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Cavitation and radiofrequency versus cryolipolysis on leptin regulation in central obese subjects: A randomized controlled study

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Abstract

Background and Objective: To investigate the efficacy of adding ultrasound cavitation and radiofrequency versus cryolipolysis to weight reduction program on leptin, insulin, waist circumference, skinfold, body weight in central obese subjects.

Material and Methods: Sixty centrally obese participants were randomly allocated into three equal groups. Subjects in the study group (I) received cavitation and radiofrequency plus dietary regimen, subjects in the second study group (II) received cryolipolysis in conjunction with the same diet program, and subjects in the control group (III) received the same dietary regimen only. Leptin, insulin level, waist circumference, skinfold, body weight, and body mass index were measured shortly before intervention techniques and 3 months afterward.

Results: There were no statistically significant differences between cavitation plus radiofrequency and cryolipolysis on leptin and insulin levels after 3 months of intervention. However, statistically significant differences were found in waist circumference, skinfold, weight reduction, and body mass index in favor of the cavitation group ($p < 0.05$). In addition, both cavitation-radiofrequency and cryolipolysis were statistically significantly different than the diet alone in favor of the study groups ($p < 0.05$) in all the outcome measures. Furthermore, there were statistically significant differences in all outcome measures ($p < 0.05$) when comparing the baseline and postintervention results in each group except for leptin level in the diet group ($p = 0.14$).

Conclusion: Subjects who underwent cavitation plus radiofrequency had better improvement on waist circumference, skinfold, and body mass index than subjects who received cryolipolysis. However, no differences were found between cavitation plus radiofrequency and cryolipolysis on leptin and insulin levels.

KEYWORDS

cavitation, central obesity, cryolipolysis, leptin, radiofrequency

INTRODUCTION

Obesity is a serious and stubborn condition that leads to fatal consequences worldwide and a deterioration in the quality of life. Central obesity has been associated with serious health issues such as hyperglycemia, hypercholesterolemia, hypertension, and type 2 diabetes.[1–5]

Obese patients are managed using various treatments, including nutritional therapy, exercise, medications, and surgery.[6,7] Over the years, a variety of drugs have been utilized to treat obesity. However, most antiobesity medications that were licensed and sold have now been discontinued due to substantial adverse effects.[8] Restrictive operations have a lower mortality risk than malabsorptive operations; however, both interventions have many serious complications.[9] As a result, there is a pressing demand for noninvasive body contouring procedures that are safer, have a shorter recovery period, and have less adverse effects.[10]

Several studies demonstrated the scientific systemic effect of many noninvasive lipolysis techniques, such as ultrasound cavitation, radiofrequency, and cryolipolysis, without side effects or hazards.[11–19] Cryolipolysis is a technique for selectively destroying adipose cells by lowering the temperature of subcutaneous adipose tissue through regulated cooling without harming the skin.[15–19] Ultrasonic cavitation has two effects on fat cells: thermogenesis, which occurs because of cell absorption, and mechanical compression results in cavitation, which destroys fat tissues.[20–23] Radiofrequency heat affects adipocyte metabolism, fat cell death, and adipose tissue volume reduction.[24,25]

Insulin and leptin are two important hormones involved in appetite regulation.[26] Both leptin and insulin regulate body weight and tonic circulating hormones, and their levels decrease after fat reduction.[26,27] Leptin level decreases after reduction of fat mass by combining radiofrequency with ultrasound cavitation.[14] Cryolipolysis affects fat reduction and body contouring,[15–19] but its effect on leptin has not been investigated. However, some studies suggested a direct relation of leptin to fat cell size and number.[28,29]

Few researchers have compared the effects of ultrasonic cavitation and cryolipolysis in subjects with central obesity. However, there were many conflicts and no clear evidence in the literature concerning the superiority of cavitation or cryolipolysis on body contour adjustment.[30–32] In addition, their effects on leptin and insulin levels have not been studied. Consequently, this study aimed to investigate the effects of adding ultrasound cavitation plus radiofrequency versus cryolipolysis to a low-calorie dietary program on total plasma leptin, insulin, and body contouring in subjects with abdominal obesity.

