RESEARCH PAPER

Ultrasound Cavitation versus Aerobic Exercise on Blood Glucose Level and Lipid Profile in Women with Central Obesity

Fatma M. Abdeen Sallam[1*], Zahra Mohamed Serry[1], Nashwa S. M. Abdeen[2], Asmaa Mohamed Sharabash[1]

[1] *Physical Therapy for Cardiovascular Respiratory Disorder & Geriatrics Department, Faculty of Physical Therapy, Cairo University, Cairo, Egypt*

[2] *Clinical Pathology Department, Faculty of Medicine, Tanta University, Tanta, Egypt*

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ABSTRACT

Background: Overweight and obesity are the consequence of the interaction between an individual's genetic predisposition and environmental factors. The objective of this investigation was to determine the aerobic exercise and ultrasound (US) cavitation effect on the lipid profile and blood glucose levels of women with central obesity. **Methods:** This case-control study included 90 female cases with central obesity suffering from elevated lipid profile, and blood glucose level. (Cholesterol level > 200 mg/dl, HBA1C from 5.8 to 6.5 %). All cases were divided randomly into 3 equal groups: Group (1) received a low caloric diet program, group (2) followed a program of moderate intensity aerobic exercise and low caloric diet and group (3) followed a program of US cavitation sessions and low-calorie diet. **Results:** The studied groups exhibited a significant difference in Hemoglobin A1C (HbA1c) levels before and after treatment (P<0.001, <0.001). Group (3) and group (2) exhibited significantly higher HbA1c pre-treatment levels than group (1) (P<0.001, <0.001), and group (2) exhibited significantly increased HbA1c levels than group (3) (P<0.001). The HbA1c levels of group (3) and group (1) were significantly decreased than those of group (2) following treatment (P =0.023, 0.001). The highest % change in the HbA1c was found in group (3). The total cholesterol was significantly different among the studied groups pre-and post-treatment (P<0.001, <0.001). The total cholesterol post-treatment was significantly decreased in group (3) than group (2) (P<0.001). **Conclusions:** The findings suggested that in conjunction with a reduced caloric diet, aerobic exercise, and US cavitation, the anthropometric and metabolic parameters of women with central obesity were enhanced.

Keywords: Ultrasound Cavitation, Aerobic Exercise, Blood Glucose Level, Lipid Profile, Central Obesity.

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INTRODUCTION

The world's population is expected to experience a 50% increase in overweight and obesity within the next 12 years, as indicated by the 2023 World Obesity Atlas Report. Obesity is anticipated to increase from 30% to over 40% among women in the Middle East by 2035 [1]. The global increase in chronic disease has been significantly influenced by the unintended weight gain that has resulted in obesity and overweight. The interaction between an individual's genetic predisposition and environmental influences is the cause of overweight and obesity. Fat may accumulate globally, regionally and in organs [2].

Central obesity, visceral fat, or abdominal fat are linked to an elevated prevalence of cardiovascular risk factors. In contrast to those without abdominal obesity, those with abdominal obesity were more likely to have metabolic risk factors, including elevated blood pressure, high low-density lipoprotein, high fasting blood glucose, high cholesterol, low high-density lipoprotein, and high triglyceride levels [3]. An abundance of abdominal adipose tissue is highly correlated with metabolic risk factors for coronary heart disease, including insulin resistance, impaired glucose tolerance, type 2 diabetes, dyslipidemia, and elevated circulating inflammatory proteins. Retroperitoneal and intraperitoneal fat are the two further subdivisions of adipose tissue in the abdominal region. These fat masses can be further divided into mesenteric and omental fat masses. The scope of this includes both intra-abdominal and subcutaneous fat. A metabolic risk indicator that is of considerable importance is intraperitoneal fat, which is also known as visceral adipose tissue [4]. The present of Type 1 and type 2 in

Diabetes mellitus (DM) is round 8% and 90% of cases, respectively [5].

