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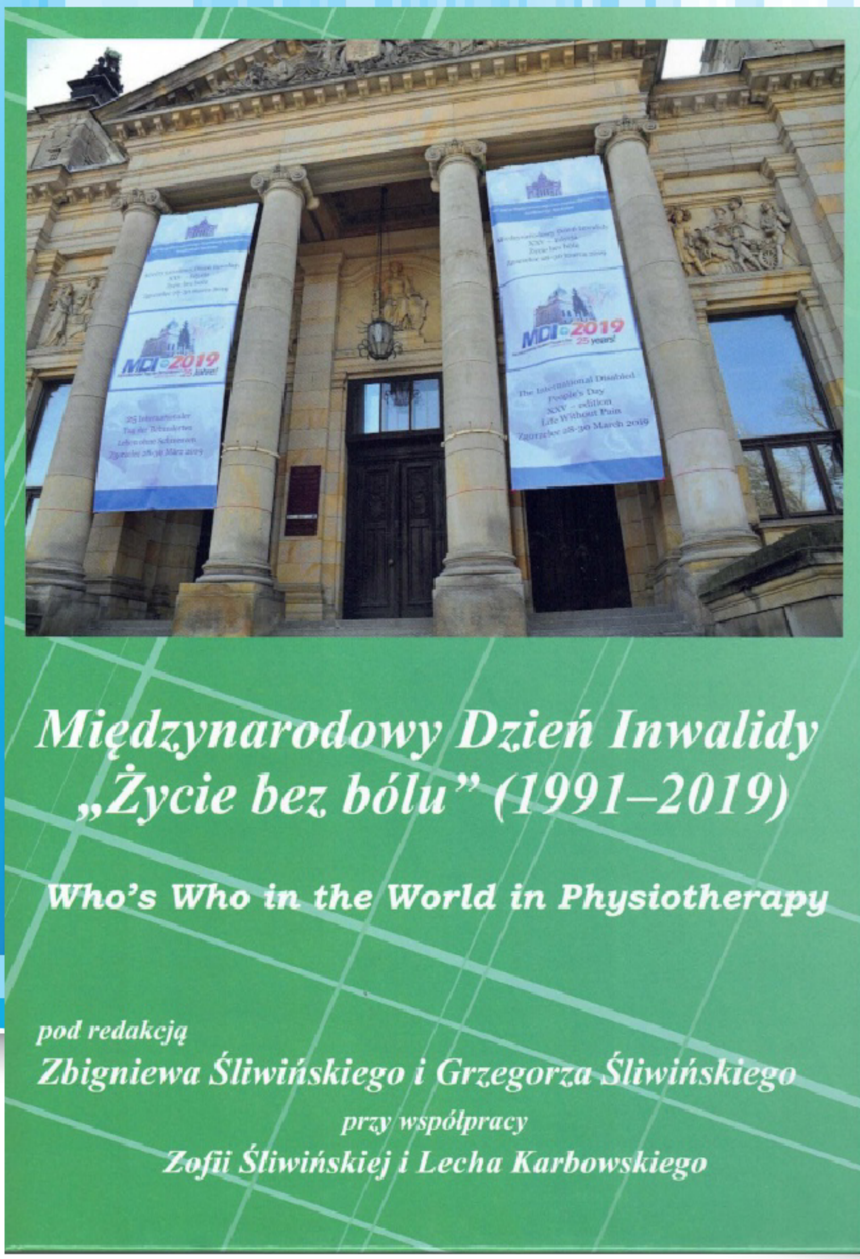

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Effect of pulsed electromagnetic field versus interferential current on abdominal fat thickness in postnatal women

Wpływ pulsacyjnego pola elektromagnetycznego oraz prądu interferencyjnego na grubość tkanki