MATERIAL AND METHODS

Design and setting

This study was conducted as a randomized controlled clinical trial. Patients were recruited from the faculty of physical therapy outpatient clinic, Kasr Al-Ainy, and JLU international PT and obesity clinic, Cairo, Egypt. The clinical application of cryolipolysis, cavitation, radiofrequency, and the physical evaluations of the subjects occurred at JLU international obesity management and physical therapy center, El haram, Cairo, Egypt, between May 2020 and March 2021. The research was accepted by the Ethical Committee board at the faculty of physical therapy, Cairo University, Egypt (P.T.REC/012/002379). The study was registered at PACTR Registry (PACTR202004762165785). Before participating in the research, subjects were asked to enroll and signed a written consent form.

Participants

The study included all individuals with abdominal obesity referred for physical therapy by their internal medicine physician and matched the inclusion criteria of being between 30 and 40 years and BMI of 30–35 kg/m^2. Participants were ruled out if they have a history of chronic disease (e.g., hypertension or diabetes), smokers, pregnant women, cardiovascular disease, skin diseases, hernia, renal disease, and receiving weight control drugs.

Sample size and randomization

G*power (version 3.1.9.2; Germany) was used to compute a priori sample size (*F* tests—multivariate analysis of variance [MANOVA]: repeated measures, within-between interaction), with an effect size of 0.49,[14] 80% power, and a two-sided 5% significance level. As a result, the overall sample size was 44 patients. This number was increased by 30% to be 60 patients to account for the dropout. Subjects were randomly assigned equally to study group (I) received cavitation and radiofrequency plus dietary regimen, study group (II) received cryolipolysis plus the same dietary regimen, and control group (III) received the same dietary regimen only via computer-generated block randomization. The block size was set at 6 to avoid selection bias and limit variability among the groups. Sealed, sequentially numbered opaque envelopes were used to ensure concealed allocation. The first author, who was not involved in data collection, produced the randomization. When the third author opened the envelope, therapy was started based on group allocation. The second author, blinded to group allocation, collected data at baseline and when the treatment period ended.

Outcome measures

All measurements were assessed at baseline and after 3 months following the first intervention session.

- **Laboratory analysis** was used for serum leptin and insulin levels analysis. Fasting for 8 hours was required for each patient before taking a blood sample at Cairo University Hospital clinical lab. A leptin enzyme-linked immunosorbent assay (ELISA) kit was used to estimate the leptin level, and an insulin ELISA kit was used to assess the insulin level.
- **Body mass index (BMI):** The Seca 769 digital column scale instrument was utilized to determine body weight (kg), height (cm), and BMI (body weight (kg)/[height (m)]^2). Body weight was measured at the same time, with the same clothes, and before eating in the morning.
- **Waist circumference:** A tape, resistant to stretching, was used to measure the waist circumference at the midpoint in line between the lower border of the last felt rib and the iliac crest's highest point. All patients were standing in a comfortable position, with both feet in close proximity, both arms beside the body. They wore very little clothes. The measurements were obtained at the end of a regular expiration. Each measurement was taken twice, and the average was

obtained if the measures were within a centimeter of each other.[33]

- **Skinfold measurement:** To assess supra-iliac skinfold thickness with a caliper, subcutaneous fat was taken away from the muscle. Men's skinfolds were pulled vertically and taken 2 cm to the side of the umbilicus, whereas women's skinfolds were pulled diagonally and taken above the iliac crest along the anterior axillary line.[34]
- **Food frequency questionnaire (FFQ):** Adherence to the diet program was assessed after the 3 months in each group by the FFQ.[35] It was designed to be brief and concentrate on foods high in a particular nutrient or a specific group of foods, such as vegetables, fruit, milk, fat, starch, and meat.[36]

Intervention

All subjects received a balanced low-calorie dietary program (1500 kcal per day) designed by the nutritionist. It was subdivided into three calculated meals and was changed every week for 12 weeks. According to the recommended dietary intake (RDI), a low-calorie diet program included a balanced macronutrient quantity of carbohydrate and protein, with reduced fat and high vegetables, fruits, and dietary fibers.[37,38] Subjects in the study group (I) received cavitation and radiofrequency sessions plus a low-calorie dietary program; subjects in the study group (II) received Cryolipolysis sessions plus the same dietary program; subjects in the control group (III) received the same dietary regimen only.