Patients are currently in search of alternative methods to effectively reduce localized fat deposits without the need for surgery. Various methods, including cryotherapy, mesotherapy, and ultrasound (US) cavitation, are being employed to achieve nonsurgical adipose disruption. All individuals who are obese or at risk of obesity or diabetes should adopt the following lifestyle changes: a weight loss of 5-10% of their initial weight and either moderate intensity physical activity for 30 minutes per day or intensive intensity physical activity for 20 minutes on three days per week [6].

**Author for Correspondence: Fatma M. Abdeen Sallam*

US fat cavitation (USFC) is a technique that is particularly effective in the treatment of obesity by eradicating fat and reshaping a specific area of the body. When it comes to mitigating the risk of complications related to obesity, USFC is the favored non-surgical correction method. US cavitation is employed to diminish adipose tissue and enhance the appearance of the body. Alterations in adipose thickness were used to determine its efficacy [7]. In female adolescents, the BMI, waist-hip ratio, waist circumference, weight, fat thickness, percentile body fat, and trunk fat were all reduced as a result of incorporating ultrasonic cavitation with aerobic exercises and a low-calorie diet. The outcome was the preservation of self-assurance and a graceful appearance [8].

This study aimed to examine the impact of aerobic exercise and US cavitation on the lipid profile and blood glucose levels of women with central obesity.

PATIENTS AND METHODS

This case-control study involved 90 female cases with central obesity suffering from elevated lipid profile and blood glucose level, free from any diseases that could affect the treatment process. At the ABED physical therapy center in El-Santa, Gharbia Governorate, participants were recruited from the internal medicine outpatient clinic at El-Santa Hospital. The investigation was conducted. The patients have provided written consent that is informed. The Ethics Committee of the Faculty of Medicine, Cairo University, granted approval for the investigation (P.T.REC/012/004794).

Inclusion criteria were age 30-45 years, waist circumference ≥88 cm in women, BMI ≥ 25to 30 kg/m^2, cholesterol level above normal ratio and hemoglobin A1C (HBA1C) from 5.8 to 6.5 %

Exclusion criteria were viral hepatitis A, B, C, cardiopulmonary diseases, peripheral vascular diseases, uncontrolled hypertension (HTN), uncontrolled diabetes mellitus (DM), drug abuse, alcohol Intake and orthopedic problems.

Randomization:

All cases were divided randomly into 3 equal groups:

Group (1): Cases received low caloric diet program.

Group (2): Patients followed a program of moderate intensity aerobic exercise and low caloric diet.

Group (3): Patients followed a program of US cavitation sessions and low-calorie diet.

Assessment equipment including height and weight scale, laboratory analysis machine to assay cholesterol and blood glucose levels, tape measurement to measure waist circumference and therapeutic equipment including electronic treadmill, US cavitation device.

All patients underwent an Obesity questionnaire.

Training program: As part of the 12-week exercise training program, each patient engaged in moderate intensity exercise on an electronic treadmill for 30-60 minutes, three times a week. For the purpose of estimating the maximal heart rate (HR), Karvonen's formula was implemented: Target HR + Resting HR = ((max HR - resting HR) × %Intensity). Handrail sensors in an electronic treadmill can be employed to quantify heart rate. Phases of exercise: Warm-up phase: 5-10 minutes of moderate intensity (30-40% of maximal heart rate). Training phase: Each patient was trained at a moderate intensity for 30-40 minutes, which was 60-70 percent of their maximal HR. Cooling down phase: five- ten minutes of moderate intensity (30-40% maximal HR).

Ultrasound cavitation sessions: A program of 12 US cavitation sessions was applied to each patient. Every patient's abdominal area is vertically divided into two sections: the right and left segments, which expand bilaterally from the line stretching out from the mid axilla to the iliac crest and above from the center of the diaphragm to the line extending between two iliac crests below, when standing. A comfortable posterior lying position was established for the patient. Conductive material is applied to the treatment area. On each abdominal segment, the cavitation head was moved at a sluggish pace in a small circular motion. Each session lasting 30 to 40 minutes, the application treatment of US cavitation was performed on each side of the abdomen for an estimated 15 to 20 minutes. Guidance regarding the post-session period was provided.

