant, *: significant.

Lipid profile; paired t- test that applied between pre and post measuremenst within each group showed that, there were significant decrease of total cholesterol ,triglycerides , HDL –C and LDL-C levels, (P<0.05) in the three groups (P<0.05). While ANOVA test revealed no significant difference between the groups in the lipid profile parameters, as shown in Table 4.

Table (4): The mean values ± SD of lipid profile in the three groups and comparison within and between the groups.

GROUPS		PRE M ±SD	POST M±SD	T	P-VALUE
ESG		168.2 ± 11.6	146.6 ± 13.1	11.972	0.0001*
PESG		175.07 ± 21.8	140.47 ± 24.5	8.392	0.0001*
CG		178.53 ± 28.9	138.13 ± 30.5	13.047	0.0001*
F	**Pre**	0.8620			
	Post	0.5054			
ESG		149.8 ± 18.6	135.93 ± 16	13.033	0.0001*
PESG		163.73 ± 25.8	122.6 ± 20.6	4.223	0.0009*
CG		155.67 ± 35.1	122.6 ± 23.7	3.698	0.002*
F	**Pre**	0.980			
	Post	2.126			
ESG		37.8 ± 2.3	42.52 ± 2.8	9.806	0.0001*
PESG		37.2 ± 4.8	42.267 ± 5.6	11.767	0.0001*
CG		40.4 ± 4.9	45.6 ± 6.2	6.925	0.0001 *
F	**Pre**	2.523			
	Post	1.965			
ESG		128. 33 ± 35.5	122.93 ± 35.5	9.812	0.0001*
PESG		142.2 ± 26.8	119.93 ± 28.7	7.007	0.0001*
CG		141.07 ± 21.7	113.2 ± 19.7	14.612	0.0001*
F	**Pre**	1.089			
	Post	0.4526			

ESG: electrical stimulation group, PESG: placebo electrical stimulation group, CG: control group, M: mean, SD: stander deviation, #: non significant, *: significant.

DISCUSSION

Obesity is a serious, prevalent, and refractory problem. Successful treatment of it will have an important impact on medical resources utilization, health care costs and patient quality of life[37]. The purpose of this study was to investigate the effect of transcutaneous electrical stimulation plus exercise and diet control on body composition and lipid profile in obese female subjects.

The main findings of this study were that body composition parameters (weight, BMI, and total body fat%,) were significantly decreased by either TES or placebo ES or diet control in obese woman but the most significant effect was obtained by TES. Also lipid profile parameters (total cholesterol, triglycerides, HDL –C and LDL-C) were significantly decreased in the three groups, with no significant difference between the groups.

Body composition parameters include (weight, BMI, WHR) were measured in this study to reflect the effect of TES on obesity as this parameters are the most useful measure of obesity and the best simple anthropometric index in predicting a wide range of risk factors and related health conditions[1,34]. The study used also body fat analyzer as bioelectrical impedance was found to be reliable and non-invasive method for estimating body composition[20,25].

The significant results obtained in placebo ES group (group II) for body composition and lipid profile parameters could be related to the effect of low calorie diet and exercise. As Bonferroni's post hoc test that applied as posttest to determine level of significant difference between pair wise group showed no significant difference between placebo and control group for body composition parameters. Also ANOVA test found no significant difference between the three groups for lipid profile parameters. Kopelman, (2007)[24] reported that the most effective treatment of obesity is provided by a combination of diet control and exercise. As diets with less fat (20-25 %) can reduce mean energy intake by 100Kcal/day that enough to stop the growing epidemic of overweight and obesity[14]. While exercise has the following effects, it burns calories and improves metabolism, suppresses appetite, improves insulin sensitivity and lowers risk for coronary artery disease and high blood pressure[31]. Public health interventions promoting 30 to 45 minutes of physical activity of moderate

intensity, performed 3 to 5 days a week, should be encouraged and walking are likely to be the most successful because of its safety, accessibility, and popularity[31].

Also the best results found in ESG (group I) could be attributed to the additional effect of TES to these of low calorie diet and exercise. Tian, D. et al., (2003)[39] anticipated that a better effect can be achieved by TENS if the treatment of obesity was accompanied with diet control and appropriate exercise.

The effect of transcutaneous electrical stimulation on fat lipolysis can be explained as flowing; (i) When electrical current pass beneath the skin to the underlying tissue, stimulates adrenergic interstitial nerve endings thus leading to release of catecholamine hormone which stimulates adenilate cyclase that converts adenosine triphosphate to cyclic adenosine monophosphate and activates lipases. It is known that lipases hydrolyzes fat (triglycerides) into free fatty acid, glycerol and water[22]. (ii) Free fatty acid unlike triglycerides which has large molecules that cannot be excreted through the cell membrane. Free fatty acid has smaller molecules that can burn up for energy[36] or it can freely pass through the cell membrane out into tissue fluid, to be further transported by the lymph vessels[23]. The released fatty acid can be used for physical effort or body heat generation at once or it will be stored somewhere in active cells[3]. So it was recommended that obese subject treated by ES should perform an active aerobic exercise for at least 30 minutes immediately after the session. (iii) ES increases rate of venous and lymphatic vessels flow that helps in easy drainage of hydrolyzed fat[30]. (iv) ES causes significant increase in muscle metabolism, dynamic local blood flow, local temperature and muscle pumping action[9].