Radiofrequency (EunSung Global Co Ltd., Seoul, Korea): Magic pot tripolar Radiofrequency (RF) device was used (Frequency: 0.8 MHz, Power:150 w, Vacuum: maximum 250 mmHg). The multipolar radiofrequency head diameter was 8 cm. The depth of penetration of the frequency used was expected to be 2–4 mm. The participant was treated in a relaxed supine lying position. The skin of the abdominal area in hypogastrium, 5 cm below the umbilicus, was cleaned, and glycerol oil was applied. The radiofrequency tripolar head was then applied to the treated area using gentle pressure in a continuous circular motion over the skin. The application of radiofrequency was one 40-minute session every 2 weeks (six sessions per 3 months).[14,25]

Ultrasound cavitation (EunSung Global Co Ltd., Seoul, Korea)**:** The ultrasound cavitation with a frequency of 32–36 KHz was used in this study. The transducer head diameter is 7.5 cm with a power of 3 watts/cm^2. The depth of penetration of the frequency used was expected to be 6–8 cm. The participants were placed in a relaxed supine position, their skin was cleaned with alcohol, and conducting gel was applied to the region to be treated. The abdominal area, 5 cm below the umbilicus, was treated with continuous circular motion for one 50-minutes session on each side of the abdomen every 2 weeks (six sessions per 3 months).[39]

The ultrasonic cavitation and radiofrequency were applied alternatively every week. The patient received ultrasonic cavitation first, then the radiofrequency was applied the week after, and this sequence of application was kept until the end of the study.

Cryolipolysis

Cryolipolysis were delivered through a 3 Max cool shaping cryolipolysis machine (ESM-8l00MO, EunSung global) with 21 x 6 x 8 cm cup dimensions. All participants in the cryolipolysis group had three sessions of cryolipolysis, one per month. The cryolipolysis was applied for 60 minutes to both sides of the abdomen, 5 cm below the umbilicus, after cleaning and applying an anti-freezing membrane to the treated area to avoid cold burn. The device has been set to a cold temperature −5°C and cooling intensity factor (CIF) 42, with an average energy extraction rate of 72.9 mW/cm^2. The vacuum level was selected according to each patient tolerance to gently draw a bulge of fat into the applicator cups. After turning on the apparatus, the participants were given safety instructions to pull the key off if any strange sensations were uncomfortable.[40] A stroking massage was performed for 2 minutes at the end of each visit.

Statistical analysis

The measured variables were statistically analyzed and compared using SPSS for windows version 25 (SPSS, Inc.) with alpha level set at 0.05. An intention to treat analysis with multiple imputations method was used to account for the missing data at the 3-month measures. Data were assessed for normality, homogeneity, and presence of outliers. Shapiro–Wilks test showed that the measured variables were normally distributed ($p > 0.5$). Data are expressed as mean and standard deviation except for gender (counts/percentages). The adherence of each group to the diet program was then computed, and χ^2 determined the relationship among the groups and degree of adherence. Two-way mixed design MANOVA was used to compare among the groups on the combined effect of all outcomes. When MANOVA was statistically significant, follow up with univariate analysis of variance (ANOVAs) for every outcome were conducted with Bonferroni correction to avoid type I error.

RESULTS

Figure 1 illustrates the flow chart of the subjects during the trial. There were no negative effects experienced by subjects in the cavitation, cryolipolysis, or diet groups because of its use. Table 1 summarizes the baseline demographic and clinical feature data of all patients in the cavitation, cryolipolysis, and low caloric diet groups.

