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Effect of Ultrasound Cavitation versus Whole Body Vibration on Abdominal Fat in Obese Adolescent Females

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ABSTRACT

Background: Egyptian central adolescents` obesity is a common inadequately treated complaint among females, with representing prevalence of 10.7%. Both ultrasound cavitation (UC) and whole-body vibration (WBV) could selectively reduce fat accumulation and enhance body contouring that safely reduces local adipogenesis in adolescent females.

Objective: To evaluate the comparative effectiveness of UC and WBV on abdominal fat in obese adolescent females.

Patients and Methods: Sixty adolescent females with abdominal obesity participated in the study. They aged from 19-25 years, their body mass index (BMI) ranged between 30-35 kg/m^2, their waist circumference (WC) was >88 centimeters, and their waist/ hip ratio was (WHR) > 0.88. They were divided randomly into three equal groups. **Group (A)** (n = 20) received UC 30 min/session, 2 times/week plus a low caloric diet (1500 Kcal/day) for 6 weeks, **Group (B)** (n = 20) received whole body vibration, 30 min/session, 2 times/week plus a low caloric diet (1500 Kcal/day) for 6 weeks, and **Group (C)** (n=20) received a low caloric diet (1500 Kcal/day) only for 6 weeks. Anthropometric measurements, skinfold thickness, and abdominal fat thickness were measured for all participants in all groups before and after treatment.

Results: Post-treatment statistical evaluation demonstrated significant reductions ($p < 0.001$) across all measured parameters, including body weight, BMI, WC, WHR, skinfold thickness, and abdominal fat thickness in all groups post-treatment, in favor of group (A).

Conclusion: UC therapy demonstrated superior efficacy compared to WBV in reducing abdominal fat in obese adolescent females.

Keywords: Abdominal thickness, Skinfold thickness, Ultrasound cavitation, Waist circumference, Whole-body cavitation.

INTRODUCTION

Adolescence represents a critical period that bridges childhood and adulthood, where physical appearance and social acceptance are highly influential. This period is critical for forming lifelong habits, including dietary patterns, which can impact growth and health. Poor nutrition in adolescence may lead to growth impairment, delayed puberty, iron deficiency anemia, and obesity [(1)].

In Egypt, obesity among adolescent females is a significant concern, with overweight and obesity rates reported at 20% and 10.7%, respectively, and is associated with psychological distress, low self-esteem, and social challenges [(2)]**.** Obesity represents a multifaceted disorder marked by excessive adiposity (BMI ≥30 kg/m²) from imbalanced caloric intake and expenditure, influenced by genetics, hormones, lifestyle, and environment [(3)]. Visceral adiposity, alternatively termed abdominal or central adiposity, describes the deposition of fatty tissue around the internal organs and abdominal region and is particularly critical in evaluating health risks in females [(4)].

Obesity is a complex condition with wide-ranging physical, metabolic, reproductive, and psychological consequences. It promotes insulin resistance, chronic inflammation, dyslipidemia, and adipose tissue dysfunction, increasing the risks of cardiovascular disease, type 2 diabetes, and osteoarthritis. During adolescence, it also contributes to low self-esteem, depression, menstrual irregularities, and infertility. Central obesity further exacerbates cardiometabolic risk. Even modest weight loss of 10% can markedly improve health outcomes and quality of life [(5)].

Obesity often emerges during adolescence due to complex interactions between hormones, metabolism, and environmental factors. Dysregulation of the hypothalamic-pituitary-adrenal and gonadal axes, along with altered insulin and leptin signaling, influences energy balance, fat distribution, and androgen levels, contributing to conditions like functional hyperandrogenism and polycystic ovary syndrome in girls. Elevated adipose proliferation and hormonal imbalances during puberty affect current and future obesity risk [(6)].

Traditional management approaches focus on diet, physical activity, and behavioral modifications. However, non-invasive techniques for localized fat reduction such as ultrasound cavitation (UC), and whole-body vibration (WBV) have gained popularity [(7)].

UC is a non-invasive method that destroys abdominal fat cells, releasing triglycerides for metabolism without harming surrounding tissues. Clinical studies show it effectively reduces waist circumference

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(WC) and subcutaneous fat in women, with high satisfaction and minimal risk, making it a safe option for central obesity and body contouring [8].

