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The Effects of Combined Noninvasive Radiofrequency and Ultrasound Cavitation on Anthropometric Indices: A Four-Group Interventional Study

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Abstract

Background: Subcutaneous fat reduction is performed using different noninvasive body contouring techniques including noninvasive radiofrequency (RF) and ultrasound cavitation (USC).
Objectives: The aim of this study was to evaluate the effects of combined RF-USC on anthropometric indices among obese and overweight people.
Methods: This four-group interventional study was conducted on 149 obese and overweight individuals. Participants were allocated to an abdomen and flank group (n = 82), an abdomen and hip group (n = 34), an abdomen and thigh group (n = 13), and a control group (n = 20). Participants in the three intervention groups received combined RF-USC twice a week for five consecutive weeks and followed a low-calorie diet.
Results: Except for hip circumference, other anthropometric indices (including abdomen, waist, and thigh circumferences) significantly decreased after ten-session combined RF-USC. However, no statistically significant differences were detected among the groups concerning pretest and posttest mean values of body fat mass and body weight.
Conclusions: Ten-session combined RF-USC is effective in significantly reducing abdomen, waist, and thigh circumferences among obese and overweight individuals.

Keywords: Radiofrequency, Ultrasound Cavitation, Obesity, Overweight, Anthropometry

1. Background

Overweight and obesity are growing problems and it seems to be increasing in most parts of the world. Overweight and obese subjects will increase to 2.16 and 1.12 billion individuals, respectively by 2030. As a general rule, obesity occurs due to an imbalance between food intake and energy consumption, which considerably influences an individual's health and appearance. Despite health impacts, obese individuals are concerned about social interaction, employment, and their body image. To shift the burden, people have moved toward effective procedures for weight loss, body contouring, and beauty improvement.

Several invasive and non-invasive body contouring methods for reduction of subcutaneous fat have been developed in the last decade. Non-invasive body contouring technics are reasonable and are non-surgical treatments with no need of hospitalization. However, there is limited data and publications regarding the clinical safety of these aesthetic techniques. The form of the percutaneous adipose tissue in different parts of the body such as the abdomen, flanks, thigh, and etc. will be improved through such methods while there are almost no pain and no post-treatment complications (1, 2). Non-invasive body contouring methods are based on various power sources such as vacuum and massage, radio frequency (RF) waves, ultrasound waves, cryogenics, and laser (2). RF waves locally increase the circulation in skin layers by extra dermal warming, which makes the collagen fibrils denature and remodel. These changes finally result in skin tightening and cellulite improvement. RF heat also influences the metabolism of adipocytes and facilitates lipid extraction (3) through apoptosis (4) to reduce the cell size (3). Ultrasound waves in ultrasonic cavitation (USC) technology enforce some vibrations to the extracellular space or water and produce empty bubbles, which grow and finally erupt; this makes some cavities in the adipocyte membrane and permanently destroys the cells with no effect on other parts of the tissue. Finally, lipid content of the cell flows out (5). In other studies the impact of combined RF and USC methods on measures of obesity was not reported, therefore, in our previous study we reported an association between low levels of leptin with the combination of radiofrequency/ultrasound cavitation that led to increased body-fat-mass (6).

2. Objectives

We aimed to compare the combination use of RF and USC methods impact on anthropometric measurements for different parts of the body in overweight and obese patients.

3. Methods

This is an interventional study on overweight and obese patients who were referred to a private nutrition clinic in Iran-Mashhad and were willing to use noninvasive body contouring methods on different areas based on their interest. Informed written consent was obtained from all participants according to the protocols of the Research Ethics Committee of Mashhad University of Medical Sciences.

3.1. Population

The cases in this study were 18 to 65 years, with a BMI of more than or equal to 25 kg/m^2, and with no background of diabetes, cardiovascular diseases, and skin sensitivity to light or heat. Excluding criteria included pregnancy, using a cardiac pacemaker, and unwillingness to continue the project. After assessments, 129 eligible cases, including 8 men and 121 women were asked to join this study. All patients were assigned to three groups based on the zone, which the patient selected to be treated (abdomen and flanks (group 1), abdomen and hips (group 2), abdomen and thighs (group 3), and control (group 4)) had only a diet (500 kcal energy deficit per day). Medical history of the subjects was collected using a questionnaire.

