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The Effect of Wearing Shoes Generating Micro-currents on Body Composition and Blood Lipid Concentrations of Overweight Females

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Abstract. [Purpose] This double-blind study was conducted to examine the effect of electric stimulation through micro-currents on body composition and blood lipid concentrations of overweight females after walking exercise. [Subjects] Overweight females in their 20s were randomly allocated to either an experimental group or a control group. Participants in the experimental group were given shoes generating micro-currents, while the control group wore shoes which did not generate micro-currents but were identical in appearance. [Methods] Both groups walked on a treadmill at a comfortable pace for 50 min/day, 5 days/week for 4 weeks, and each participant's body weight, body composition, and blood lipids were examined at baseline and after 4 weeks. [Results] The results show that body weight and the waist-to hip ratio decreased significantly in the experimental group, but no significant differences were seen in blood tests. [Conclusion] Based on the results of this study, we think that, along with regular walking exercise, electric stimulation through micro-currents positively affected the reduction of body weight and body composition of overweight females, helped to maintain the improvement of their health, and facilitated a better quality of life.
Key words: Microcurrent, Exercise, Bodyweight

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INTRODUCTION

Among the health problems of modern society, obesity is a major concern. Obesity not only induces physical and mental stress, but also deteriorates the quality of human life due to its associations with various diseases, including hypertension, diabetes, hyperlipidemia, cardiovascular diseases and metabolic disorders[1)], as well as creating a huge economic burden as a consequence. In many studies, obesity is identified as the worst chronic and progressive disease. Not only in Western society but also in South Korea, the number of obese men and women has rapidly increased at the rate of 1.3% per year from 1998 to 2001[2)]. Obesity is becoming a dangerous problem that increases health risk factors. In particular, abdominal obesity is a leading cause of type II diabetes. The incidence of abdominal obesity in Koreans is 24.4% and 23.8% in males and females, respectively[3)]. In addition, physical inactivity as a result of obesity limits activity in day-to-day life, thereby reducing quality of life[4)].

The cause of decreased motor ability in obese persons is known to be a composite process, including a decrease in fatty acid utilization by the skeletal muscles due to reduced activity of carnitine palmitoyltransferase-1 (CPT1), the transmitter of fatty acid into mitochondriae. In addition, the reduced activity of mitochondrial oxidative enzymes, related to adenosine triphosphate (ATP) formation, and reduced binding of blood-circulated catecholaminergic hormones to receptors at fat-cell membrane receptors, due to decreases in blood flow to adipose tissues, consequently reduce the formation and use of the energy sources necessary for exercise[5,6)].

Since body weight control involves composite processes, appropriate treatments for individual patients with obesity also require diverse composite processes such as behavioral patterns, diet, drugs, and surgical treatments[7)].

To date, micro-currents have been successfully used to treat soft tissues and nonunion of fractures[8–11)]. Micro-currents have also been widely used as, and compared to, general electric treatments including percutaneous electric nerve stimulations or faradizations which treat diseases in milliampere (mA) doses. Micro-currents treat diseases in microampere (μA) doses. Since they are both similar to bio-currents, they have been effective at wound healing and in many studies. It has been reported that low electric stimulation is a promising approach to angiogenesis treatment[12,13] and that electric fields promote the secretion of growth factors[14]. In addition, micro-currents have been found to promote the switch of skin fibroblasts and U937 cells into growth factor-β1 (TGF-β1), an important regulator of inflammation and tissue regeneration[15]. Other studies have reported that while 1000 μA or higher currents decrease ATP production, micro-currents ranging from 10 μA to 500 μA increase ATP accumulation in tissues and stimulate amino acid transportation and protein binding in the skin tissues of mice[16]. In addition, recently, it was reported that ultra-low micro-currents has clear therapeutic effects on diabetes, hypertension, and wound healing[11].

Based on this empirical evidence, this study investigated the effects of micro-currents on body weight, body composition, and blood lipid content of obese persons to seek ways to control weight and improve the health of the obese.

