Response of Irritable Bowel Syndrome to Abdominal Fat Reduction

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KEYWORDS
Irritable Bowel Syndrome, abdominal fat, central obesity, high intensity focused ultrasound, FODMAPs diet.

ABSTRACT
Objectives: The study aimed to evaluate the response of Irritable Bowel Syndrome (IBS) among patients having central obesity to reducing abdominal fat using Focused Ultrasound (cavitation) in addition with aerobic exercise as well as a low calorie, low-FODMAPs diet. Methods: A total of 60 individuals, between the ages of 20 and 45, who were diagnosed with both irritable bowel syndrome (IBS) as well as abdominal obesity, having a body mass index (BMI) ranging from 30 to 39.9 kg/m², were divided into two groups of similar size by a random assignment process. Group A were given focused ultrasound cavitation accompanied by moderate aerobic exercise and a low calorie, low-FODMAPs diet over a period of three months, whereas Group B (control group) were given moderate aerobic exercise and a low calorie, low-FODMAPs diet only. Assessments of total body fat, abdominal fat, severity of IBS, as well as quality of life related to IBS were conducted prior to and after the study period. Results: Overall body fat mass, abdominal fat mass, IBS severity, and IBS quality of life were all significantly improved in both groups. All evaluated variables showed a highly significant improvement in favor of the study group when comparing the two groups. Conclusion: Focused Ultrasound (cavitation) in addition with aerobic exercise as well as a low calorie, low-FODMAPs diet cause more improvement of irritable bowel syndrome symptoms and quality of life.

1. Introduction

Irritable Bowel Syndrome (IBS) is a persistent gastrointestinal condition characterized by functional abnormalities. The condition is marked by abdominal pain accompanied by bloating and alterations in bowel patterns [1,2.] irritable bowel syndrome causes changes in patient lifestyle, but it is not life-threatening [3]. It was suggested that it affects about 5% to 20% of the global population [4,5,6,7]. IBS is more prevalent in females rather than males and is primarily diagnosed in patients under the age of 50. [8]. Obesity has been found to contribute to gastrointestinal problems, including IBS characterized by stomach pain and discomfort. Research has shown that the occurrence of IBS is more common in obese individuals compared to those with a normal body weight [9,10]. The prevalence of IBS among obese patients is higher in patients with visceral obesity. After adjustment of potential confounders of IBS, patients with abdominal obesity still have frequent symptoms of IBS[11, 12]. Central obesity and visceral adiposity as determined by VAT, VAT/SAT, as well as waist circumference are strongly correlated with IBS and considered a risk factor for IBS[11, 13]. Increased visceral adiposity was found to be associated with enhanced perception of luminal stimuli, dysmotility, as well as stomach pain, which are commonly observed in patients having IBS[14]. In certain circumstances, it becomes necessary to reduce localized subcutaneous adipose tissue using non-invasive methods. The common noninvasive tools used are cryolipolysis, low-level laser therapy (LLLT), radio frequency, as well as high-intensity focused ultrasound (HIFU) [15]. Ultrasound cavitation, also known as HIFU, is a technique that delivers focused ultra sound waves to certain subcutaneous tissue depths. HIFU ablates subcutaneous fat tissue by inducing molecular vibrations that increase the temperature of the surrounding tissue and accelerate cell death [16,17,18,19]. Beside the thermal effect of HIFU on adipose tissue, Non-thermal ultrasonic energy causes cavitation, which leads to fat cell lysis while protecting the surrounding vasculature[20]. Cavitation is a multifaceted phenomenon caused by mechanical energy that includes the formation, oscillation, expansion, and collapse of bubbles that liquefy fat and destroy tissue[21]. These fat cells are either eliminated by catabolic mechanisms or metabolized in the liver. As a result, using HIFU in