The difference in the quantity of change in the subjects' scores on the combined outcome measures among the three groups was determined using a mixed design multivariate analysis. The main effects of groups were shown to have statistically significant multivariate effects, Wilk's $\Lambda = 0.4$, $F_{(12,104)} = 5.0$, $p < 0.001$, $\eta^2 = 0.37$, for time, Wilk's $\Lambda = 0.02$, $F_{(6,52)} = 433.1$, $p < 0.001$, $\eta^2 = 0.98$, as well as for the interaction between groups and time, Wilk's $\Lambda = 0.03$, $F_{(12,104)} = 45.56$, $p < 0.001$, $\eta^2 = 0.84$. Follow-up univariate ANOVAs reveal that significant change for Insulin, $F_{(2,57)} = 18.34$, $p < 0.001$, $\eta^2 = 0.39$, for Leptin, $F_{(2,57)} = 19.27$, $p < 0.001$, $\eta^2 = 0.4$, for waist circumference, $F_{(2,57)} = 43.94$, $p < 0.001$, $\eta^2 = 0.61$, for skin fold, $F_{(2,57)} = 38.73$, $p < 0.001$, $\eta^2 = 0.58$, body weight, $F_{(2,57)} = 23.98$, $p < 0.001$, $\eta^2 = 0.46$, and for body mass index, $F_{(2,57)} = 40.36$, $p < 0.001$, $\eta^2 = 0.59$.

There were no statistically significant differences between cavitation and cryolipolysis groups in insulin and leptin level ($p > 0.05$) after 3 months of treatment. However, there were statistically significant differences between cavitation and cryolipolysis groups in weight reduction, body mass index, waist circumference, and skinfold, in favor of the cavitation group ($p < 0.05$). There were also statistically significant differences between cavitation and diet groups in favor of the cavitation group ($p < 0.0001$) for all outcome measures. In addition, there were statistically significant differences between cryolipolysis and diet groups in favor of the cryolipolysis group ($p < 0.05$) for all outcome measures, as in Tables 2 and 3.

Statistically significant differences were found in all measured outcome ($p < 0.05$) when comparing the baseline and postintervention results in each group except for leptin level in the diet group ($p = 0.14$), as in Table 4. The subjects' adherence was 90%, 85%, and 80% in the cavitation, cryolipolysis, and diet groups, respectively. There was no statistically significant relationship between the groups and the adherence to diet, χ^2 (21, $n = 60$) = 0.78, $p = 0.68$.