Low caloric diet: Four distinct low-caloric diet programs were implemented. The diet regimen was gradually modified every three weeks, progressing from 1800 kcal/day to 1500, 1200, and 1000 kcal. An example of a diet program that is based on 1800 kcal per day is as follows:

Breakfast: One leaf of dark bread, three spoonfuls of legumes with olive oil, and a small amount of light cheese. Includes two vegetables. A small cup of coffee or tea with a teaspoon of sugar and a solitary fruit are served as a refreshment. a main meal that includes a vegetable salad, 250 g of any reduced protein (chicken, tuna, fish, liver, or flesh), and nine spoonfuls of macaroni or rice. For a snack, combine one fruit with one cup of cinnamon and one spoonful of sugar. Dinner: grilled or boiled aubergine, two vegetables, a boiled egg, and half a loaf of brown bread. Snack: A cup of green tea and one fruit. The calorie intake was gradually decreased every three weeks during the final two weeks until it reached 1000 kcal/day [9].

STATISTICAL ANALYSIS:

The investigation was carried out using the SPSS v28 statistical program, which was developed by IBM of Armonk, NY, USA. The quantitative parametric data used for evaluation was an unpaired student t-test, which included means and standard deviations (SD). Repeated measures ANOVA tests was used to analyze differences across multiple time points or conditions with the same participants. After assessing qualitative variables using the Chi-square test, the frequency and percentage (%) were obtained. Any two-tailed P value below 0.05 was considered statistically significant.

RESULTS

In this investigation, 113 patients were assessed for eligibility; 15 patients did not meet the criteria, and eight

patients declined to participate. The remaining 90 cases were randomly divided into three categories, with each group comprising 30 cases. The analysis and follow-up of all cases that were allocated were conducted. Figure 1

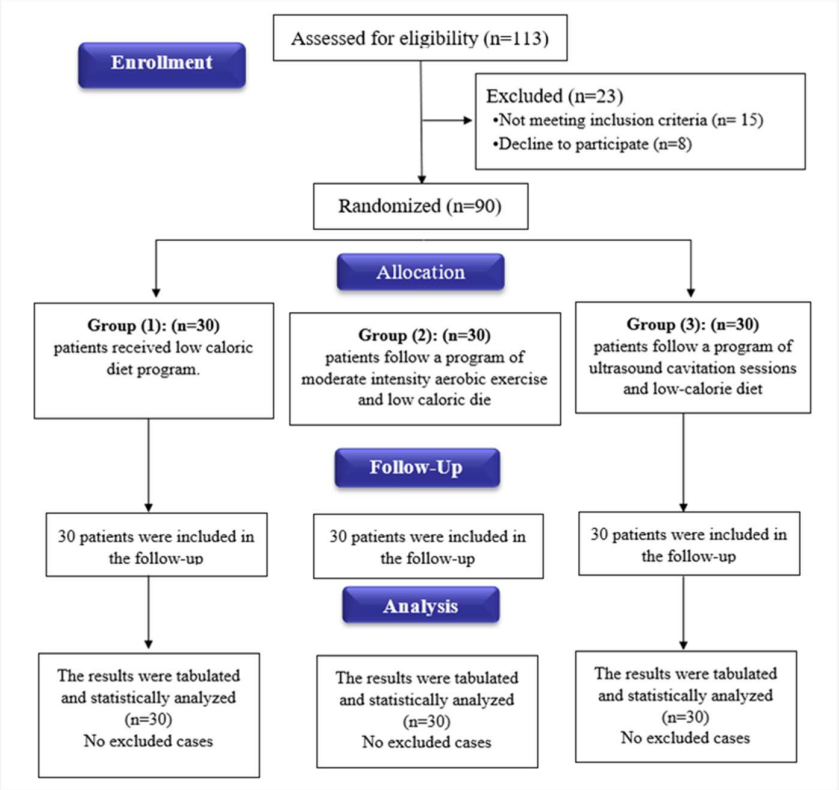

Figure 1: CONSORT flowchart of the enrolled patients

Regarding the baseline characteristics, baseline weight was significantly increased in group (2) than group (1) and (3) (P=0.003, 0.022), with insignificant difference between group (3) and group (1). The baseline BMI was significantly increased in group (2) than group (1) (P=0.020), with insignificant difference between the other groups and each others. Height and age were not significantly different among the investigated categories. Table 1