SUBJECTS AND METHODS

Pursuant to the criteria of the American College of Sports Medicine (ACSM), 22 overweight females in their 20s with 26% or higher body fat ratio were selected for participation in the study after providing sufficient explanation about the experiment; receipt of informed consent; satisfactory completion of a health evaluation in which no cardiovascular diseases or metabolic disorders including diabetes, thyroid diseases, and neurological disorders were present; and being found to have had no participation in any form of diet therapy or exercise program during the 6 months before the commencement of the study.

The subjects in this double-blind study were randomly assigned to either an experimental group (n=10) or a control group (n=10). The general characteristics of the 20 subjects (except for 2 subjects who could not continue the exercise while the study was in progress), are given in Table 1.

Table 1. General characteristics of subjects

	EG	CG
Height (cm)	160.3 ± 4.3	160.4 ± 7.4
Year (yr)	24.0 ± 3.7	22.0 ± 2.5
Weight (kg)	63.1 ± 9.1	59.9 ± 10.0
Percent Body fat (%)	34.4 ± 6.6	33.1 ± 3.3
Waist-Hip Ratio (%)	0.87 ± 0.08	0.84 ± 0.03

Values are M ± SD. EG: Exercise with microcurrent shoes. CG: Exercise only.

The study procedure was explained to the participants, who then signed consent forms. In order to examine the effect of micro-current stimulation during walking exercise on body composition and blood lipid concentration, obesity degree tests and blood tests were conducted twice, at baseline and after 4 weeks. Using a body fat measuring device (Inbody 330, Biospace, Korea), participants' levels of obesity and body composition were checked. To examine changes in blood lipid content, blood was collected when the subjects had maintained fasting for at least 12 hours. Blood was drawn from the subjects' brachial veins using vacutainer tubes suitable for the purpose, and 22-gauge needles. The collected blood was then analyzed using an automatic blood analyzer (ADVIA 1200, Siemens, Japan).

After the tests, the subjects were randomly assigned to either the experimental group or the control group. Sneakers were fitted with a device that generates micro-currents and given to the experimental group subjects, while identical sneakers without the devices for generating micro-currents were given to the control group subjects. Both groups were instructed to walk on a treadmill wearing the sneakers for 50 minutes a day, 5 times a week, for 4 weeks at comfortable speeds. The micro-currents applied to the experimental group's sneakers were 0.3/1 second 60 μA -80 μA static pulse micro-currents.

Data on the results of the study were statistically processed using SPSS® version 12.0 software (SPSS®Inc., an IBM Company, Chicago, USA) and the degrees of significance of differences in mean values of the measurement items between and within the groups were checked using Student's t-test. A significance level (α) of 0.05 was used for the statistical analysis.

RESULTS

Blood lipid concentrations of the subjects at baseline and at the end of week 4 were observed as follows. Total cholesterol (TC) values in the experimental group were 182.70 ± 27.47 mg/dl at baseline and 182.90 ± 25.79 mg/dl at the end of week 4. TC values in the control group were 190.80 ± 17.08 mg/dl at baseline and 204.40 ± 20.74 mg/dl at the end of week 4. No significant difference was seen. Triglyceride (TG) values in the experimental group were 63.00 ± 19.09 mg/dl at baseline, 60 ± 25.11 mg/dl at the end of week 4, while TG values in the control group were 134.60 ± 91.75 mg/dl at baseline and 111.10 ± 52.41 mg/dl at the end of week 4 with no significant difference. High-density lipoprotein (HDL) values in the experimental group were 68.99 ± 13.53 mg/dl at baseline and 69.55 ± 7.98 mg/dl at the end of week 4, while HDL values in the control group were 65.45 ± 11.42 mg/dl at baseline and 72.00 ± 13.14 mg/dl at the end of week 4 with no significant difference. Low-density lipoprotein (LDL) values in the experimental group were 101.11 ± 24.85 mg/dl at baseline and 101.43 ± 24.47 mg/dl at the end of week 4, while LDL values in the control group were 98.43 ± 19.01 mg/dl at baseline and 110.18 ± 22.08 mg/dl at the end of week 4 with no significant difference (Table 2).