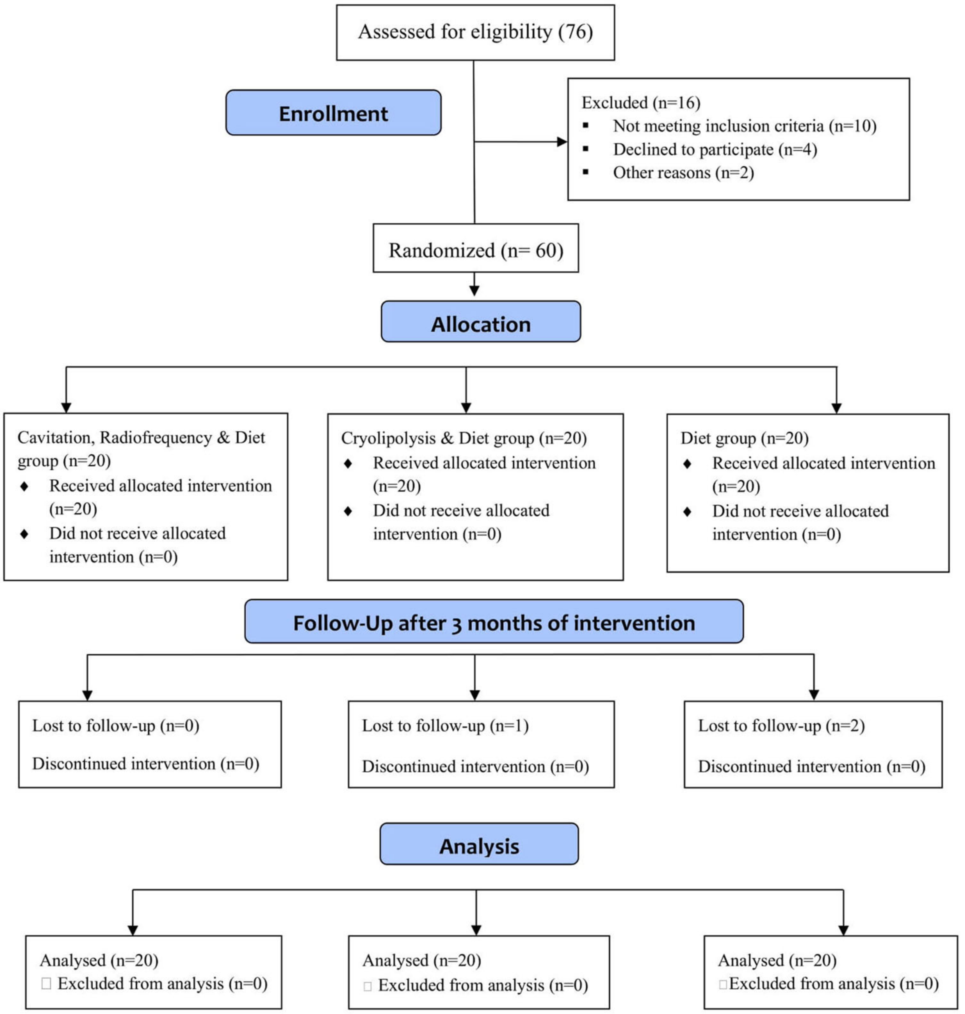

FIGURE 1 Flow diagram showing the progress of subjects at each stage of the clinical trial.

TABLE 1 Baseline demographic and clinical characteristics of subjects ($N = 60$).*

Characteristics	Group I ($n = 20$)	Group II ($n = 20$)	Group III ($n = 20$)
Age (years)	34.4 ± 2.98	34.75 ± 3.16	35.1 ± 2.81
Sex, n (%)			
Males	10 (50%)	12 (60%)	11(55%)
Females	10 (50%)	8 (40%)	9(45%)
Weight (kg)	87.15 ± 5.6	83.6 ± 8.98	88.1 ± 4.36
Height (cm)	164.1 ± 6.92	163.7 ± 5.74	164.9 ± 4.59
BMI (Kg/m^2)	32.36 ± 1.12	31.99 ± 1.06	31.82 ± 0.8
Insulin (mlU/ml)	7.57 ± 1.72	6.65 ± 1.53	7.5 ± 2.18
Leptin (ng/ml)	21.44 ± 7.22	17.17 ± 5.46	17.88 ± 6.3
Waist (cm)	96.35 ± 10.1	95.88 ± 6.98	101.05 ± 2.95
Skin fold (mm)	32.41 ± 3.91	30.49 ± 6.41	33.85 ± 2.13

Abbreviations: BMI, body mass Index; CI, Confidence interval; F, fisher test; p, probability value.
*Data are mean ± SD, $p < 0.05$ indicates statistical significance.

TABLE 2 Clinical characteristics of subjects after 3 months of intervention ($N = 60$).*

Characteristics	Group I (n = 20)	Group II (n = 20)	Group III (n = 20)	F-value	p value
Insulin (mlU/ml)	3.92 ± 0.9	5.06 ± 1.54	7.11 ± 2.31	18.43	<0.0001
Leptin (ng/ml)	8.5 ± 2.74	10.58 ± 3.59	16.66 ± 5.96	19.27	<0.0001
Waist (cm)	70.52 ± 9.46	82.18 ± 9.07	93.93 ± 3.93	43.94	<0.0001
Skin fold (mm)	21.51 ± 3.64	27.46 ± 5.92	33.23 ± 2.22	38.73	<0.0001
Weight (kg)	69.65 ± 5.51	76.6 ± 8.28	83.43 ± 4.45	23.98	<0.0001
BMI (Kg/m^2)	25.88 ± 1.71	28.5 ± 1.79	30.7 ± 1.59	40.36	<0.0001

Abbreviations: BMI, body mass index; F, fisher test; p, probability value.
*Data are mean ± SD, $p < 0.05$ indicates statistical significance.