WBV is a low-amplitude, low-frequency mechanical therapy applied in physical therapy to improve muscle strength, flexibility, and metabolic function. Platforms can be side-alternating, mimicking gait, or linear, with higher frequencies and lower amplitudes. WBV enhances energy expenditure, stimulates muscle activation, and improves blood flow, promoting fat mobilization and abdominal fat reduction. Combined with diet or conventional exercise, WBV effectively reduces WC, abdominal fat, and overall fat mass, making it a time-efficient adjunct in obesity management [9].

Although UC and WBV have been studied individually, evidence comparing their efficacy in obese adolescent females is limited. Given the high prevalence and complications of obesity in this population, this study aimed to evaluate the comparative effectiveness of UC and WBV on abdominal fat. The findings are expected to inform clinical practice and support interventions that improve the health and life quality of obese adolescent females.

PATIENTS AND METHODS

Study design:

It is a prospective, pre-post-test, randomized controlled clinical trial.

Ethical consideration:

The study was approved by the Research Ethical Committee, Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/004858) on 8/10/2023. All participants read and signed an informed consent form prior to the start of the study. The study was conducted from March 2024 to December 2024, in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Sample size estimation:

The sample size was calculated using G*Power software (version 3.1.9, Heinrich-Heine University, Düsseldorf, Germany) based on a one-tailed test. Effect size was obtained from a pilot study. Using F tests for multivariate analysis of variance (MANOVA) and considering effect and interactions, a total of 51 participants were deemed adequate, with type I error (α) of 0.05, power ($1-\beta$) of 0.75, and partial eta squared of 0.438. To account for potential dropout, 60 participants were recruited, providing a minimum of 20 participants per group.

Participants:

A total of sixty adolescent females with abdominal obesity were selected from the Physical Therapy Department of Tropical Hospital, Sohag Governate, Egypt.

Eligibility criteria:

All participants had to meet the following: Adolescent females with abdominal obesity, aged from 19-25 years, their body mass index (BMI) ranged between 30-35 kg/m^2, their WC >88 centimeters, their waist/ hip ratio (WHR) > 0.88, and all of them were of sedentary life style.

Participants with thyroid, hepatic disorders, kidney disorders, diabetes mellitus, ischemic heart disease, and cardiac failure, recent abdominal surgical scar or umbilical hernia, and history of orthopedic implants or cardiac pacemaker were excluded from the study [9].

Randomization:

Random group allocation employed SPSS software (Windows version 25) to generate computerized randomization tables before study initiation. Participant enrollment resulted in a unique identification number assignment. Three equal-sized groups (A, B, C) of twenty subjects each were formed through systematic randomization of these numbers. Sequential index card numbering occurred within sealed, opaque envelopes. Blinded research personnel distributed hand-selected envelopes to participants, enabling group determination upon envelope opening.

Group (A) (n = 20) received UC, 30 min/ session, 2 times/ week in addition to a low caloric diet (1500 Kcal/day) for 6 weeks, **Group (B)** (n = 20) received whole body vibration, 30 min/session, 2 times/week in addition to a low caloric diet (1500 Kcal/day) for 6 weeks, and **Group(C)** (n=20) received a low caloric diet (1500 Kcal/day) only, as in groups (A and B) for 6 weeks **(Figure 1)**.