conjunction with exercise improves the fat cells' ability to metabolize and use them as fuel through the fatty acid oxidation pathway [22]. This is linked to improved fat oxidation through an improved hormonal response at the local (increased skeletal muscle irisin) as well as systemic (increased catecholamine and insulin sensitivity) levels [19, 23, 24]. Similar outcomes to invasive ultrasound liposuction can be achieved with non-invasive ultrasound cavitation regarding fat removal and body form. Still, it is somewhat less costly, safer, and has fewer risks [19, 25]. Additional benefits of non-invasive ultrasound cavitation include its lack of side effects as well as reduction of peri-procedural morbidity, which is frequent following liposuction surgery and includes anesthesia, infection, and scarring [26]. The authors propose that the implementation of focused ultrasound cavitation could enhance the overall severity of IBS by reducing abdominal fat. Based on the authors' current understanding, there is a lack of studies that definitively establish the correlation between reducing abdominal fat with focused ultrasound cavitation and the alleviation of symptoms associated with IBS. As a result, the objective of this study was to examine the impact of focused ultrasound cavitation, in conjunction with aerobic exercise as well as a low-calorie, low-FODMAPs diet, on the overall severity of IBS among patients having central obesity who underwent abdominal subcutaneous adipose tissue ablation. The results of this study can benefit individuals having abdominal obesity or IBS, as well as healthcare professionals, by offering insights into a non-invasive and efficient treatment for symptoms associated with abdominal obesity as well as IBS.

2. Materials and methods

Among the 75 patients who fulfilled the study's eligibility criteria, only 60 individuals, both male and female, participated in this parallel-group randomized controlled trial. Before commencing the study, ethical approval was obtained from the Institutional Review Board of the Cairo University Faculty of Physical Therapy (P.T.REC/012/004475). Subsequently, on November 23, 2022, approval was also granted by the Research Ethics Committee of the General Organization of Teaching Hospitals (No. HS000112). Before participating in the trial, the patients provided their assent by signing an informed consent form. May 2023 marked the beginning of the study's planning and recruitment. ClinicalTrials.gov has this study registered (NCT05879692, first release 18/05/2023). The real research was conducted from July 2023 to January 2024. All tests were conducted in accordance with the Declaration of Helsinki.

The participants in this trial were between the ages of 20 and 45, with a BMI ranging from 30 to 39.9 kg/m². They were diagnosed with IBS based on the Rome IV criteria, had a score of 75 to less than 300 on the Irritable Bowel Syndrome Severity Scoring System (IBS-SS), in addition a waist circumference above 88 cm for females and above 102 cm for males. The subjects were divided into two equal groups and given either focused ultrasound, LCD in conjunction with low FODMAPs as well as moderate aerobic exercise (Group A) or a LCD in conjunction with low FODMAPs as well as moderate aerobic exercise (Group B) as a control.

Following their registration, all eligible patients were divided into groups at random (1:1) using a random block randomization approach to select numbers blindly from sealed envelopes. The participants were grouped into A or B in sequential order. Anyone involved in the trial, including participants, outcome assessors, as well as the data analyzer, were unaware of the participants' group assignment. Everyone involved in the study—the patient, their caregiver, the researcher, and the person evaluating the results—was either unaware of or asked not to reveal their group assignment.

All the following conditions precluded participation: diminished neural sensitivity or neurological disorders; intrauterine devices or pacemakers; articular prosthesis; liver, kidney, or diabetes; carcinogenic or autoimmune diseases; localized abdominal scarring; skin diseases; hernias; pregnant women. Irritable Bowel Syndrome patients were excluded, as were those who had engaged in weight loss or exercise regimens during the preceding six months, as well as those with other recognized organic gastrointestinal illnesses.

The subjects were advised not to engage in any more physical activity throughout the trial, nor should they use any irritable bowel syndrome drugs or items that target weight loss or change how the skin looks (such as vitamin creams as well as retinoids). In addition, for about two months before the procedure, topical steroids were intentionally not used on the treatment site. This was done to evaluate any possible complications that may arise throughout and following the application of focused ultrasound cavitation, and to avoid any interference from topical steroids on the inflammatory response following the treatment.

Outcome measures

Two independent assessors, who were unaware of the group assignment, conducted measurements for each

outcome measure at the beginning of the study and again after three months.