DISCUSSION

Central obesity has a significant impact on human health and quality of life. Cryolipolysis, cavitation, and radiofrequency are time-saving and do not have the risks of invasive surgery.[41,42] This study results revealed the superiority of cavitation and radiofrequency over cryolipolysis on waist circumference, skinfold, weight reduction, and BMI. However, there were no differences between body contouring modalities on insulin and leptin levels after 3 months of intervention. In the within-group effect, there were significant reductions in insulin and leptin levels, skinfold, body weight, and BMI when comparing the baseline and postintervention results except for leptin level in the diet group.

Leptin is secreted from the adipose tissues, and its plasma levels are positively correlated with body fat percentage and body mass index. Obese individuals are four times higher on leptin levels than nonobese subjects.[43] Leptin has essential roles in glucose and lipid homeostasis,[27,28] and insulin resistance is significantly associated with serum leptin. Therefore, the increase in serum leptin could be an essential predictor of insulin resistance and type 2 diabetes mellitus.[29,44,45] In turn, decreasing the serum leptin level could induce metabolic benefits on insulin sensitivity. Therefore, measures that lower the levels of leptin improve insulin resistance.[26,46]

The results of this study did not support the authors' hypothesis that adding radiofrequency to cavitation was more effective than cryolipolysis on decreasing leptin and insulin levels. Adding cavitation-radiofrequency or cryolipolysis to a low-calorie diet significantly decreased the leptin and insulin levels ($p > 0.05$). No randomized clinical trials compared the efficacy of cavitation, radiofrequency, and cryolipolysis on leptin and insulin levels to the authors' knowledge. However, Arabpour-Dahoue et al. investigated the additive effect of cavitation and radiofrequency to low-calorie diet on leptin only.[14]

Arabpour-Dahoueet al. revealed that adding radiofrequency to cavitation had a substantial beneficial impact on reducing abdomen, waist circumferences, and leptin levels in 50 obese women with 27–45 years old.[14] However, the BMI range was not mentioned in the

TABLE 3 Between groups effects after 3 months of intervention.*

Outcome	Group 1 versus Group 2 MD (95% CI)	*p* value	Group 1 versus Group 3 MD (95% CI)	*p* value	Group 2 versus Group 3 MD (95% CI)	*p* value	Partial Eta Square
Insulin (mlU/ml)	−1.14 (−2.46, 0.18)	0.11	−3.2 (−4.51, −1.88)	<0.0001	−2.06 (−3.37, −0.74)	0.0009	0.39
Leptin (ng/ml)	−2.08 (−5.45, 1.29)	0.4	−8.16 (−11.53, −4.79)	<0.0001	−6.08 (−9.49, −2.71)	0.0001	0.4
Waist (cm)	−11.67 (−17.83, −5.5)	<0.0001	−23.43 (−29.58, −17.25)	<0.0001	−11.75 (−17.91, −5.59)	<0.0001	0.61
Skin fold (mm)	−5.95 (−9.24, −2.67)	0.0001	−11.72 (−15.01, −8.44)	<0.0001	−5.77 (−9.06, −2.49)	0.0002	0.58
Weight (kg)	−6.95 (−11.85, −2.04)	0.003	−13.78 (−18.68, −8.87)	<0.0001	−6.83 (−11.74, −1.92)	0.003	0.46
BMI (Kg/m^2)	−2.62 (−3.95, −1.3)	<0.0001	−4.81 (−6.14, −3.49)	<0.0001	−2.19 (−3.52, −0.87)	0.0004	0.59

Abbreviations: BMI, body mass index; CI, confidence interval; F, fisher test; p, probability value.

*Data are mean ± *SD*, $p < 0.05$ indicates statistical significance.