3.2. Measurements

At first, waist, abdomen circumferences, and height were measured by wall-mounted stadiometer (the subjects wore a light dress without shoes) (7). Weight (kg), BMI, and percent of body fat were measured with a bioelectrical impedance analysis device (Tanita BC-418, TanitaCorp., Tokyo, Japan). Measurements of weight and height were achieved while individuals were wearing light dress and no shoes. Having completed all primary measurements, all subjects (case group and control group) were prescribed a similar diet (500 kcal energy deficit per day) for five weeks. For compliance with the research protocol a research technician contacted the subjects every week.

3.3. Treating Utilities

In this study, two non-invasive body contouring machines; Magic pot and Megason were used. Magic pot is the radiofrequency (RF) device (EunSung Global Co. Ltd., Seoul, Korea) used on the treating mode of 0.8 MHz penetrating to tick layers of 2 - 4 mm.

The brand name of the ultrasound cavitation (USC) machine used in this study was Megason (EunSung Global Co. Ltd., Seoul, Korea). The frequency of vibration was 32 - 36 kHz with penetration of about six to eight cm.

3.4. Intervention

Assessing different literatures (8-11), a five-week intervention (12), according to the Mohammadzadeh et al., study was chosen for the current trial. In this study both RF (Magic pot) and USC (Megason), two times per week, were conducted in two sessions with about three day intervals. The same trained practitioner did the treatment for each individual.

Each of the devices were used while subjects laid on the bed and were in a relax status. A trained practitioner used special gel (Megason) or oil (Magic pot) on the marked zones while working with each of the devices. These materials are used to facilitate coupling of the applicator with skin. Then, during the treatment, the practitioner rubs the applicator on the targeted zones repeatedly.

According to the group, each patient was treated on different sites, including abdomen and flanks (group 1), abdomen and hips (group 2), and abdomen and thighs (group 3). Patients were treated with either of the two technics for 20 minutes every session. Anthropometric parameters also were measured at baseline and after the 10th session of intervention.

3.5. Statistical Analysis

The data analysis in this study was completed with the SPSS V. 20 software (SPSS Inc., IL, USA). The Kolmogorov-Smirnov test was used to check the distribution. The normal distributed data was assessed through Paired-sample *t*-test and an Independent-sample *t*-test. The one-way ANOVA test was recruited for analyzing the difference between the four therapeutic groups. Statistically significant P value in this study was ≤ 0.05.

4. Results

4.1. Baseline Characteristics

A total number of 134 participants, including 9 men and 125 women were studied in the case group and 20 participants were studied in the control group. The average age of all patients was 34.98 $\pm$ 10.25 years and the mean height was 160.5 $\pm$ 6.91 cm. Before treatment the weight range was 70.77 - 81.52 kg and the mean value of BMI was 29.37 $\pm$ 3.06 kg/m^2 (Table 1).

All participants were assigned to four groups, based on the treating site. Subjects in different groups were treated on abdomen (group 1), abdomen and hip (group 2), and abdomen and thighs (group 3) (Table 2). At first, there were no differences between weight and fat mass among three therapeutic groups (P = 0.116, and P = 0.16, respectively). After the 10th session the reduction of weight and fat mass were not statistically significant across three groups (P > 0.05), however, data revealed the weight decreased significantly in each group pre-and post-treatment (P < 0.001 for all groups). Similar results were obtained for fat mass in group 1 (P < 0.001).

After a five week intervention, the results showed that in group 1 the reduction in both waist and abdomen circumferences were significant (< 0.001) (Table 3). Similarly, in group 2 waist and abdomen circumferences were significantly reduced (< 0.001), however, hip circumferences showed no significant change (P = 0.884). Waist (P = 0.017), abdomen (P = 0.015), and thigh (P = 0.023) circumferences had a significant reduction after treatment in group 3. After treatment, there were 4.5%, 8.93%, and 6.59% reduction in the abdomen circumference in group 1, 2, and 3, respectively.

Additionally, we showed that waist, abdomen, and thighs, before and after treatment, had a significant different between the study groups (P < 0.001) (Table 4).