Total body fat and abdominal fat measurement Dual-energy X-ray Absorptiometry (DXA), considered the most reliable method for assessing body composition in various clinical situations, is utilized to measure body fat [27,28]. A DXA device, Horizon Wi (S/N 303461M), made by HOLOGIC Co., UK was used.

IBS Severity. It was measured by IBS-SSS, considered a valid tool to assess IBS severity [29]. The assessment has five questions that evaluate the degree of stomach discomfort, the frequency of occurrence (measured as the number of days out of every 10 days), abdominal bloating, dissatisfaction with bowel habits, and the impact on QOL. Each question is scored on a scale of 0 to 500 [30, 31,32]. The severity of the condition was classified as mild (scores below 150), moderate (scores between 150 and 300), or severe (scores over 300) using the IBS-SSS score [4].

Quality of Life. The evaluation of QOL was conducted utilizing the irritable bowel syndrome Quality of Life Questionnaire (IBS-QOL) published by Patrick et al. in 1998 [32]. The 34 items on the (IBS-QOL) questionnaire evaluate patients' well-being across eight subscales: relationships (3items), avoiding foods (3 items), body image (4 items), social reaction (4 items), dysphoria (8 items), interfering with activity (7 items), Physical appearance (4 items), and sexual (2 items) [33, 34]. The responses are scored on a scale of 1 to 5, which determines the total QOL for each item. A 0–100 scale is created by averaging the scores; values around 100 indicate a higher quality of life, while those near 0 indicate the lowest quality of life among IBS patients [35].

Treatment procedures

During the 12-week trial, all patients in groups A and B adhered to a diet plan that combined a low- (FODMAP) diet to mitigate symptoms of IBS by the implementation of a LCD with the objective of weight reduction [36,37].

The LCD: was an equilibrated diet with a caloric content that was 10% less than each person's total energy consumption (or metabolic expenditure). It was determined individually based on each participant's needs and BMR[28]. The formula for BMR was the Harris-Benedict equation. The individuals' total energy requirements were calculated by multiplying their BMR with an activity factor of 1.2 [38]. The macronutrient ratios provided were 45–55% carbohydrates, 15–25% proteins, & 25–30% fat [39].

The low FODMAPs diet (LFD) includes foods that are low in fermentable oligosaccharides (FODMAPs), such as fructans (found in wheat, onion & garlic), galacto-ligosaccharides (found in pulses & legumes), disaccharides (such as lactose found in dairy products), monosaccharides (fructose over glucose, found in figs &honey), and polyols (such as sorbitol found in stoned fruit, mannitol found in cauliflower, as well as xylitol found in sugar-free gum) [1,2]. A LFD started with An elimination phase of four to eight weeks, during which all foods high in FODMAP were restricted and then gradually reintroduced based on tolerance, allowing for long-term customization of the diet [3]. There were no recommended dietary supplements. A certified and experienced dietitian closely supervised the participants' adherence to the diet plan through individual counseling sessions and diet regimen interviews. The group assignment was hidden from the dietician. For 12 weeks, every participant in both groups engaged in a supervised aerobic exercise regimen consisting of three times a week of moderately intense treadmill walking (12–14 on the Borg Scale) [40]. Throughout the trial, all subjects in both groups (A & B) were told to stay hydrated by drinking an adequate amount of water. Focused ultrasound cavitation was administered to subjects in group (A) Using the "Mabel 6 DUO. Ultra Cavitation Technology system manufactured by DAEYANG MEDICAL CO., KOREA." By directing targeted ultrasonic waves to the abdominal region, namely from the centre of the diaphragm to the line connecting both iliac crests below, as well as on both sides of the line extending from mid-axilla through the iliac crest. During the therapy session, the patient maintained a relaxed and reclined position. A 45W transducer with an 8.0 cm diameter and 45 W of power was used to deliver 40 kHz ultrasound pulsed waves. For 12 weeks, the focused ultrasound sessions lasted 30 minutes each, twice a week at intervals of typically three days.