The results of TES were supported by the work of Bjorontrop and Brodorf (1992)[2] who stated that a session of ES for lipolysis demands about 1.5 hours through three phase. During first phase, microcurrents were adjusted to reactivate circulation around adipose cells, by acting on capillary vessels and by interaction with ion balance, the hormonal system for production of fat conversion enzyme was also activated. In the second phase, the microcurrents stimulate the fibers in the connective tissue under the skin where the fat had been located. For the 3rd phase, adhesive pads of ES were positioned at the legs, the respective leg muscles were strained and restrained so that a pumping action results to affect drainage.

The results of this study were in line with Tochikubo et al. (1994)[40], who treated abdominally obese subjects with non dependent pulse-synchronized transpercutaneous electrical abdominal stimulation 30,000 muscle contraction /day for 4 weeks and found significant improvement through reduction in body weight, intra-abdominal visceral fat, abdominal subcutaneous area at the level of umbilicus, blood pressure, heart rate and total cholesterol. Yongjun et al., (2008) [44] found that twelve week training with neuromuscular electrical stimulation on the rectus-abdominis muscle with frequency 30Hz,pulse width 300 μs, on and off ratio 1∶ 3,intensity 10—20mA was a potent visceral fat losing method for the women suffered from simple ventral obesity. It′s effect was better than only education for weight control. Also Liping H, et al., (2008)[26] concluded that the serum glucose, lipids, insulin resistance and leptin resistance decreased significantly after 12 weeks electrical stimulation program the women suffered from abdominal obesity, while the rehabilitation education only for weight control didn′t result in significant change. The underlying mechanism was probably due to reduction of visceral fat. The findings of this study are contradicted by the work of Hopp and Warren (1990)[19], who stated that the lipid used by skeletal muscle during electrical stimulation was derived entirely from plasma free fatty acid because intracellular triglyceride in skeletal muscle was not decreased during ES. Porcari et al. (2002)[32] concluded that electrical muscle stimulation had no significant effect to increase muscle strength, to decrease body weight and body fat, and to improve muscle firmness and tone in healthy individuals.

Conclusion

The study findings indicated that TES with diet control and exercise could be considered as a useful therapy for reducing

various obesity-related parameters: body weight, body fat %, body mass index and waist hip ratio. This lipolytic effect of TES may reduce obesity by mobilizing the energy stores that result in weight reduction.

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الملخص العربي

فعالية التنبيه الكهربائي عبر الجلد على تكوين الجسم والدهون في المرأة البدينة

البدانة هى اضطراب مزمن للأيض و المرتب عليه امراض اخرى كالسكري وأمراض القلب والأوعية الدموية وزيادة معدلات الاعتلال والوفيات . التنبيه الكهربائي عبر الجلد هو أسلوب يستخدم على نطاق واسع للتخفيف من أعراض الاضطرابات العصبية والعضلية المختلفة. ويجري حاليا التحقق منه في علاج السمنة. وكان الغرض في هذه الدراسة معرفة مدى تأثير التنبيه الكهربائي عبر الجلد بالاضافة الى النظام الغذائي و التمرينات الرياضية على وزن الجسم ، و نسبة الخصرالى الورك ومؤشر كتلة الجسم ونسبة الدهون بالجسم وكذلك مستويات الكولسترول ، الدهون الثلاثية في الدم في النساء البدينات و قد اجريت الدراسة على خمسة واربعون امرأة تم تقسيمهن الى ثلاث مجموعات متساوية : المجموعة الأولى(التحفيز الكهربائي عبر الجلد) المجموعة الثانية(الايحاء بالتنبيه الكهربائي عبر الجلد) والمجموعة الثالثة (الحاكمة). وشاركت الثلاثة مجموعات في برنامج تقييد النظام الغذائي اليومي المحتوى على 1000 سعر حرارى فقط و 30 دقيقة من الجرى ثلاثة ايام اسبوعيا لمدة 12 أسبوعا. النتائج بعد12 اسبوعا أظهرت المشاركات من المجموعة الاولى انخفاض ملحوظ فى وزن الجسم ، و نسبة الخصرالى الورك ومؤشر كتلة الجسم ونسبة الدهون بالجسم اكثر من تلك الناتجة فى المجموعتين الاخرتين. في حين لم يوجد فرق كبير بين الجموعات الثلاث فى مستويات الكولسترول ، الدهون الثلاثيةفى الدم . والخلاصة : يمكن اعتبار التنبيه الكهربائي عبر الجلد بالاضافة الى النظام الغذائي و التمرينات الرياضية وسيلة علاجية فعالة لتقليل وزن الجسم ، و نسبة الخصرالى الورك ومؤشر كتلة الجسم ونسبة الدهون في النساء البدينات .

الكلمات الدالة : التحفيز الكهربائي عبر الجلد ؛ السمنة .