5. Discussion

The main achievement of this study was that combined RF-USC treatment in different areas including: abdomen, buttocks, and thighs after a five-week intervention improved body contouring. Sheck et al., showed that three sessions of treatment using focused ultrasound with one-month interval made no significant change in circumferences (11). Toward this, several studies demonstrated that non-invasive body contouring methods effectively improve body contour. In this regard, 27 women with a BMI < 29 had a reduction of the circumference average of buttocks, thighs, and abdomen reported as 3.31, 2.94, and 2.14 cm, respectively, after that, they received eight sessions of RF treatment (8). Moradi and Palm evaluated the effect of RF energy alone on contouring of the abdomen and love handles, which RF treatment in four sessions led to significant reduction in waist circumference (13). Moraga designed a treating method using focused ultrasound in three sessions. The treated areas were abdomen, inner and outer thighs, flanks, and breasts. They demonstrated that the fat thickness of these areas significantly reduced after treatment (14). Similar to our study Leal in 2010 showed that one session of combined RF and focused ultrasound treatment on the abdomen can decrease circumference in 24 obese (9). Evidently, this research concurred with most of the previous studies and significant changes in circumferences with RF-USC treating on abdomen, waist, thighs, and arms were observed. We found no study comparing the influence of RF-USC tools on different treated zones. This method is effective on waist circumference, abdomen, and arms. The hips area was treated only for patients in group 2 (areas of abdomen and hip were treated) and revealed no considerable changes in size after ten sessions. On the basis of these results, it seems that RF-USC was not effective on reduction of the hip circumference. A main power of this study is that it was performed in a large sample size in case and control groups, while the main limitation is a small number of patients entirely in a group where hips were treated on (group 2). Therefore, we need longitudinal investigations with more sessions to clarify the impact of RF-USC therapy.

In this study, the net impact of RF-USC therapy on each zone might be declared if there were two more groups of patients, undergoing treatment only on thighs and only on hips, in addition to the current groups. The abdomen zone was treated for patients in groups of 1, 2, and 3. This method had an effect on the abdomen and waist circumferences in each of the 3 groups while, waist circumference in group 1 decreased more than the other groups (2 and 3) (5.22%).

The most potential abdomen circumference reduction (8.93%) was proven when both abdomen and hips underwent treatment together in group 2. The impact of RF-USC, on abdomen and hips bilaterally decreased the abdomen

Table 1. Baseline Characteristics of the Population[a]

Variables	Group 1	Group 2	Group 3	Group 4	Group 5	P Value
Age	35.76 ± 10.97	35.35 ± 9.39	33.46 ± 9.23	28.00 ± 7.00	36.10 ± 9.18	0.69
Height	160.88 ± 7.38	159.39 ± 4.91	159.50 ± 7.79	169.67 ± 8.73	160.65 ± 4.38	0.13
BMI	29.36 ± 3.45	27.98 ± 2.56	29.56 ± 2.95	29.12 ± 5.04	27.40 ± 1.54	0.048
Waist circumference	86.96 ± 9.30	82.00 ± 4.52	93.16 ± 18.58	-	80.80 ± 5.54	0.001

[a] One-way ANOVA was used on five groups based on the zone, which the patient selected to be treated; abdomen and flanks (group 1), abdomen and hips (group 2), abdomen and thighs (group 3), and control (group 4).

Table 2. Weight and Fat Mass Changes Pre- and Post-Treatment[a]

Obesity Indices, Week	Groups				P Value	P Value for Changes
	1	2	3	4		
Weight, kg						0.434
0	76.64 ± 12.16	70.77 ± 7.67	73.76 ± 9.16	81.52 ± 19.63	0.116	
5	72.99 ± 11.88	67.97 ± 7.91	71.00 ± 9.97	77.35 ± 19.25	0.206	
Difference	3.64 ± 2.76	2.80 ± 2.28	2.76 ± 3.68	4.17 ± 1.58		
P Value	< 0.001	< 0.001	0.055	0.013		
Fat, %						0.161
0	36.18 ± 5.05	35.64 ± 3.91	36.25 ± 4.20	30.77 ± 5.47	0.159	
5	34.21 ± 4.92	35.40 ± 3.99	35.17 ± 4.59	30.57 ± 4.83	0.375	
Difference	1.96 ± 2.57	0.24 ± 1.33	1.08 ± 2.26	0.20 ± 1.38		
P Value	< 0.001	0.646	0.148	0.791		

[a] One-way ANOVA was used; abdomen and flanks (group 1), abdomen and hips (group 2), abdomen and thighs (group 3).