TABLE 4 Within-group changes at pre, after 3 months of intervention.*

Outcome	Group I (n = 20) Change from baseline to 3 months MD (99% CI)	*p* value	Group II (n = 20) Change from baseline to 3 months MD (99% CI)	*p* value	Group III (n = 20) Change from baseline to 3 months MD (99% CI)	*p* value
Insulin (mlU/ml)	−3.66 (−3.98, −3.33)	<0.0001	−1.59 (−1.92, −1.26)	<0.0001	−0.39 (−0.72, −0.06)	0.02
Leptin (ng/ml)	−12.94 (−14.6, −11.3)	<0.0001	−6.6 (−8.25, −4.94)	<0.0001	−1.23 (−2.88, 0.43)	0.14
Waist (cm)	−25.84(−27.9, −23.7)	<0.0001	−13.7(−15.8, −11.6)	<0.0001	−7.12(−9.21, −5.03)	<0.0001
Skin fold (mm)	−10.9(−11.4, −10.4)	<0.0001	−3.03(−3.56, −2.5)	<0.0001	−0.61(−1.15, −0.1)	0.02
Weight (kg)	−17.5(−18.6, −16.4)	<0.0001	−7.0 (−8.06, −5.94)	<0.0001	−4.65(−5.71, −3.59)	<0.0001
BMI (Kg/m^2)	−6.48(−7.12, −5.83)	<0.0001	−3.49(−4.13, −2.84)	<0.0001	−1.12(−1.77, −0.48)	0.001

Abbreviations: BMI., body mass index; CI, Confidence interval; F, fisher test; p, probability value.

*Data are mean ± *SD*, $p < 0.05$ indicates statistical significance.

characteristics of subjects and was wrongly reported in their results. Unfortunately, the study of Arabpour-Dahoue et al. was not reported according to Consort guidelines of reporting randomized controlled trials as the authors based their conclusions on within-group effects, not on between-groups differences.

This study supported the authors' hypothesis that adding radiofrequency to cavitation was more effective than cryolipolysis on waist circumference, skinfold, weight reduction, and BMI. This study was consistent with other studies regarding the positive effect of cavitation and radiofrequency on body contouring and measures of adiposity.[14,32,45,46]

Naeimi et al.[32] investigated the adding effect of cryolipolysis to radiofrequency and ultrasound cavitation on body weight, BMI, body fat, waist, and abdominal circumference in 44 overweight individuals ($25 \le BMI \le 30$) with 18–60 years old. Cryolipolysis did not add benefits to the combined treatment of radiofrequency and ultrasound cavitation, except for waist circumference for 5 weeks.[32] These results may be attributed to the inflammatory effect and subsequent edema of cryolipolysis. Edema may lead to changes in anthropometric measurements that might take several weeks to resolve.

Mohammadzadeh et al.[45] investigated the combined effect of radiofrequency and ultrasound cavitation on waist circumference, BMI, fat mass, abdominal circumference, and trunk fat in 50 healthy women with 18–64 years old and BMI between 25 and 29.9 kg/m^2. The combination of RF and ultrasound cavitation plus a low-calorie diet significantly decreased the measures of adiposity.[45] However, the results had not been protected against type 1 error, which might affect the internal and external validity of their study.

El Gendy et al.[46] compared the effectiveness of radiofrequency, ultrasound cavitation, and their combination on waist circumference and subcutaneous fat thickness in 30 obese subjects with 25–50 years old and BMI over 30 kg/m^2. The combination of RF and ultrasound cavitation was more effective at reducing waist circumference and fat thickness than RF or cavitation alone.[46] However, the authors investigated a small sample size, and their results had not been protected against type 1 error, which might affect the internal and external validity of their study.

On the contrary, other studies[30,31] contrasted with this study results. ELdesoky et al.[30] investigated the effects of ultrasound cavitation versus cryolipolysis on body weight, BMI, waist circumference, and supra-iliac skin fold in 60 obese subjects with 25–45 years old and

BMI over 30 kg/m^2. It was shown that both techniques produce nearly significantly equal reduction than the diet on waist circumference and skinfolds after 2 months of the intervention.[30] This discrepancy with the current study could be due to the absence of radiofrequency. Abotaleb et al.[31] compared the effect of ultrasound cavitation versus cryolipolysis on BMI, waist circumference, and abdominal fat percentage in 30 central obese subjects with 45–55 years old and their BMI > 25 kg/m^2. There was an improvement in body contouring after applying cavitation and cryolipolysis with no superiority of cavitation over cryolipolysis.[31] This discrepancy with current research could be due to differences in subjects' age, sample sizes, application duration, study duration, and the absence of the radiofrequency.