3. Results

The data analysis was conducted using the Statistical Package for the Social Sciences computer programme, version 20 for Windows, developed by SPSS Inc. in Chicago, Illinois, USA.A significance level of $P \leq 0.05$ was determined significant. An unpaired t-test revealed that there was no substantial difference among the mean value of age as well as height of both groups (p= 0.911 and 0.961) respectively. The sex distributions of the two groups were not significantly different, according to the chi-square test (p =1) Table 1.

Table (1): Demographic data of subjects of both groups

Demographic data	Study group	Control group	t-value	p-value
Age (years)	35±6.8	34.9±6.9	0.112	0.911
Height (cm)	164.7±7.8	164.6±7.9	0.049	0.961
Sex distribution Males Females	N (%) 10 (33.3%) 20 (66.7%)	N (%) 10 (33.3%) 20 (66.7%)	χ^2= 0	1

Data was expressed as mean ± standard deviation, p-value: Significance.

We checked the data for outliers, homogeneity of variance, and the assumption of normality. Every one of the observed variables followed a normal distribution, according to the Kolmogorov-Smirnov test (p>0.05). To examine how the therapy affected the assessed variables, MANOVA was used. Time and treatment both had substantial main effects, and the interaction effect of treatment and time was statistically significant (p = 0.001) (Table 2).

Table 2. MANOVA table for the effect of treatment on the measured variables

	F value	p-value	η2
Interaction effect (treatment * time)	198.6	0.001	0.964
Effect of time	841.5	0.001	0.991
Effect of treatment	23.59	0.001	0.761

F value: Mixed MANOVA F value p value: Probability value η2: Partial eta square

There was a substantial difference in all outcome indicators between each group before and after therapy. There was no substantial difference among the groups before treatment, but there was a substantial difference among the groups after treatment, favouring the study group (table 3,4).

Table (3): Mean ±SD of IBS pre as well as post-study for both groups.

	Study group	Control group	f-value	P-value	η2
IBS-SSS Pre-study Post-study % of change P-value	 258.7 ± 31.2 90.6 ± 19.2 65% 0.001*	 258.2± 32.6 202.4 ± 36.9 21.6% 0.001*	 0.005 216	 0.946 0.001*	 0.001 0.788
IBS-QOL Pre-study Post-study % of change P-value	 47.9 ± 7.5 91.2 ± 3.5 90% 0.001*	 47.1 ± 8 58.2 ± 9 23.6% 0.001*	 0.152 347.2	 0.698 0.001*	 0.003 0.857

Data was represented as mean ± standard deviation, *: significant, η2: Partial eta square.

Table (4): Mean ±SD of total body fat and abdominal fat pre and post-study of both groups.

	Study group	Control group	f-value	P-value	η2
Total body fat (gram) Pre-study Post-study % of change P-value	 46281 ± 5227 31995 ± 3508 31% 0.001*	 45718± 5585 36924 ± 4240 19.2% 0.001*	 0.162 24	 0.688 0.001*	 0.003 0.293
Abdominal fat (gram) Pre-study Post-study % of change P-value	 4146 ± 632 1964 ± 346 52.6% 0.001*	 4023 ± 746 3437 ± 761 14.6% 0.001*	 0.480 93	 0.491 0.001*	 0.008 0.616

Data was represented as mean ± standard deviation, *: significant, η2: Partial eta square

4. Discussion

This study set out to determine whether reducing belly fat alleviates IBS by using Focused Ultrasound (cavitation) as a noninvasive procedure in addition with aerobic exercise as well as a low-caloric, low-FODMAP diet among patients having central obesity.