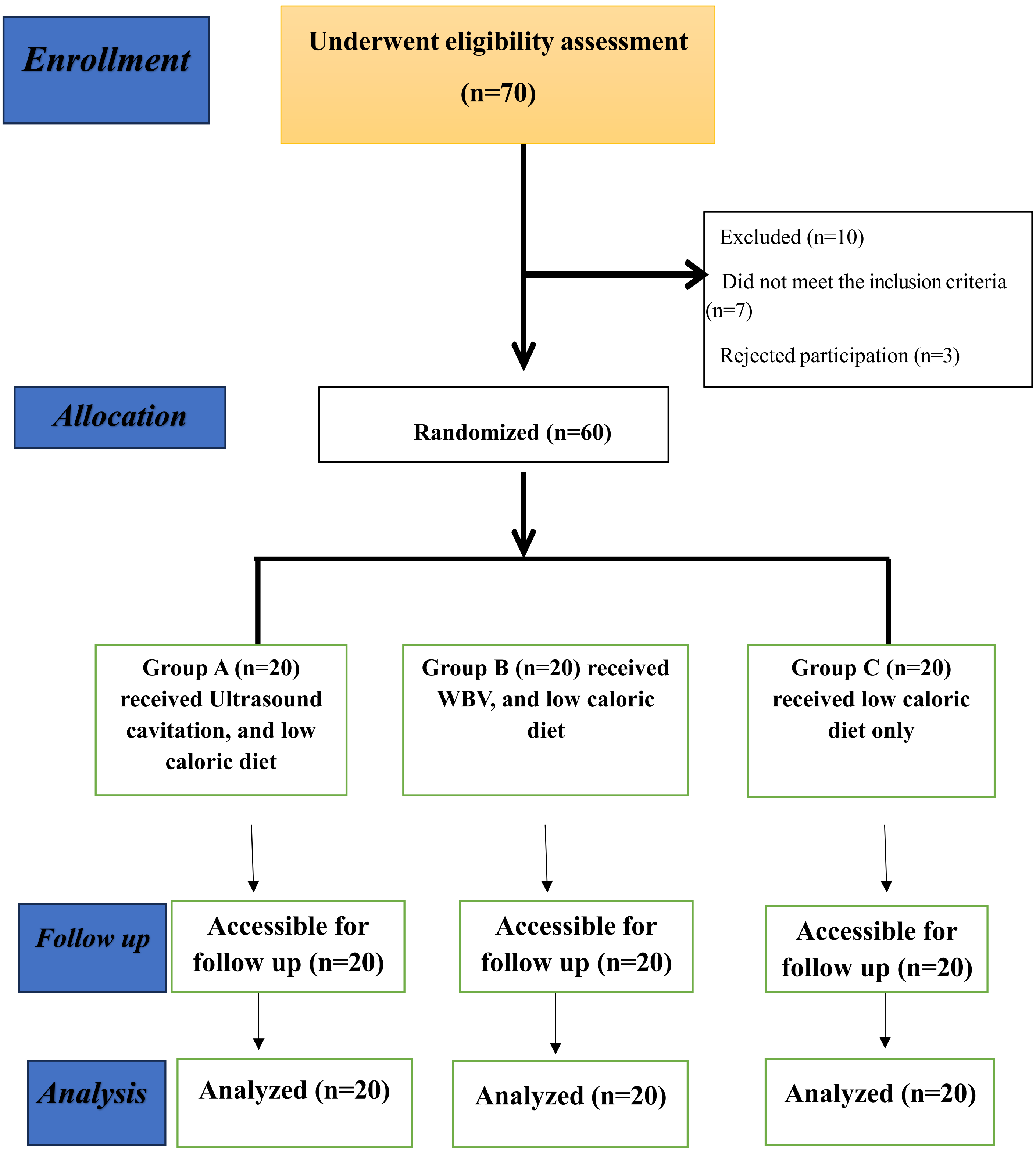

Fig. (1): Flow chart of the study

Outcome Measures

Body composition and obesity-related parameters were evaluated for all participants in the three study groups (A, B, and C) both before and after the intervention period. The following assessments were performed:

1. **Body Weight, Height, and BMI:** Body weight and height were measured for each participant using a calibrated weight–height scale. Participants removed heavy clothing and shoes before standing upright at the scale's center. Weight recording occurred following reading stabilization. Height was measured by positioning the ruler of the scale flat against the participant’s head, marking the top point, and measuring the distance from the mark to the floor using a tape measure. BMI calculation followed the established equation:
   BMI (kg/m²) = Weight (kg) / Height (m)^2 [10].

2. **Waist Circumference (WC) and Waist-to-Hip Ratio (WHR):** WC and WHR were assessed for all participants in a standing position. WC determination occurred midway between the inferior rib margin and iliac crest following gentle expiration, utilizing a non-stretchable measuring tape held horizontally. Hip circumference assessment occurred at the buttocks' widest point, ensuring that the tape was parallel to the floor and at the same level all around. WHR calculation employed the equation: **WHR = Waist Circumference (cm) / Hip Circumference (cm) [4, 11].**

3. **Abdominal Skinfold Thickness (SFT):** Subcutaneous abdominal fat was measured using a skinfold caliper (Sequoia Fitness Trimcal 4000, made in USA) at a vertical fold about 2 cm to the right of the umbilicus or at the suprailiac site. The participant stood upright, and the skinfold was grasped between the thumb and forefinger before applying the caliper perpendicularly. Three measurements were taken and averaged for accuracy. This method has been shown to be both valid and reliable for assessing subcutaneous abdominal fat in adults and adolescents [12].