Table 1: Baseline characteristics of the studied groups

		Group (1): Low Caloric Diet (n=30)	Group (2) : Aerobic Exercises & low caloric diet (n=30)	Group (3): Cavitation & low caloric diet (n=30)	P value
Age (years)		37.89±2.58	36.05±4.66	36.17±3.77	0.111
Weight (kg)	**Mean± SD**	80.97±4.09	85.02±6.03	80.3±9.18	**0.004***
	P value	**P1=0.003*** P2 =0.716**, P3=0.022***			
Height (m)		1.65±0.04	1.67±0.06	1.63±0.08	0.067
BMI (kg/m^2)	**Mean± SD**	29.7±1.05	30.5±1.48	30.02±1.22	**<0.001***
	P value	**P1=0.020***, P2=0.283, P3=0.181			

*Data are presented as mean ± SD or frequency (%). BMI: Body mass index, *: statistically significant as P value < 0.05, P1: p value between group 1 and group 2, P2: p value between group 1 and group 3, P3: p value between group 2 and group 3.*

In group 1: (Low Caloric Diet), the body weight, BMI, and waist circumference post treatment were significantly decreased than pre-treatment (P<0.001, <0.001, <0.001). The percentage of weight and BMI, and waist circumference change were 12.96%, 12.96%, 9.52% respectively. In group 2: (Aerobic exercise & low caloric diet), the body weight, BMI, and waist circumference post treatment were significantly decreased than pre-treatment (P<0.001, <0.001, <0.001). The percentage of BMI, weight, and waist circumference change were 14.47%, 14.34%, 11.79% respectively. In group 3: (Cavitation & low caloric diet (n=30), the body weight, BMI, and waist circumference post treatment were significantly decreased than pre-treatment (P<0.001, <0.001, <0.001). The percentage of

BMI, weight, and waist circumference change were 18.94%, 18.88%, 22.38% respectively. Table 2.

Table 2: Anthropometric measurements of the studied groups

	Group (1): Low Caloric Diet (n=30)		**P value**
	Pre	**Post**	
Weight (kg)	80.97±4.09	70.48±4.48	**<0.001***
Percentage of change %	12.97%		
BMI (kg/m²)	29.7±1.05	25.85±1.27	**<0.001***
Percentage of change %	12.97%		
Waist circumference (cm)	101.39±3.75	91.74±3.65	**<0.001***
Percentage of change %	9.52%		
	Group (2): Aerobic exercises & low caloric diet (n=30)		
	Pre	**Post**	
Weight (kg)	85.02±6.03	72.83±6.41	**<0.001***
Percentage of change %	14.34%		
BMI (kg/m²)	30.5±1.48	26.08±1.22	**<0.001***
Percentage of change %	14.47%		
Waist (cm)	106.28±9.4	93.75±8.77	**<0.001***
Percentage of change %	11.79%		
	Group (3): Cavitation & low caloric diet (n=30)		
	Pre	**Post**	
Weight (kg)	80.3±9.18	65.13±8.05	**<0.001***
Percentage of change %	18.88%		
BMI (kg/m²)	30.02±1.22	24.34±1.27	**<0.001***
Percentage of change %	18.94%		
Waist (cm)	104±8.01	80.73±5.97	**<0.001***
Percentage of change %	22.37%		

*Data are presented as mean ± SD or frequency (%). BMI: Body mass index, *: statistically significant as P value < 0.05.*