Changes in the subjects' body compositions were observed as follows. Body weight in the experimental group decreased significantly, from 63.08 ± 9.13 kg at baseline to 61.78 ± 9.25 kg at the end of week 4. Body weight in the control group was 59.93 ± 0.02 kg at baseline and 60.21 ± 9.71 kg at the end of week 4 with no significant difference. Body fat mass in the experimental group was 38.52 ± 1.84 kg at baseline and 38.61 ± 1.66 kg at the end of week 4, while body fat mass in the control group was 38.23 ± 5.18 kg at baseline and 37.84 ± 4.46 kg at the end of week 4 with

Table 2. Changes of blood lipids in the experimental group and the control group

	group	Pre–test	Post–test	Mean difference
TC	EG	182.70 ± 27.47	182.90 ± 25.79	–0.20 ± 22.34
	CG	190.80 ± 17.08	204.40 ± 20.74	–3.60 ± 19.34
TG	EG	63.00 ± 19.09	59.60 ± 25.11	3.40 ± 23.24
	CG	134.60 ± 91.75	111.10 ± 52.41	23.50 ± 76.09
HDL	EG	68.99 ± 13.53	69.55 ± 7.98	–0.56 ± 14.96
	CG	65.45 ± 11.42	72.00 ± 13.14	–6.55 ± 14.41
LDL	EG	101.11 ± 24.85	101.43 ± 24.47	–0.32 ± 21.47
	CG	98.43 ± 19.01	110.18 ± 22.08	–1.75 ± 27.86

Values are M ± SE. EG: Exercise with microcurrent shoes, CG: Exercise only.

Table 3. Changes in body compositions of the Experimental and Control groups

	group	Pre-test	Post-test	Mean difference
Weight (kg)	EG	63.08 ± 9.13	61.78 ± 9.25	1.30 ± 1.38*
	CG	59.93 ± 0.02	60.21 ± 9.71	–0.28 ± 1.13
Soft lean mass (kg)	EG	38.52 ± 1.84	38.61 ± 1.66	–0.90 ± 0.80
	CG	38.23 ± 5.18	37.84 ± 4.46	0.39 ± 1.08
Percent body fat (%)	EG	34.38 ± 6.59	32.80 ± 6.72	1.58 ± 2.49
	CG	33.11 ± 3.37	32.81 ± 4.14	0.30 ± 1.38
Waist-hip ratio (%)	EG	0.87 ± 0.08	0.85 ± 0.07	0.02 ± 0.01*
	CG	0.85 ± 0.03	0.84 ± 0.03	0.01 ± 0.01

Values are M ± SE. EG: Exercise with microcurrent shoes, CG: Exercise only, *$p<0.05$ compared to the control.

no significant difference. Percent body fat in the experimental group were 34.38 ± 6.59 kg at baseline and 32.8 ± 6.72 kg at the end of week 4 showing a slight decrease in body fat, though not statistically significant. Body fat rates in the control group were 33.11 ± 3.37 kg at baseline and 32.81 ± 4.14 kg at the end of week 4 with no significant difference. Abdominal fat rates in the experimental group decreased significantly, from 0.87 ± 0.08% at baseline to 0.85 ± 0.07% at the end of week 4; those in the control group also decreased significantly, from 0.85 ± 0.03% at baseline to 0.84 ± 0.03% at the end of week 4 (Table 3).

DISCUSSION

This study examined the effects of micro-currents delivered during continuous walking exercise performed by overweight female subjects. The subjects' dietary habits were maintained without limitation by any particular diet or therapies for their body weight, body composition, or blood lipid concentrations.

Due to the increasing number of obese people and a heightened interest in health issues, many obesity studies examining exercise, drug treatments, and physiotherapy intended to decrease body weight have been conducted. However, there have been few studies focusing on the utilization of electrotherapy in particular, micro-currents.

In this study, no significant differences in blood lipid concentrations (TC, TG, HDL, and LDL) were shown between before exercise and at the end of 4 weeks in either the walking exercise group or the combined micro-currents and walking exercise group ($p<0.05$).