4. **Bioelectrical Impedance Analysis (BIA):** BIA was conducted using an InBody Body Composition Analyzer (In body BODECODER, made in China). Participants were prepared by ensuring proper hydration, avoiding caffeine and vigorous exercise, emptying the bladder, and removing metal objects. During the test, subjects positioned themselves without footwear on pedal sensors and grasped handheld conductors while maintaining arms in a slightly abducted position from the torso. The device applied a low-level electrical current to determine body composition, providing values for body fat percentage, lean body mass, and total body water [13,14].

Procedures:

1- **Low Caloric Diet:**

All participants in the **three groups (A, B, and C)** followed a low-calorie diet program of 1500 kcal/day for 6 weeks, consisting of 45% carbohydrates, 20% fat, and 35% protein. Energy requirement calculations employed the Harris-Benedict methodology for basal metabolic rate (BMR) assessment:
[665 + (9.6 × weight in kilograms) + (1.8 × height in centimeters) - (4.7 × chronological age in years)] [15], and adjustments were made for sedentary activity by multiplying BMR by 1.2. The diet plan was reviewed weekly and modified as needed. Participants were closely monitored for adherence through weekly counseling sessions and review of dietary records to ensure compliance [7].

2- **Ultrasound cavitation (UC):**

All participants in **Group A** received UC therapy to the abdominal region for 30 minutes per session, twice weekly for six weeks. Before each session, participants were instructed about the procedure, asked to empty their bladder, and positioned in a supine lying position. The abdomen was divided into six sections—three on the right (Upper right, middle right, and lower right abdomen) and three on the left (Upper left, middle left, and lower left abdomen)—to ensure uniform application. A conductive gel was applied, and the device head was moved slowly in circular motions. Treatment was delivered using the CRYOSYSTEM Ultra Cavitation device (DGN Medical, China) with a 5 cm hand probe, operating at a frequency of 40 kHz, power input of AC100–240 V, and power output of 45 W. Pulsed ultrasound waves were applied for 5 minutes per section (15 minutes per side), totaling 30 minutes per session [16].

3- **Whole body vibration (WBV):**

All participants in **Group B** received WBV therapy using the Super Fit Massage platform (14.5 × 21 cm surface, 23 cm base, 2 HP motor, 5–99 Hz, Made in China) for 30 minutes/session, twice weekly for six weeks. Participants were instructed on WBV procedures, performed a 5-minute breathing warm-up, and stood on the platform with feet shoulder-width apart while holding handrails. Vibration intensity was gradually increased to 45 Hz for 20 minutes, followed by a 5-minute cool-down and hydration guidance to ensure safety, comfort, and efficacy [17].

Statistical Analysis

Analytical procedures for participant data employed the Statistical Package for Social Sciences (SPSS) version 25, Windows edition. Descriptive statistical calculations (means ± standard deviations) were performed on demographic variables (age, weight, height, WC, WHR) alongside all assessment parameters. Normal distribution confirmation utilized Shapiro-Wilk methodology, whereas variance homogeneity validation across groups applied Levene's testing approach. Baseline characteristic comparisons between groups A, B, and C were conducted using analysis of variance (ANOVA). Paired t-test procedures enabled within-group pre-intervention and post-intervention comparisons. Moreover, analysis of variance explored temporal influences (baseline versus post-intervention), inter-group treatment impacts, and temporal-treatment interaction effects on measured outcomes. Multiple comparison post-hoc testing implemented Bonferroni adjustment. Statistical significance was determined at p less than 0.05.

RESULTS

The study population showed similar baseline characteristics across the three groups (A, B, and C). There were no statistically significant differences in age, weight, height, or BMI among the groups, indicating that the groups (A, B, and C) were comparable at the start of the study **(Table 1)**.