Pre- and post-treatment, the body weight of the studied groups differed significantly (P=0.004, <0.001). In comparison to groups (1) and (3), group (2) exhibited a significant rise in weight pre-treatment (P=0.003, 0.022), while there was insignificant difference between groups (3) and (1). The body weight of group (3) was significantly reduced in comparison to that of group (2) and group (1) following the treatment (P=0.002, <0.001). Nevertheless, there was no significant difference between group (1) and group (2). The highest % change in the body weight was found in group (3) (Cavitation & low caloric diet). The BMI of the studied groups was significantly different pre- and post-treatment (P<0.001, <0.001). Group 2 exhibited a significantly higher BMI pre-treatment than group 1 (P=0.020), while the other groups did not differ significantly from one another. After the treatment, the BMI of group (3) was significantly lower than that of group (1) and group (2) (P <0.001, <0.001), while there was no significant difference between group (1) and group (2). The group with the greatest percentage change in BMI was the third group (Cavitation & limited caloric diet). Table 3

Pre- and post-treatment waist circumferences of the studied groups were significantly different (P=0.025, <0.001). In group (1), the waist circumference prior to treatment was substantially higher than in group (2) (P=0.020), whereas there was insignificant difference among the other groups. Group (3) exhibited a statistically significant reduction in body weight subsequent to treatment, as opposed to group (1) and group (2) (P <0.001, <0.001). Groups (1) and (2) did not exhibit any significant differences. The group with the greatest percentage change in waist circumference was the third group (Cavitation & low caloric diet). Table 3

Group (1): The HbA1 and cholesterol levels were significantly lower post-treatment than they were pre-treatment due to the low calorie diet (P<0.001, <0.001). The percentage changes of HbA1 and Cholesterol were 8.63% and 18.24%, respectively. In group 2: (Aerobic exercise & low caloric diet), the HbA1, and Cholesterol post treatment were significantly reduced than pre-treatment (P<0.001, <0.001). The % change of HbA1, and Cholesterol change were 11.45%, 22.45%) respectively. In group 3: (Cavitation & low caloric diet), the HbA1, and Cholesterol post treatment were significantly diminished than pre-treatment (P<0.001, <0.001). The % change of HbA1, and Cholesterol change were 13.83%, 31.40%) respectively. Table 4

Table 3: Comparison of weight, BMI and waist circumference of the studied groups

	Group (1): Low Caloric Diet (n=30)	**Group (2): Aerobic exercise & low caloric diet (n=30)**	**Group (3): Cavitation & low caloric diet (n=30)**	**P value**
Weight				

Pre	**Mean± SD**	80.97±4.09	85.02±6.03	80.3±9.18	**0.004***
	P value	**P1=0.003*** P2 =0.716**, P3=0.022***			
Post	**Mean± SD**	70.48±4.48	72.83±6.41	65.13±8.05	**<0.001***
	P value	P1=0.105 **P2 =0.002*, P3<0.001***			
	% change	12.97%	14.34%	18.88%	
BMI					
Pre	**Mean± SD**	29.7±1.05	30.5±1.48	30.02±1.22	**<0.001***
	P value	**P1=0.020***,P2=0.283, P3=0.181			
Post	**Mean± SD**	25.85±1.27	26.08±1.22	24.34±1.27	**<0.001***
	P value	P1=0.468 **P2 <0.001*, P3<0.001***			**--**
	% change	12.97%	14.47%	18.94%	**--**
Waist circumference					
pre	**Mean± SD**	101.39±3.75	106.28±9.4	104±8.01	**0.025***
	P value	**P1=0.010*** ,P2=0.112, P3= 0.315			**--**
post	**Mean± SD**	91.74±3.65	93.75±8.77	80.73±5.97	**<0.001***
	P value	P1=0.251, **P2 <0.001*, P3<0.001***			**--**
	% change	9.52%	11.79%	22.37%	**--**

*Data are presented as mean ± SD or frequency (%). BMI: Body mass index, *: statistically significant as P value < 0.05, P1: p value between group 1 and group 2, P2: p value between group 1 and group 3, P3: p value between group 2 and group 3.*