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Abstract

Objective. To compare the efficacy of the pulsed electromagnetic field and the interferential current effects on abdominal fat thickness in postnatal women.
Method. This study enlisted the participation of sixty obese postnatal multipara women, ages ranged between 30 and 40 years, body mass index ranged between 30 to 39.9 kg/m2, and they were chosen at least two years after the previous delivery. They were selected and equally divided at random into two groups (A&B). Group A (n = 30) was treated with pulsed electromagnetic field on the abdomen. Each session lasted about 20 minutes and was held three days per week for four weeks. Group B (n = 30) was treated with interferential current on the abdomen. Each session lasted about 20 minutes and was held three days per week for four weeks.
Body mass index was evaluated by weight and height scale, waist circumference was evaluated by tape measurement, abdominal subcutaneous fat thickness was evaluated by skin fold caliper, and blood lipid profile was measured in both groups before and after treatment.
Results: Within groups, there were significant reduction in BMI, WC, abdominal subcutaneous thickness, and blood lipids profile (TC, TG, LDL, and VLDL), and significant increase in HDL in both groups (A&B) post-treatment in compare to pre-treatment. Between groups, there were no significant differences in all measurement values between both groups (A&B) pre and post-treatment.
Conclusion: PEMF and IFC are safe and have the same effect in reducing BMI, WC, abdominal subcutaneous fat thickness, and blood lipids in postnatal women.

Key words:

pulsed electromagnetic field, interferential current, abdominal fat thickness, postnatal women, waist circumference

Streszczenie

Cel. Porównanie skuteczności pulsacyjnego pola elektromagnetycznego i prądu interferencyjnego na grubość tkanki tłuszczowej brzucha u kobiet po porodzie.
Metoda. W badaniu wzięło udział sześćdziesiąt otyłych kobiet wieloródek, w wieku od 30 do 40 lat, o wskaźniku masy ciała od 30 do 39,9 kg/m2, co najmniej dwa lata po poprzednim porodzie. Zostały one wybrane i równo podzielone losowo na dwie grupy (A&B). Grupa A (n = 30) była poddawana działaniu pulsacyjnego pola elektromagnetycznego na brzuchu. Każda sesja trwała około 20 minut i odbywała się trzy dni w tygodniu przez cztery tygodnie. Grupa B (n = 30) była poddawana działaniu prądu interferencyjnego na brzuchu. Każda sesja trwała około 20 minut i odbywała się trzy dni w tygodniu przez cztery tygodnie.
Wskaźnik masy ciała oceniano za pomocą skali wagi i wzrostu, obwód talii zmierzono za pomocą pomiaru metrem, grubość podskórnej tkanki tłuszczowej brzucha oceniano suwmiarką fałdów skórnych, a profil lipidowy krwi mierzono w obu grupach przed i po leczeniu.
Wyniki: W obrębie grup zaobserwowano istotne zmniejszenie BMI, obwodu talii, grubości podskórnej brzucha i profilu lipidów we krwi (TC, TG, LDL i VLDL) oraz znaczny wzrost HDL w obu grupach (A&B) po leczeniu w porównaniu ze stanem przed leczeniem. Między grupami (A&B) nie zaobserwowano istotnych różnic we wszystkich wartościach pomiarowych przed i po leczeniu.
Wniosek: PEMF i IFC są bezpieczne i mają taki sam wpływ na zmniejszenie BMI, obwodu talii, grubości podskórnej tkanki tłuszczowej brzucha i lipidów we krwi u kobiet po porodzie.

Słowa kluczowe

pulsacyjne pole elektromagnetyczne, prąd interferencyjny, grubość tłuszczu brzusznego, kobiety po porodzie, obwód talii

Introduction

Heart disease, diabetes, and metabolic syndrome have all been related to central obesity which causes abnormalities in blood lipid profile, in particular, triglycerides (TG), as well as, reduced high density lipoprotein (HDL) [1]. Obesity affects a large proportion of Egyptians, with 70% of the adult population being obese [2], and a prevalence rate of 48.8% in hypertensive women [3, 4]. A rapid and accurate abdominal visceral fat estimation can be achieved by using waist circumference (WC) and abdomen subcutaneous fat thickness [5].