Table (1): Mean values of patients' demographic data for the three groups (A, B and C) at the baseline

Demographic data	Group A (n=20) Mean±SD	Group B (n=20) Mean±SD	Group A(n=20) Mean ±SD	P- value
Age (years)	22.75 ± 1.37	22.80 ± 1.19	22.25 ± 1.48	0.99
Height (cm)	164.8 ± 4.24	166.9 ± 3.86	166.2 ± 2.89	0.20

Within- and between-group's analysis:

As presented in **Table 2**, the results indicated significant post-treatment decreases in body weight, BMI, waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), skin fold thickness (SFT), and abdominal fat thickness (AFT) mean values across all groups (A, B, and C) relative to pre-treatment measurements (p = 0.001). Baseline between-group comparisons were non-significant. Post-treatment ANOVA demonstrated statistically significant superior reductions in body weight, BMI, WC, HC, WHR, SFT, and AFT for Group A compared with Groups B and C, confirming the superiority of the intervention in Group A.

Table (2): Mean values of body weight, BMI, WC, HC, WHR, SFT, and AFT measured pre and post treatment in the three groups (A, B and C)

Variables	Group A (n=20) Mean ±SD	Group B (n=20) Mean ±SD	Group C (n=20) Mean ±SD	P-value [b]
Body weight				
Pre- treatment	85.55 ± 4.85	87.25 ± 3.46	88.30 ± 3.85	0.11
Post treatment	72.03 ± 6.96	76.10 ± 4.75	78.00 ± 4.43	0.004*
MD	13.52	11.15	10.30	
% of improvement	15.80%	12.78%	11.66%	
P value [a]	0.001*	0.001*	0.001*	
Body Mass Index (BMI)				
Pre- treatment	31.47 ± 1.01	31.35 ± 1.59	31.99 ± 1.30	0.27
Post treatment	26.49 ± 1.87	27.32 ± 1.36	28.00 ± 1.5	0.012*
MD	4.98	4.03	3.99	
% of improvement	15.82%	12.85%	12.47%	
P value [a]	0.001*	0.001*	0.001*	
Waist circumference (WC)				
Pre- treatment	117.75±11.64	117.70 ± 11.74	118.00 ± 10.26	0.99
Post treatment	86.00 ± 2.50	92.50 ± 2.20	104.00 ± 1.63	< 0.001*
MD	31.75	25.20	14.00	
% of improvement	26.95%	21.42%	11.86%	
P value [a]	0.001*	0.001*	0.001*	
Hip Circumference (HC)				
Pre- treatment	127.95±10.50	127.05±16.03	127.30±10.31	0.97
Post treatment	102.75 ± 9.00	105.60 ± 1.60	115.40 ± 2.21	< 0.001*
MD	25.20	21.45	11.90	
% of improvement	19.70%	16.88%	9.35%	
P value [a]	0.001*	0.001*	0.001*	
Waist/Hip ratio (WHR)				
Pre- treatment	0.9203	0.9264	0.9269	0.97
Post treatment	0.8370	0.8759	0.9012	< 0.008*
MD	0.0833	0.0505	0.0257	
% of improvement	9.05%	5.45%	2.77%	
P value [a]	0.001*	0.001*	0.001*	
Skin fold thickness (SFT)				
Pre- treatment	26.87 ± 0.71	26.85 ± 0.65	26.88 ± 0.51	0.99
Post treatment	21.00 ± 0.51	22.01 ±0.63	25.75 ± 0.69	< 0.001*
MD	5.87	4.84	1.13	
% of improvement	21.85%	18.03%	4.20%	
P value [a]	0.001*	0.001*	0.001*	
Abdominal fat thickness (AFT)				
Pre- treatment	105.90 ± 2.08	108.12 ± 0.87	108.20 ± 0.95	0.001*
Post treatment	84.78 ± 1.37	100.80 ±7.37	101.29±3.46	< 0.001*
MD	21.12	7.32	6.91	
% of improvement	19.94%	6.77%	6.39%	
P value [a]	0.001*	0.001*	0.001*	

DISCUSSION

Adolescence represents a key stage of physical and psychological development, during which changes in body composition may predispose individuals to obesity. **Kennedy *et al.*** [18] and **Obert *et al.*** [19] emphasized that central obesity in adolescents increases the risk of insulin resistance, dyslipidemia, hypertension, and long-term metabolic complications. Early intervention is therefore essential to improve health outcomes and prevent chronic disease.

The study's objective centered on comparing the effects of UC and WBV on abdominal fat in obese adolescent females.