Table 3. Anthropometric Measurements Categorized Based on Treatment Site[a]

Group - Treatment Site (No.), Measurements	Before Treatment	After Treatment	P Value	Circumference Reduction, %
Group 1 - abdomen (n = 82)				
Waist	87.6 ± 9.07	83.02 ± 7.97	< 0.001	5.22
Abdomen	96.86 ± 8.07	92.49 ± 7.02	< 0.001	4.5
Group 2 - abdomen and hips (n = 34)				
Waist	82.03 ± 4.59	78.73 ± 4.84	< 0.001	4.02
Abdomen	93.89 ± 5.84	85.50 ± 6.28	< 0.001	8.93
Hips	101.01 ± 17.70	100.60 ± 5.78	0.884	0.40
Group 3 - abdomen and thighs (n = 13)				
Waist	93.17 ± 18.58	90.08 ± 18.85	0.017	3.31
Abdomen	94.75 ± 3.40	88.50 ± 2.38	0.015	6.59
Thighs	62.90 ± 5.43	60.75 ± 4.31	0.023	3.89
Group 4 - control (n = 20)				
Waist	80.80 ± 5.54	77.25 ± 5.01	< 0.001	
Abdomen	89.50 ± 7.21	85.40 ± 5.28	< 0.001	
Hip	106.30 ± 3.35	102.90 ± 3.30	< 0.001	
Thighs	73.95 ± 7.97	68.30 ± 8.69	< 0.001	

[a] Paired-sample *t*-test and an independent-sample *t*-test were used.

size. However, performing this combined method on abdomen solely leads to significant circumference reduction. Applying a combined method of RF-USC and diet on abdomen and hips were considered as a good treating design for abdomen contouring. Maybe RF-USC treatment, on other mixture of zones, also shows appreciable results, which should be investigated more.

In group 1 the body fat percent decreased significantly on subjects who were treated only on the abdomen. Considering that all individuals were prescribed a uniform

Table 4. Difference of Waist, Abdomen, Thighs and Hips Circumference in Different Groups[a]

Measurements, Group - Treatment Site (No.)	Before Treatment	After Treatment	P Value
Waist			
Group 1 - abdomen (n = 82)	87.6 ± 9.07	83.02 ± 7.97	< 0.001
Group 2 - abdomen and hips (n = 34)	82.03 ± 4.59	78.73 ± 4.84	< 0.001
Group 3 - abdomen and thighs (n = 13)	93.17 ± 18.58	90.08 ± 18.85	0.017
Group 4 - control (n = 20)	80.80 ± 5.54	77.25 ± 5.01	< 0.001
P value	< 0.001	< 0.001	
Abdomen			
Group 1 - abdomen (n = 82)	96.86 ± 8.07	92.49 ± 7.02	< 0.001
Group 2 - abdomen and hips (n = 34)	93.89 ± 5.84	85.50 ± 6.28	< 0.001
Group 3 - abdomen and thighs (n = 13)	94.75 ± 3.40	88.50 ± 2.38	0.015
Group 4 - control (n = 20)	89.50 ± 7.21	85.40 ± 5.28	< 0.001
P value	< 0.001	< 0.001	
Hips			
Group 2 - abdomen and hips (n = 34)	101.01 ± 17.70	100.60 ± 5.78	0.884
Group 4 - control (n = 20)	106.30 ± 3.35	102.90 ± 3.30	< 0.001
P value	0.37	0.26	
Thighs			
Group 3 - abdomen and thighs (n = 13)	62.90 ± 5.43	60.75 ± 4.31	0.023
Group 4 - control (n = 20)	73.95 ± 7.97	68.30 ± 8.69	< 0.001
P value	< 0.001	< 0.001	

[a] One-way ANOVA test were used.

low-calorie diet, we conclude the centered appliance of RF-USC on the abdomen, which contains a large amount of fat, for a continual of five weeks, which caused more fat contents to get out of the body. The probable mechanism in this work consists of ultrasound cavitation facilitates lipolysis while the vibrations around adipocytes induce cavities in the membrane, which fat deposits were drained from cells. Then RF immediately propels intercellular fat content to lymphatic circulation by heating and improving circulation. On the other hand, a low-calorie diet prevents the body from receiving more fat. Accordingly, by means of this process, the weight will be reduced and body shape will be improved subsequently. Lack of enough patients who volunteered for the treatment only in thighs or hips was a limitation in this study. The investigation of other combined treatments with these methods is necessary. Lack of a period of follow up is another limitation in this study.

5.1. Conclusions

Our findings demonstrated applying combined RF-USC treatments with diet intervention may be suggested for improving body contouring.

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Footnotes

Conflict of Interests: The authors have no conflict of interest to disclose.

Ethical Considerations: This study was presented at the Ethics Committee of the Mashhad University of Medical Sciences, Mashhad, Iran, and was approved with ID: IR.NIMAD.REC.1397.224.

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Patient Consent: Written informed consent was obtained from all subjects.

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