WC is the most important predictor of cardiac or metabolic risk than body mass index (BMI). In both sexes, WC between the 12th rib and the iliac crest was the most precise indicator of body fat percentage, and visceral fat [6]. The abdominal obesity diagnosis will be established if the WC rises above a certain threshold [7]. The cutoffs for Egyptian men and women are 100.5 cm and 96.25 cm, respectively [8, 9]. WC is a reliable tool to evaluate total abdominal fat. Higher triglyceride levels were linked to higher (intraperitoneal fat/abdominal subcutaneous fat) ratios across all ethnic groups [10].

Abdominal subcutaneous fat thickness can be measured using a non-invasive caliper which exerts a standard pressure at abdominal site [11, 12].

Pregnancy increases waist girth between two to three centimeters every birth postpartum compared to nulliparous women [13].

Interferential current therapy (IFC) is a type of electric stimulation therapy, that manages obesity when applied to the abdomen reducing the WC and the length of visceral fat by minimizing skin resistance and stimulating deep tissues [14, 15].

Furthermore, magnetic fields reduced BMI, and WC, when applied to the abdomen by stimulating calcium channels, causing non-obvious muscle contraction, resulting in increasing lipase output and intramuscular triglyceride hydrolysis [16].

As a result, this study was carried out in order to compare pulsed magnetic field and interference current effects on shedding of abdominal fat in obese postnatal women.

Subjects and methods

Design

This was a randomized clinical trial performed in the outpatient Kasr El Ainy University Hospital in Cairo, from August 2019 to September 2020. The approved ethical committee for this study, P.T. REC/012/002408, at Cairo University's Faculty of Physical Therapy.

Sample size

Based on a previous study by Mahmoud et al [17], The sample size was calculated according to the difference in the mean value of cholesterol between PEMF group and exercise group measured after treatment with α = 0.05, power of 80%, and an effect size of 0.8. So the sample size of 26 patients per group (total = 52) was required (G*Power version 3.1.9.2; Franz Faul, Kiel University, Germany). 30 subjects per group were included in this study to compensate for possible withdrawals.

Subjects

This study enlisted the participation of sixty obese, multipara, and postnatal women. Their ages ranged between 30 and 40 years. The BMI of the participants ranged between 30 to 39.9 kg/m^2. Their births were vaginal deliveries and caesarian sections. They were chosen at least two years after the previous delivery. During the study, they did not use any fat-burning drugs. Women with active kidney or hepatic disease, heart disease, diabetes mellitus, hypertension, pregnancy, pacemaker, psychosis, thyroid disease, central nervous system dysfunction, mental retardation, and metastases are excluded from the study.

Randomization

Before conducting the study, all women in both groups (A&B) signed the approved faculty of physical therapy informed consent form after receiving clarification of the procedures then they equally divided at random using sealed envelopes into two groups (A&B), Group A (n = 30) was treated with pulsed elecromagnetic field on the abdomen. Each session lasted about 20 minutes and was held three days per week for four weeks. Group B (n = 30) was treated with interferential current on the abdomen, Each session lasted about 20 minutes and was held three days per week for four weeks, (Figure 1).