Regarding anthropometric measures, within-group analysis revealed statistically significant reductions in body weight, BMI, WC, WHR, skin fold thickness, and abdominal fat thickness in all three groups (A, B and C) post-treatment compared to pre-treatment. Between-groups comparisons showed no significant differences at baseline, while post-treatment analysis revealed statistically significant difference in all outcome measures, with the superiority of group A (UC).

The significant reduction in all assessed variables in all groups highlighted the importance of following a low caloric diet. **Barquissau *et al.*** [20] reported that caloric dietary restriction diminishes total fat mass, visceral adipose tissue, and improves hormone-sensitive lipase phosphorylation and insulin sensitivity in subcutaneous adipose tissue. In addition, **Makris *et al.*** [21] concluded that calorie-restricted diets demonstrate effectiveness in weight reduction, especially when combined with behavioral therapy and ongoing support, and can improve lipid profiles by reducing triglycerides and increasing HDL cholesterol, benefiting dyslipidemic individuals or those predisposed to type 2 diabetes.

The significant reduction in anthropometric measures in the UC group can be attributed to adipocyte membrane disruption and fat cell apoptosis. **Eldesoky *et al*.** [22] studied 60 obese adults aged 25–45 years (BMI >30 kg/m²), comparing UC, cryolipolysis, and a diet-only group for abdominal fat reduction. The study concluded that both UC and cryolipolysis, administered over 2 months, significantly reduced WC and suprailiac skinfold thickness compared to diet alone, with no significant difference between the two interventions.

Separate research by **El-Din *et al.*** [23] examined UC effects on abdominal adiposity in female adolescents (17–21 years old, BMI 30–35 kg/m²). Group A received abdominal UC twice weekly for 30 minutes, alongside 30 minutes of moderate-intensity aerobic exercises and low caloric diet, while Group B implemented aerobic training with calorie-restricted diet. The study found that Group A experienced significantly superior decreases in weight, BMI, WC, fat thickness, WHR, body fat percentage, and trunk adiposity versus Group B, demonstrating the effectiveness of combining UC with exercise and dietary intervention in reducing abdominal obesity in adolescents.

In another study, **Kiedrowicz *et al.*** [24] studied 60 women aged 25–35 years with abdominal obesity (BMI >30 kg/m²), randomly assigned to UC, radiofrequency (RF), or combined (RF/UC) treatment groups. Participants received 10 sessions, three times per week over 3–4 weeks, with each session consisting of a 20-minute abdominal application. Anthropometric and biochemical parameters were measured before treatment, after 10 sessions, and at 6-month follow-up. The study concluded that both ultrasound and radiofrequency treatments, especially when combined, effectively reduced abdominal fat and improved body contour, with effects maintained at 6 months.

Amr *et al.* [16] conducted a related investigation examining UC and cryolipolysis impacts on central adiposity among thirty participants (fifteen males and fifteen females) between forty-five and fifty-five years of age. Group A received eight UC sessions over one month, while Group B underwent a single cryolipolysis session during the same period. Both interventions resulted in significant decreases in BMI, abdominal fat percentage, and WC, with cryolipolysis showing slightly greater improvements. These findings indicate that UC can effectively reduce central obesity, though cryolipolysis may offer marginally enhanced outcomes.

In addition, the study by **Mohammadzadeh *et al.*** [25] involved 50 overweight women (BMI 25–29.9 kg/m²) aged 18–65 years. The intervention group received combined radiofrequency and UC treatments once a week for five weeks, while the control group followed a low-calorie diet. Both interventions significantly reduced waist and abdominal circumferences, but neither had a significant effect on serum C-reactive protein or oxidative stress markers.

Moreover, **Moravvej *et al*.** [26] conducted a study involving 28 consecutive participants (27 females and 1 male) with abdominal cellulite, aged approximately 37.8 ± 8 years. Participants underwent weekly sessions of focused ultrasound lipolysis combined with vacuum drainage for up to eight sessions. The study concluded that this treatment effectively reduced abdominal circumference, with an average reduction of 8.21 cm immediately post-treatment, which slightly decreased to 7 cm at the 3-month follow-up. However, some reversal of circumference reduction was observed over time.