In many studies conducted on the changes in blood cholesterol concentrations arising from regular long-term exercise, conflicting results have been reported, some indicating that TC, TG, HDL, and LDL concentrations changed significantly[2,17] and others indicating no significant changes[18,19]. In a study in which 20 obese females performed resistance exercises for 12 weeks, James and Pometta[19] reported that only muscle strength increased without any significant change in TC, while a study by Kokkinos et al.[18], concluded that there was no significant change in HDL concentration after the implementation of a 10-week program of resistance exercises. On the contrary, Wallace et al.[20] reported that high-intensity and high-frequency circulating repetitive exercises performed by middle-aged males produced significant increases in HDL concentrations. Additionally, Park[21] reported that a 16-week program of elastic band exercises performed by stroke patients resulted in significant outcomes in LDL concentrations.

Studies conducted on changes of blood cholesterol concentrations in relation to diverse styles and intensities of exercise have shown that with higher exercise intensities and longer periods of exercise time, blood cholesterol concentrations change more significantly[22]. Durstine et al.[23] also reported that changes in HDL were not seen as a result of low-intensity exercise; thus, in order to increase HDL concentrations through exercise, the exercise intensity should be enhanced or the amount of exercise time increased. These differences in study results are thought to be due to differences in the types of exercise, the lengths of the exercise periods, hormonal changes and dietary habits of the study subjects. In this study, the subjects' dietary habits, including fat intake, were not restricted, and we believe that the exercise intensity of the light walking exercise program for a 4weeks was insufficient.

TG is located in adipose cells and in the musculoskeletal system, and works as an energy source to produce ATP through aerobic metabolism in vivo. In a previous study, it was reported that applying 500 μA or lower micro-currents increased ATP accumulation and protein binding[16].

The present study also compared body weights and body compositions at baseline and after 4 weeks, and body weights had significantly decreased at 4 weeks. In the experimental group ($p>0.05$), abdominal fat rates had significantly decreased in both the experimental group and the control group ($p>0.05$), and body fat rates decreased in the experimental group, although the difference from baseline was not significant. These results are consistent with many previous studies which have reported that aerobic exercise directly converts body fat to kinetic energy and thus reduces body weight, body fat and subcutaneous fat[3,24]. However, in the present were found no significant differences in body fat mass in either the experimental or control group, probably indicating that exercise for at least 8 weeks, rather than 4 weeks, is essential for the decrease of body fat mass. This would corroborate the study by Kim et al.[2], who reported that decreases in body fat mass appeared after exercising for at least 8 to 16 weeks.

Given that body fat masses were maintained or increased between baseline and 4 weeks in some subjects, it is thought that exercise programs which appropriately adjust the intensity and exercise time for individual differences will be necessary.

In this study, there were no differences in blood lipid concentrations in either the experimental or control groups, but body weight and abdominal fat rate decreased significantly in the experimental group subjects, who executed a regular walking exercise program combined with stimulation through micro-currents. Therefore, applying micro-current stimulation to regular walking exercise may be more effective than only exercise at reducing overweight females' body weights and abdominal fat rates.

We acknowledge that this study has limitations. For example, reducing the weight of overweight women and maintaining the reduced weight should be conducted for a longer period than four weeks and in addition, the number of subjects who participated in this study was small. Thus, we acknowledge that additional studies will be necessary.