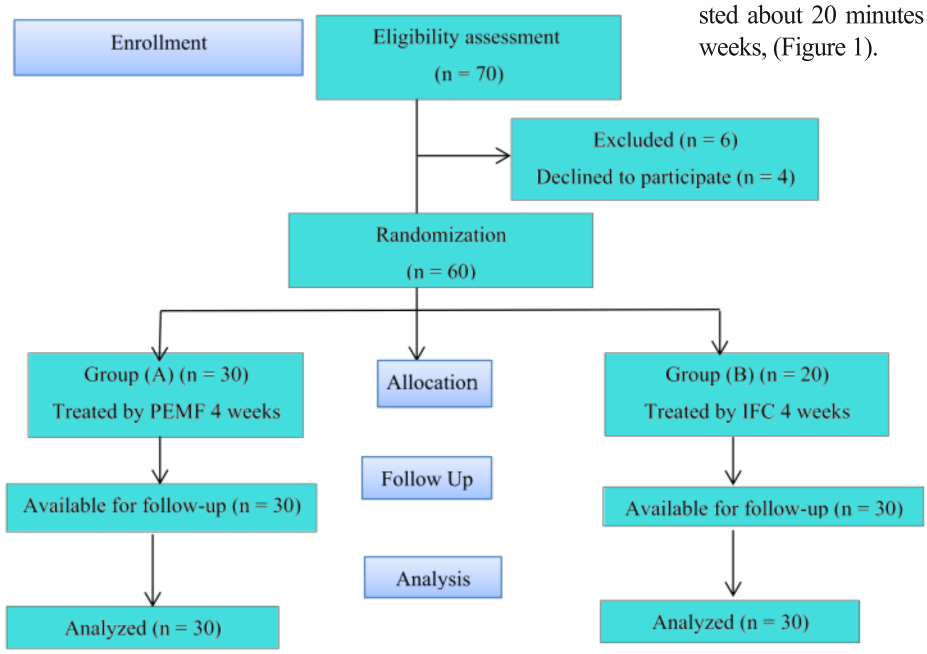

Figure 1. Flow chart of the study

Outcome Measures

All outcome measurements in this study evaluated preceding and following the study.

BMI of all women in both groups (A & B) was measured while the woman wears light clothes and bare feet by the weighting and height scale. The BMI formula is Weight (kg) / Height (m^2). BMI categorize into six-category variable: BMI ranged between 18.5 and 24.9 is normal weight, BMI ranged between 25.0 and 29.9 is overweight, BMI ranged between 30.0 and 34.9 is class I obesity, BMI ranged between 35.0 and 39.9 is class II obesity, and BMI ≥ 40.0 is indicated class III obesity [18].

Waist circumference (midline between the 12^{th} rib and iliac crest) was measured by a standard non stretching tape measurement while the woman in a standing position and at the end of gentle expiration [6], Figure 2.

The abdominal subcutaneous fat was measured while the woman in standing position, by pinching a vertical fold of abdominal skin with the help of skin fold caliper at about 1 inch to the right of the umbilicus [19], Figure 3.

In addition, after a 12-hour nighttime fast, a sterile syringe was used to take 3 ml of blood from the antecubital vein in the morning while the participant's back and arms were supported in half laying, and the blood was transported to a laboratory for serum lipid profile analysis [total cholesterol (TC), TG, LDL, very low denisty lipoprotein (VLDL), and HDL]. The collected blood samples were transferred to a test tube and centrifuged at 2500 rpm/10 minutes. Plasma was drawn using a micropipette and saved at -80°C before analysis.

Figure 2. Waist circumference measuremrnt

Figure 3. Skin fold caliper at abdominal site

Interventions

Before starting each treatment session, each woman in both groups (A&B) was instructed to evacuate her bladder to make sure that she was comfortable and relax throughout the treatment session.

ASA Magnetictherapy

It is a practical device, easy to use, and suitable for targeted treatment. It was used for treatment of all women in group (A) while lying in supine position.

The PEMF applied with one flexa above and one flexa below the abdominal area supported by long strap (Figure 4), the apparatus was turned on and set to output 15 Hz frequency, 100 percent gauss strength, 20 minutes, three days per week for 4 weeks [19].

Interferential current

Interferential current using the Gymna Duo 200 contains different types of current. It was used for treatment of all women in group B.

An interfering current therapy device (The Gymna Duo 200) was used as follow: IF electrodes were applied across the abdominal area supported by long strap (Figure 3), the apparatus was turned on and set to output a 100 Hz beat frequency, 8-second duration of swing, 4 pole vector techniques, 20 minutes, three days per week for 4 weeks [20], Figure 5.