Furthermore, the study by **Yousef *et al.*** [27] included 50 prediabetic obese female patients aged 25–40 years, presenting BMI measurements of 30–35 kg/m² and WC exceeding 88 cm. The researchers divided subjects into two groups: the control group received calorie-restricted nutrition (500 kcal daily) and aerobic training thrice weekly for twelve weeks, whereas the experimental group received the same diet and exercise plus UC therapy twice per week for 6 weeks. The study concluded that adding UC significantly enhanced weight loss, reduced BMI, WHR, and skinfold thickness, and improved fasting/postprandial glucose and HbA1c compared to the control group.

The significant improvement in all outcome measures that was noticed in group B can be attributed to WBV effects. **Milanese *et al.*** [28] investigated fifty obese women (average age 46.8 years, BMI 35.1 kg/m²) who completed a ten-week WBV training protocol. Subjects engaged in biweekly WBV sessions lasting fourteen minutes with five-minute rest periods, utilizing vibration frequencies of 40–60 Hz and amplitudes of 2.0–5.0 mm. The investigation established that WBV training significantly decreased BMI, total body and trunk adiposity, skinfold measurements, and body circumferences, while improving lower extremity strength compared to non-exercising control subjects.

Additionally, **Vissers *et al.*** [29] conducted a 6-month intervention combining WBV training with caloric restriction in 79 overweight and obese adults. Participants were assigned to WBV, aerobic fitness, diet-only, or control groups. The WBV group performed three 30-minute sessions per week at 30 Hz and 2 mm amplitude. The study concluded that WBV training with caloric restriction significantly reduced visceral adipose tissue, suggesting it may be an effective strategy for obese adults.

In addition, **Deng** [30] explored twelve-week whole-body vibration training (WBVT) program influences on body composition in obese female college students aged 18–21 years. Seventeen subjects participated in WBVT five times weekly for thirty-minute sessions, while nineteen controls maintained their usual lifestyle without intervention. Post-treatment evaluations demonstrated significant reductions in body fat mass, trunk fat mass, and body fat percentage, accompanied by an increase in muscle mass in the WBVT group. However, body weight and BMI exhibited no significant variations. These findings are in relative agreement with our study, suggesting that WBVT may constitute a valuable non-invasive intervention for improving body composition in young adult females with obesity.

Moreover, **Gobbi *et al.*** [31] included 41 obese participants (BMI ≥35 kg/m²) in a 3-week multidisciplinary inpatient rehabilitation program. Participants received low-intensity WBV sessions alongside fitness training, with posture monitored via an optoelectronic system. Primary outcomes were body composition, metabolic syndrome factors, functional activity, muscle strength, and life quality, while secondary outcomes included salivary irisin, testosterone, growth hormone, and IGF-1 levels. The study found significant increases in salivary irisin in the WBV group ($p < 0.01$), with insignificant changes in other metabolic, hormonal, or functional parameters, suggesting potential metabolic benefits of low-intensity WBV as an adjunct for obesity management.

Furthermore, **Maciejczyk *et al.*** [32] investigated the acute effects of a single WBV session on resting metabolic rate (RMR) and substrate utilization in healthy young women aged 20–30 years. Participants underwent a randomized crossover design with WBV and placebo sessions, during which RMR was measured at baseline, during vibration, immediately after, and one-hour post-vibration, and blood samples were collected. The study concluded that a single WBV session acutely increased RMR and altered substrate utilization (mainly carbohydrates and proteins), with RMR returning to baseline shortly after, suggesting potential metabolic benefits, although glucose and lipid concentrations remained unchanged.

STRENGTHS AND LIMITATIONS

Based on our understanding, this represents the initial investigation comparing the effects of UC and WBV on abdominal fat in obese adolescent females. Additional research strengths encompass the randomized methodology, objective assessment measures, and therapeutic intervention implementation by qualified physiotherapists. However, specific limitations should be acknowledged. Participants' psychological and physical conditions may have influenced their responses to treatment. Environmental factors could also have impacted the outcomes. Moreover, the study did not include longitudinal analysis to investigate the maintenance of results or potential metabolic and hormonal changes over time. These limitations should be considered in future studies.

CONCLUSION

In conclusion, both UC and WBV effectively reduced abdominal fat and improved body composition in obese adolescent females, with superior effect for the UC in reducing body weight, BMI, WC, WHR, skin fold thickness, and abdominal fat thickness, highlighting its potential benefits as a safe and efficient intervention for managing adolescent central obesity.

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