Table 4: Laboratory investigation of the studied groups

		Group (1): Low Caloric Diet (n=30)		**P value**
		Pre	**Post**	
HbA1 (%)	**Mean± SD**	5.99±0.21	5.47±0.34	**<0.001***
	% of change	8.63%		
Cholesterol (mg/dL)	**Mean± SD**	283.95±46.98	232.17±27.39	**<0.001***
	% of change	18.24%		
		Group (2): Aerobic exerciseerciseercise & low caloric diet (n=30)		
		Pre	**Post**	
HbA1 (%)	**Mean± SD**	6.38±0.24	5.65±0.24	**<0.001***
	% change	11.45%		
Cholesterol (mg/dl)	**Mean± SD**	295.03±39.81	228.79±40.19	**<0.001***
	% change	22.45%		
		Group (3): Cavitation & low caloric diet (n=30)		
		Pre	**Post**	
HbA1 (%)	**Mean± SD**	6.23±0.28	5.37±0.34	**<0.001***
	% change	13.83%		
Cholesterol (mg/dL)	**Mean± SD**	310.2±54.69	212.79±28.17	**<0.001***
	% change	31.40%		

*Data are presented as mean ± SD or frequency (%). HbA1C: hemoglobin A1C, *: statistically significant as P value < 0.05.*

Pre- and post-treatment, the HbA1c levels of sudied groups were significantly different (P<0.001, <0.001). The HbA1c pre-treatments of group (2) and group (3) were significantly higher (P<0.001, <0.001) than those of group (1) (P<0.001). Additionally, group (2) had significantly higher HbA1c pre-treatments than group (3) (P<0.001). Groups (1) and (3) significantly reduced their HbA1c levels compared to group (2) following treatment (P =0.023, 0.001), while there was no significant difference between groups (1) and (3). The highest % change in the HbA1c was found in group (3) (Cavitation & low caloric diet). The total cholesterol was significantly different among the sudied groups pre-and post-treatment (P<0.001, <0.001). Compared to group (2), group (3) exhibited a significantly greater total cholesterol pre-treatment (P<0.001), while there was no significant difference between the other groups or among themselves. Following the treatment, the total cholesterol levels in group (3) were significantly lower than those in group (2) (P<0.001). Nevertheless, there was no other significant difference in the two categories. Table 5

Table 5: Comparison of hemoglobin A1C (HbA1c) and cholesterol of the studied groups

		Group (1): Low Caloric Diet (n=30)	**Group (2) : Aerobic exercises & low caloric diet (n=30)**	**Group (3): Cavitation & low caloric diet (n=30)**	**P value**
HbA1c					
pre	**Mean± SD**	5.99±0.21	6.38±0.24	6.23±0.28	**<0.001***
	P value	**P1<0.001*, P2<0.001*, P3=0.034***			**--**

post	**Mean± SD**	5.47±0.34	5.65±0.24	5.37±0.34	**<0.001***
	P value	**P1=0.023*,** P2=0.253, **P3=0.001***			**--**
% change		8.63%	11.45%	13.83%	**--**
Cholesterol					
pre	**Mean± SD**	283.95±46.98	295.03±39.81	310.2±54.69	**<0.001***
	P value	P1=0.328, P2=0.224, **P3<0.001***			**--**
post	**Mean± SD**	232.17±27.39	228.79±40.19	212.79±28.17	**<0.001***
	P value	P1=0.704, P2=0.080, **P3<0.001***			**--**
% change		18.24%	22.45%	31.40%	**--**

*Data are presented as mean ± SD or frequency (%). HbA1C: hemoglobin A1C, *: statistically significant as P value < 0.05, P1: p value between group 1 and group 2, P2: p value between group 1 and group 3, P3: p value between group 2 and group 3.*

DISCUSSION

Obesity has become one of the most serious global public health challenges due to its rapidly increasing prevalence and its strong association with metabolic and cardiovascular diseases. According to the World Obesity Atlas Report 2023, the overweight and obesity prevalence is expected to affect nearly half of the world's population within the coming years, with particularly high rates among women in the Middle East. Type 2 diabetes mellitus, dyslipidemia, hypertension, cardiovascular diseases, and other metabolic disorders are all associated with an increase in mortality and morbidity that is associated with obesity [10].