This study results revealed a superiority of cryolipolysis over diet alone on all outcome measures, which were in line with other studies.[19,30,47] Abdel-aal et al.[19] investigated the additive effect of cryolipolysis to a low-calorie diet on body mass index, lipid profile, waist-to-hip ratio, liver enzymes, and subcutaneous fat tissue thickness. Sixty central obese women participated; their ages ranged from 40 to 50 years, and their BMI ranged from 35 to 40 kg/m^2. The authors demonstrated the effectiveness of cryolipolysis in body reshaping and re-contouring compared with diet.[19] Moreover, adding cryolipolysis to a balanced hypocaloric diet was more effective than diet alone in reducing waist circumference and supra-iliac skinfold, which were in line with this study. However, no differences were found in body weight and BMI, contradicting this study's results.[30] This discrepancy could be due to the difference in study duration.

Serag Eldein et al.[47] investigated the additive effects of cryolipolysis versus laser lipolysis to diet on waist-hip ratio, body weight, skinfolds, BMI, and subcutaneous fats in 45 adolescents with 13–16 years old and BMI less than 30 kg/m^2. Cryolipolysis was more effective than diet alone in decreasing waist-hip ratio, Suprailiac skin folds, and subcutaneous fats but not in body weight or BMI.[47] This discrepancy with this study in weight and BMI may be attributed to the differences in subjects' age, sample sizes, and study duration.

In this study, the low-calorie diet alone decreased waist circumference, skinfold, weight reduction, and BMI, insulin but not leptin level. This nonsignificant change in leptin may be attributed to the fact that subcutaneous fat produces more leptin than visceral fat.[48–51] In addition, the absence of re-contouring modalities such as cavitation, radiofrequency, and cryolipolysis resulted in a relatively small amount of subcutaneous fat loss in the diet group. Reduction of insulin level in diet group may be attributed to enhanced insulin sensitivity by weight loss due to a reduction in plasma fatty acid mobilization and uptake.[52]

Suyardi et al. concluded that a balanced low-caloric program had a substantial impact on decreasing body weight, skinfold thickness, BMI, fat mass, waist to hip ratio, and leptin level.[53] These findings did not support the current study results on the leptin level. This contradiction can be explained by the fact that the Suyardi et al. study included a small sample size ($n = 39$), females only, wide age range (19–55 years), overweight and obese subjects (BMI ≥ 25 kg/m^2), no control group, and for a short duration (14 days).

Röhling et al.[54] investigated the effect of diet on body weight, BMI, waist circumference, fat mass, fasting blood glucose, hemoglobin A1c and fasting insulin in 30 subjects aged ≥18 years and BMI ≥ 25 kg/m^2. There were improvements in body weight, BMI, waist circumference, fat mass after 12 weeks. In addition, there were reductions in fasting blood glucose, hemoglobin A1c, and fasting insulin in within-group effect,[54] which support this study.

Limitations

This study examined a limited sample size; therefore, large sample size is required in future investigations. Also, the intermediate effects of combining cavitation and radiofrequency versus cryolipolysis were measured after 3 months in this study. So, future research is needed to assess their impacts over time with a calorie-restricted diet. Moreover, although skinfold thickness and waist circumference are valid, reliable, and cost-effective measurements of adipose thickness, ultrasound, computerized tomography, and magnetic resonance imaging are objective measurements of adipose thickness and might add a great value in future studies.

Conclusion

Adding radiofrequency to cavitation was better than cryolipolysis in improving body mass index, waist circumference, as well as skinfold thickness. However, there was an equivalent effect of radiofrequency plus cavitation and cryolipolysis on leptin and insulin levels.

AUTHOR CONTRIBUTIONS

We are four authors for this study, and we did all requirements to accomplish this study, there are no other researchers participating in this study.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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