Figure 4. Application of pulsed electromagnetic field

Figure 5. Application of interferential current

Statistics
For data analysis, SPSS for windows version 23 (SPSS, Inc., Chicago, IL) has been used. In this analysis, there are two independent variables: The tested group (group A receiving pulsed magnetic and group B receiving IFC) and measuring periods (a two-level within-subject dimension, pre, and post). In addition, eight dependent variables were evaluated in this analysis (BMI, WC, Abdominal subcutaneous fat thickness, TC, TG, LDL, VLDL and HDL). The Shapiro-Wilk test revealed that all dependent variables were normally distributed. T-tests were used to compare between both groups' physical characteristics (weight, age, and height), and multiple pairwise comparison tests (Post hoc tests) were conducted to compare between groups the effect of interventions on all tested dependent variables.
In addition, 2×2 mixed design MANOVA was used for comparing the dependent variables at different tested groups and measurement times, with the level of significance was set at 0.05.

General characteristics of patients
According to the independent t-test, there were no significant differences in both groups' mean age and height, with T and P values of (−0.51, 0.612) and (0.432, 0.667) respectively (Table.1).

Table 1. Physical characteristics in both groups

	Study group Mean ± SD	Mean ± SD Control group	Comparison	
			t-value	P-value
Age [years]	35.36 ± 1.82	35.63 ± 2.2	−0.51	0.612 (NS)
Height [cm]	158.86 ± 7.53	158.06 ± 6.79	0.432	0.667 (NS)

**SD: standard deviation, P: probability, S: significance, NS: non-significant*

2- 2× 2 mixed design MANOVA

Overall effect

2x2 mixed design MANOVA revealed that interventions had significant effects on all tested dependent variables: weight, BMI, WC, Abdominal subcutaneous fat thickness, TC, TG, LDL, VLDL and, HDL (F = 2.023, P = 0.056), and Measuring periods had significant effects on the tested dependent variables (F = 69.559, P = 0.0001*).

Furthermore, there was significant interaction between intervention and time on the tested dependent variables (F = 3.167, P = 0.004*).

Multiple pairwise comparison tests (Post hoc tests)

Within groups

Within groups, multiple pairwise comparison tests (Post hoc tests) showed that post-treatment there was significant decrease in the mean values of BMI, WC, abdominal subcutaneous fat thickness, TC, TG, LDL, VLDL and significant increase in HDL, compared to pre-treatment where the p-value < 0.05 (Table 2).

Between groups

Between groups, Post hoc tests indicated that there were no significant differences in BMI, WC, abdominal subcutaneous fat thickness, and serum lipid profile pre-and post-treatment, where the p-value was > 0.05 (Table 2).

Table 2. Mean, SD, and percentage change values of BMI, WC, Abdominal subcutaneous fat thickness, TC, TG, LDL, VLDL, and HDL in both tested groups

		Pre- treatment Mean ± SD	Post- treatment Mean ± SD	Mean difference	% of change	P-value*
BMI	Group A	35.31 ± 2.87	33.24 ± 2.92	2.07 kg/m²	5.86	0.0001^S
	Group B	34.99 ± 3.32	32.97 ± 3.17	2.02 kg/m²	5.77	0.0001^S
	P-value**	0.69^NS	0.74^NS			
WC	Group A	104.2 ± 12.86	95.16 ± 10.7	9.04 cm	8.67	0.0001^S
	Group B	103.4 ± 9.84	96.46 ± 9.88	6.94 cm	6.71	0.0001^S
	P-value**	0.788^NS	0.627^NS			
Abdominal subcutaneous fat thickness	Group A	36.4 ± 6.72	28.78 ± 4.72	7.62 mm	20.93	0.0001^S
	Group B	37.68 ± 7	30.11 ± 6	7.57 mm	20.09	0.0001^S
	P-value**	0.472^NS	0.343^NS			
`TC	Group A	219.4 ± 39.88	191.8 ± 40.48	27.6 mg/dL	12.57	0.0001^S
	Group B	211.63 ± 42.48	175.73 ± 39.15	35.9 mg/dL	16.96	0.0001^S
	P-value**	0.468^NS	0.124^NS			
TG	Group A	140.2 ± 59.34	117.73 ± 49.54	22.47 mg/dL	16.02	0.041^S
	Group B	143.13 ± 64.03	105.36 ± 26.06	37.77 mg/dL	26.38	0.0001^S
	P-value**	0.855^NS	0.231^NS			
LDL	Group A	145.32 ± 38.03	130 ± 43.31	15.32 mg/dL	10.54	0.011^S
	Group B	140.53 ± 39.39	112.81 ± 34.04	27.72 mg/dL	19.72	0.0001^S
	P-value**	0.634^NS	0.093^NS			
VLDL	Group A	29.2 ± 12.85	22.11 ± 5.28	7.09 mg/dL	24.28	0.001^S
	Group B	29.1 ± 12.98	20.08 ± 5.59	9.02 mg/dL	30.99	0.0001^S
	P-value**	0.976^NS	0.153^NS			
HDL	Group A	46.53 ± 6.07	50.5 ± 4.23	−3.97 mg/dL	8.53	0.007^S
	Group B	44.46 ± 5.74	48.43 ± 4.32	−3.97 mg/dL	8.92	0.007^S
	P-value**	0.181^NS	0.067^NS			