BMI, waist circumference and Body weight in the Low Caloric Diet group exhibited significant reductions in comparison to their baseline values following treatment (P < 0.001 for all). The percentage reductions in waist circumference, BMI, and body weight were 9.52%, 12.96%, and 12.96% respectively.

Similarly, Sun et al. [11] the study indicated that obese participants experienced significant reductions in body weight, BMI, and waist circumference as a result of calorie-restricted dietary strategies.

The study suggested that caloric restriction decreases visceral fat accumulation and improves body composition through enhanced fat oxidation and reduced caloric intake.

In contrast, Dansinger et al. [12] referred to the negligible variations in waist circumference between calorie-restricted diets and low-carbohydrate diets.

In the Aerobic Exercise and Low Caloric Diet group, our results demonstrated that body waist circumference, weight, and BMI declined statistically significantly in comparison to their baseline values (P < 0.001 for all). BMI, waist circumference, and body weight were reduced by 14.34%, 14.47%, and 11.79%, respectively.

Our findings indicate that compensatory appetite increases that arise as a consequence of daily energy intake deficits can be prevented through the implementation of exercise interventions in conjunction with calorie restriction. This outcome is in accordance with the results of a study that demonstrated that obese women could reduce their fasting appetite and maintain satiety by implementing a 2-week caloric restriction in conjunction with an exercise intervention [13]. Appetite-related peptides are one of the numerous mechanisms that have been proposed to influence eating behaviors.

Wu et al. [14] the results consistently demonstrated that a 500 kcal reduction in daily energy intake through dietary control was effective in reducing body weight by over 5%, even when additional meals were provided to counteract the energy expenditure produced by exercise, which is in accordance with results of Tang et al. [15].

Nevertheless, lifestyle intervention was unsuccessful for the majority of the participants in achieving their intended weight loss. After undergoing nutritional and exercise counseling for six months, the average weight loss of the patients was 3.6% [16]. In large part, it is due to the challenge of adhering to lifestyle changes [16].

The meta-analysis determined that the reduction of caloric intake and the increase of energy expenditure through exercise was a significant factor in the reduction of visceral fat mass [17].

In the Cavitation and Low Caloric Diet group, we observed that BMI, body weight, and waist circumference had significant reductions following treatment compared to the baseline values (P < 0.001 for all). The percentage decreases in BMI, body weight, and waist circumference were 18.94%, 18.88%, and 22.38%, respectively.

These outcomes are in accordance with the investigation showed by Maher et al. [18], According to the report, obese female patients experienced substantial decreases in BMI, body weight, waist-hip ratio, and skinfold thickness as a result of incorporating US cavitation into a low-calorie balanced diet and treadmill exercise. The authors concluded that US cavitation could be considered an effective adjunctive modality for obesity management and body contouring.

Furthermore, Kiedrowicz et al. [19] found that abdominal US cavitation therapy significant decreased BMI, body weight, and waist circumference, with sustained improvements observed up to six months after treatment. The study highlighted the potential long-term effectiveness of cavitation therapy in reducing abdominal adiposity.

The present study's results indicated that the studied groups exhibited statistically significant differences in body weight, BMI, and WC both before and after treatment. The Cavitation and Low Caloric Diet group exhibited the greatest percentage reduction.

Moreover, Kiedrowicz et al. [19] reported that repeated US cavitation treatments significant decreased BMI, body weight, and waist circumference, with the beneficial impacts persisting for up to six months after treatment. The authors highlighted the long-term efficacy of cavitation therapy in reducing abdominal adiposity and improving anthropometric outcomes.

The current study's results have shown that the Low Caloric Diet intervention resulted in statistically significant

reductions in HbA1c and total cholesterol levels following treatment compared to baseline values.

Similarly, Mohamed et al. [20], demonstrated that low-calorie diets significantly improved cardiometabolic parameters, including HbA1c and lipid profile. The review further reported that caloric restriction was related to clinically meaningful weight loss and improved metabolic control.