The study demonstrated that focused ultrasound cavitation is a safe as well as effective noninvasive method for decreasing subcutaneous fat thickness in the treated area. After utilizing a single ultrasound cavitation therapy, a 2 cm decrease in abdominal circumference was noted [41]. In addition, HIFU was determined to be a safe and

effective way to reduce subcutaneous adipose tissue; patients reported high levels of satisfaction (between 47% and 86%) with the therapy, and there were no reported local adverse effects or prolonged recovery times. [42]. In a recent study, the efficacy and safety of HIFU for abdominal obesity were assessed. A reduction of 3.43 cm in the average waist circumference (WC) was documented. Which is statistically significant, there was a progressive reduction in WC as well as fat thickness due to the treatment. The researchers provided evidence that by removing unwanted adipose tissue and stimulating the production of new collagen, targeted ultrasonic cavitation is a safe therapeutic approach for reducing abdominal obesity [43].

Additionally, Taha et al., 2021 discovered a statistically significant reduction in the study group's waist circumference in comparison to the control group and came to the conclusion that focused ultrasonic cavitation in conjunction with aerobic exercise is an effective non-invasive approach to reduce abdominal obesity. [19]. Similarly, at 12 weeks after a single HIFU treatment, Shek et al., 2014 discovered a decrease in WC of almost 2.1 cm. The study attested that, in contrast to liposuction, HIFU has much less downtime and infection risk. The most frequent side effects were soreness, bruising, and redness; they were all generally temporary and went away on their own [44]. In addition, Guth et al. (2017) examined the level of safety and efficacy of HIFU for subcutaneous fat reduction within 30 minutes following a single treatment and stated that HIFU is an effective and safe technique for diminishing abdominal fat [45]. Additionally, Lee et al. (2017) employed ultrasound images to study the tissue's initial responses to focused ultrasound. They discovered round-to-oval ablation thermally injured zones in the fat (subcutaneous) layers of the thigh as well as abdomen of a human cadaver [21]. In contrast to these findings, Moravvej et al. (2015) observed that while the abdomen circumference decreased by 1.8 cm throughout the focussed ultrasound session, additional sessions did not cause the circumference to drop any further. This can be attributed to the lack of nutritional alteration throughout the treatment, as well as other limitations such as the absence of a randomised control group [46]. The fundamental process of focused ultrasonic cavitation involves the utilization of ultrasound energy to cause both the destruction of subcutaneous fat tissues and dermal portions by inducing coagulation necrosis along with acoustic cavitation specifically in the targeted tissues [47]. Ultrasound irradiation causes gaseous nuclei to rapidly expand, generating cavitation bubbles through pressure-induced forces within cellular as well as subcellular structures. Abrupt breakdown of the acoustic cavitation transfers enormous amounts of energy to nearby structures [48]. Moreover, composite molecules shake in response to ultrasonic vibrations, resulting in coagulation necrosis and frictional heat [21]. Fat cells lyse as a result of this cavitation, but the surrounding vasculature is preserved [49]. Visceral fat secretes a number of adipokines and cytokines that cause chronic systemic inflammation and visceral hypersensitivity among individuals with IBS, which results in clinical symptoms of dysmotility and pain. These factors, along with the strong correlation between increased severity of IBS symptoms and obesity, particularly abdominal obesity, can lead to elevated intra-abdominal pressure due to mechanical interference with GI motility along with an excessive amount of intra-abdominal fat [11]. The findings of the study revealed that reduction of abdominal fat by focused ultrasound cavitation led to improvement of IBS symptoms mechanically by decreasing intra-abdominal pressure which enhanced GI motility as well as by decreasing systemic inflammation and visceral hypersensitivity and pain. In this study, focused ultrasound treatment in addition with a low-FODMAP, low-calorie diet and moderate aerobic exercise resulted in greater improvement of IBS symptoms as well as QOL and reduction of both excess intra-abdominal and total body fat in obese participants. There was either no discomfort or just minimal discomfort reported during and after the treatment sessions, along with no side effects were noted throughout the trial.

5. Limitation

One of the study's limitations was not having of a group that obtained focused ultrasound cavitation exclusively, as it is essential to promote lipolysis through a low-calorie diet and/or exercise in addition to the low-FODMAPs diet to improve intestinal distention and GI motility, and lack of longer follow-up assessments of the intervention’s effects. Further studies are required to be conducted on a larger sample to confirm the findings’ generalization.

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