*BMI: Body mass index, WC: Waist Circumference, TC: Total Cholesterol, TG: Triglycerides, LDL: Low Density Lipoprotein, VLDL: Very Low Density Lipoprotein, HDL: High Density Lipoprotein, SD: Standard Deviation, P: Probability, S: Significance for p < 0.05, and NS: non-significant for p > 0.05; *Within groups; **Between groups*

Discussion

Central obesity is categorized as large waist-hip ratio, even in people of average weight, and is linked to a higher risk of death from dyslipidemia, metabolic syndrome, and cardiovascular disease than obesity categorized by BMI [21, 22].

Waist circumference was highly correlated with MRI measured visceral abdominal fat than BMI [23].

In comparison to nulliparous women, parous women have larger WC and lower thigh girth [24], as gains in abdominal fat are linked to pregnancy [25].

Recently, PEMF and IFC have been applied as physiotherapy for obesity management [26, 27].

The focus of this study was to compare the efficacy of magnetic field and interferential current on abdominal fat thickness in postnatal women.

Within groups; there was significant decrease in BMI, WC, abdominal subcutaneous fat thickness, TC, TG, LDL, VLDL and significant increase in HDL post-treatment compared to pre-treatment. However, there were no significant differences in BMI, WC, abdominal subcutaneous fat thickness, and blood lipid profile between the two groups (A & B) preceding and following treatment.

So, it could be concluded that the pulsed electromagnetic field and interferential current have the same effect on abdominal adiposity in postnatal women. Both methods are effective and safe in reducing BMI, WC, abdominal skin fold thickness, and blood lipids.

Low frequency PEMF and high intensity focused PEMF effective in reducing the patients' waist circumference on obese subjects [17, 28] by stimulating noninvasive muscle contraction that triggers abdominal fat burning similar to regular physical activity contraction [16].

Results agreed with Jankowicz-Szymańska and Spodaryk [29] who assessed the effect of magneto-stimulation on the lipid metabolism in laboratory rats. There was a decline in TC, LDL levels, and a rise in the HDL to LDL ratio.

Furthermore, Luo et al [30] & Ozlem and Selcuk [31] found that magnetic field diminished the TC and TG in the rat serum. in addition, Luo et al [30] found rising of HDL in rabbits subjected to PMF of 15 Hz.

Hilal et al. [32] reported that female rabbits exposed to an electromagnetic field at 104 µT had a rise in HDL as well as a drop in TC and LDL.

Results also supported by Hori et al. [33] who suggested that decrease in plasma total cholesterol levels when mice exposed to 50 Hz magnetic field.

In this study, the average reduction in weight, BMI, and WC was 5.25kg, 5.86%, and 9.04 cm respectively after 12 sessions of electromagnetic fields. These results agreed with Beilin et al. [16 &34] who found that the average reduction in weight, BMI, and waistline was 5.45 kg, 6% (> 6 cm) respectively following 12 sessions of PEMF.

Furthermore, Results agreed with Jacob and Paskova [28] who approved that the 30 minutes high Intensity PEMF diminished WC by 3.29 ± 1.9 cm following four sessions, two sessions per week for two weeks.