Following treatment, the Aerobic Exercise and Low Caloric Diet groups exhibited statistically significant decreases in both HbA1c and total cholesterol levels in comparison to their baseline values ($P < 0.001$ for both). The reductions in HbA1c and total cholesterol levels percentage were 11.45% and 22.45%, respectively.

These findings are consistent with the investigation conducted by Al-Mhanna et al. [21], In obese individuals with type 2 diabetes, a combination of aerobic exercise and dietary intervention led to a significant decrease in insulin resistance, fasting blood glucose, HbA1c, and lipid profile parameters. The authors concluded that combining aerobic exercise with dietary modification provides greater cardiometabolic benefits than either intervention alone.

Following treatment, the Cavitation and Low Caloric Diet group exhibited statistically significant decreases in both HbA1c and total cholesterol levels in comparison to their baseline values ($P < 0.001$ for both). The HbA1c and total cholesterol levels were reduced by 13.83% and 31.40%, the respective percentages.

The findings of this investigation are also corroborated by the findings of Abdelhamid et al. [8] and Saharan et al. [22] The individual who demonstrated that obese women who were prediabetic experienced a reduction in fasting blood sugar, HbA1c, , and postprandial blood sugar levels when they combined ultra-sonic cavitation, a balanced diet, low-caloric, and treadmill exercise.

The present study's results indicated that the studied groups exhibited statistically significant differences in HbA1c levels both before and after treatment. The Cavitation and Low Caloric Diet group exhibited the greatest percentage reduction.

Furthermore, Abdel-Aal et al. [23] found that cavitation combined with radiofrequency significantly improved waist circumference, BMI, and metabolic markers in centrally obese subjects compared with cryolipolysis. The authors suggested that cavitation-induced adipocyte disruption may contribute to improvement in obesity-associated metabolic abnormalities.

The present study's results indicated that the studied groups exhibited statistically significant differences in total cholesterol levels both before and after treatment, with the greatest percentage reduction observed in the Cavitation and Low Caloric Diet group.

In accordance with the most recent discoveries, Maher et al. [18] In conjunction with a low-calorie balanced diet and treadmill exercise, the study found that obese female patients experienced a significant decrease in total cholesterol levels, body weight, BMI, and abdominal obesity indices when US cavitation was implemented. The authors suggested that cavitation therapy could serve as an effective adjunctive modality for obesity management and metabolic improvement.

Our result contradict with, Mahmoud et al 2024. [24] who found that radiofrequency is more effective than Cavitation in the decrease of abdominal fat thickness as well as waist hip ratio.

The study's limitations lie in the relatively small sample size, the relatively brief study duration, and the exclusivity of women with central obesity. In addition, dietary adherence and physical activity outside the supervised sessions were difficult to monitor completely. Finally, other metabolic and inflammatory biomarkers associated with obesity were not evaluated.

CONCLUSIONS

In women with central obesity, the results indicated that a reduced caloric diet, US cavitation, and an aerobic exercise regimen were all effective in improving anthropometric and metabolic parameters. Body weight, HbA1c, waist circumference, BMI, and total cholesterol levels were all significantly reduced in all of the groups that were studied as a result of the treatment. Nevertheless, the cavitation and reduced caloric diet group demonstrated the most significant improvements, exhibiting the highest percentage reductions in body weight, HbA1c, waist circumference, and total cholesterol levels.

Therefore, to assess the long-term safety and efficacy of US cavitation in the treatment of central obesity, it is advised that additional large-scale studies with extended follow-up periods be conducted. Future research should include both genders and different age groups to improve the generalizability of the findings. Moreover, assessment of additional metabolic and inflammatory markers and combining US cavitation with structured lifestyle modification programs are also recommended.

List of abbreviations:

BMI	Body mass index
DM	Diabetes mellitus
HbA1c	Hemoglobin A1C
HR	Heart rate
HTN	Hypertension
US	Ultrasound
USFC	US fat cavitation

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