REFERENCES

1) Kopelman PG: Obesity as a medical problem. Nature, 2000, 404: 635–643.
2) Kim DM, Ahn CW, Nam SY: Prevalence of obesity in Korea. Obes Rev, 2005, 6: 117–121.
3) Chung HR, Perez-Escamilla R: Risk factors of type 2 diabetes among Korean adults: The 2001 Korean national health and nutrition examination survey. Nutr Res Pract, 2009, 3: 286–294.
4) Katzmarzyk PT, Janssen I: The economic costs associated with physical inactivity and obesity in Canada: an update. Can J Appl Physiol, 2004, 29: 90–115.
5) Horowitz JF: Regulation of lipid mobilization and oxidation during exercise in obesity. Exerc Sport Sci Rev, 2001, 29: 42–46.
6) Kanaley JA, Haymond MW, Jensen MD: Effects of exercise and weight loss on leucine turnover in different types of obesity. Am J Physiol, 1993, 264: E687–E692.
7) Kaplan LM: Pharmacologic Therapies for Obesity. Gastroenterology Clinics of North America, 2010, 39: 69–79.
8) Lambert MI, Marcus P, Burgess T, et al.: Electro-membrane microcurrent therapy reduces signs and symptoms of muscle damage. Med Sci Sports Exerc, 2002, 34: 602–607.
9) Cho, MS: Effects of non-invasive constant microcurrent stimulation on bone healing after tibia fracture in rabbits. Daegu University Dissertation of Doctorte Degree. 2007
10) El-Husseini T, El-Kawy S, Shalaby H, et al.: Microcurrent skin patches for postoperative pain control in total knee arthroplasty: a pilot study. Int Orthop, 2007, 31: 229–233.
11) Lee BY, Al-Waili N, Stubbs D, et al.: Ultra-low microcurrent in the management of diabetes mellitus, hypertension and chronic wounds: report of twelve cases and discussion of mechanism of action. Int J Med Sci, 2009, 7: 29–35.
12) Kanno S, Oda N, Abe M, et al.: Establishment of a simple and practical procedure applicable to therapeutic angiogenesis. Circulation, 1999, 99: 2682–2687.
13) Vite CH, Melniczek J, Patterson D, et al.: Congenital myotonic myopathy in the miniature schnauzer: an autosomal recessive trait. J Hered, 1999, 90: 578–580.
14) Zhao M, Bai H, Wang E, et al.: Electrical stimulation directly induces pre-angiogenic responses in vascular endothelial cells by signaling through VEGF receptors. J Cell Sci, 2004, 117: 397–405.
15) Todd I, Clothier RH, Higgins ML, et al.: Electrical stimulation of transforming growth factor-beta 1 secretion by human dermal fibroblasts and the U937 human monocytic cell line. Altern Lab Anim, 2001, 29: 693–701.
16) Cheng N, Van Hoof H, Bockx E, et al.: The effects of electric currents on ATP generation, protein synthesis, and membrane transport of rat skin. Clin Orthop Relat Res, 1982: 264–272.
17) Suzuki I, Nagaya T, Machita N, et al.: Effects of long-term physical training on body composition, cardiovascular function, and serum lipids in mildly obese middle-aged subjects. Nippon Eiseigaku Zasshi, 1996, 50: 1047–1056.
18) Kokkinos PF, Hurley BF, Vaccaro P, et al.: Effects of low- and high-repetition resistive training on lipoprotein-lipid profiles. Med Sci Sports Exerc, 1988, 20: 50–54.
19) James RW, Pometta D: The distribution profiles of very low density and low density lipoproteins in poorly-controlled male, type 2 (non-insulin-dependent) diabetic patients. Diabetologia, 1991, 34: 246–252.
20) Wallace MB, Moffatt RJ, Haymes EM, et al.: Acute effects of resistance exercise on parameters of lipoprotein metabolism. Med Sci Sports Exerc, 1991, 23: 199–204.
21) Park, SH: The effect of elastic band training on blood lipids and body composition, physical fitness of stroke patients. Hanyang University Dissertaton of Doctorte Degree. 2005
22) Williams OD, Stinnett S, Chambless LE, et al.: Populations and methods for assessing dyslipoproteinemia and its correlates. The Lipid Research Clinics Program Prevalence Study, Circulation. 1986, 73: I4–I11.
23) Durstine JL, Grandjean PW, Cox CA, et al.: Lipids, lipoproteins, and exercise. J Cardiopulm Rehabil, 2002, 22: 385–398.
24) Bray GA: Medical Therapy for Obesity –Current status and future hopes. Medical Clinics of North America, 2007, 91: 1225–1253.