The current study analyzed by statistical analysis using 2x2 mixed design MANOVA indicated that the measuring periods have an effect on the results of PEMF and that approved by Kinney and Lozanova [35] & Klaus et al. [36] who suggested the average reduction of waist circumference, subcutaneous fat percentage was 3.85 and 19.6% with no change in the subjects' weight after four treatments of PMF on the abdomen. So, short duration of these two studies explains why kinney and klaus results were lower than current results.

Mahmoud's findings [17] corroborate our findings. He discovered that there was 6.67% of body mass index, and 11.64% of triglyceride reduction in subjects who received 15 Hz and 60 gauss PEMF for 20 min for 60 days.

This study's findings contradicted those of Hilal et al. [32], who noticed increase in triglycerol in exposure of female rabbits to electromagnetic field at 104 µT.

Results of this study also disagreed with Mhaibes and Ghadhban [37], who revealed increase in cholesterol and triglyceride when electromagnetic field exposed on female rats.

The findings of this study also contradicted those of Mahmoud [17], who discovered a significant rise in TC, LDL, and drop in HDL in participants receiving 15 Hz, 60 gauss and length of 20 minutes PEMF for 60 days.

The reasons electromagnetic fields causes a change while in other studies cause no changes are the type of MF such as a static or an alternative MF, MF frequency, different intensities, and duration time [38]. The parameters e.g frequency, intensity, and duration are the critical aspect of PEME therapy [39]. Mahmoud [17] & Hilal et al. [32] used PEMF with different intensities. Kinney and Lozanova [35] applied PMF only for four abdominal sessions so the weight did not change significantly. In Mhaibes and Ghadhban [37] study they applied a static magnetic field.

IFC triggers muscle contraction by stimulating motor nerves. A broad variety of frequencies can be used to contract muscles. Obviously, excitation at a low frequency (e.g. 1 Hz) triggers a series of twitches, while excitation at 30-100Hz triggers a tetanic contraction [40]. For deep penetration and stimulation of IFC, use a 4-pole (true IFC) vector [41].

IFC proved to be effective in reduction of abdominal fat by regaining abdominal muscle tone, increasing local blood flow, mobilizing and stimulating large muscle fibers, and breaking the fatty membrane covering the muscles respectively [20].

Results of this study agreed with Doshi and Nagrale [42] that showed that the use of IFCT is effective in reducing the waist circumference level with a mean difference of 5.5. The average reduction in WC after IFC in the current study was 6.94 cm.

The findings of this study corroborated those of Sharma et al. [15] who discovered a diminished in IFC's body fat at abdominal region compared to females who were given aerobic exercise on a treadmill at 50-70 percent of their maximum heart rate.

Results of this study also agreed with Park and Lee [26] who found that there was a decrease in WC (measured by tape) and visceral fat (measured by B-mode ultrasound) in subjects who received IFC three days per week for four weeks than subjects who received TENS.

To our knowledge, the current research is the first one comparing the effect of PMF and IFC on abdominal fat and blood lipid profile. The current study showed that PMF and IFC are

effective in reduction of BMI, WC, abdominal subcutaneous fat thickness, TC, TG, LDL, VLDL, and increasing the HDL, and there were no statistical differences between their outcomes.
MF and IFC trigger stimulation of muscle contraction, MF by stimulating calcium channels which increase lipase, causing intramuscular TG lipolysis [16]. While IFC triggers muscle contraction by stimulating the motor nerves [40], IFC contraction induced lipolysis of intramyocellular triacylglycerol during contractions [43].

Study limitations

There were some limitations to this research. There has been no control group in the sample. The procedure was also just four weeks long, which is a relatively short period of time. Furthermore, there has been no follow-up evaluation.

Conclusion

Pulsed electromagnetic field and interferential current have the same effect on abdominal adiposity in postnatal women. Both methods are effective and safe in reducing BMI, WC, abdominal skin fold thickness, and blood lipids.

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