Hindawi
Dermatologic Therapy
Volume 2024, Article ID 9179759, 9 pages
https://doi.org/10.1155/2024/9179759

Research Article

Efficacy of Radiofrequency Diathermy versus Focused Ultrasound Therapy, Both Combined with Intermittent Pneumatic Compression, for Edematous Fibrosclerotic Panniculopathy Treatment: A Randomized Intrasubject Assessor-Blind Trial

V. Mihaiescu-Ion,[1,2] **J. A. Moral-Munoz**,[1,2] **D. Lucena-Anton**,[1,2] **F. J. Martin-Vega**,[1] **M. Rebollo-Salas**,[3] **and I. M. Carmona-Barrientos**[1,2]

[1]*Department of Nursing and Physiotherapy, University of Cadiz, Cadiz, Spain*
[2]*Institute for Biomedical Research and Innovation of Cadiz (INiBICA), University of Cadiz, Cadiz, Spain*
[3]*Department of Physiotherapy, University of Seville, Seville, Spain*

Correspondence should be addressed to J. A. Moral-Munoz; joseantonio.moral@uca.es

Received 22 September 2023; Revised 23 March 2024; Accepted 30 March 2024; Published 27 April 2024

Academic Editor: Sebastian Yu

Background. Edematous fibrosclerotic panniculopathy (EFP), commonly known as cellulite, is a cosmetic concern affecting a large percentage of women. Radiofrequency diathermy (RFD) and focused ultrasound (FUS) are noninvasive treatments proposed for the reduction of EFP. *Objective*. This study aimed to evaluate the efficacy of RFD versus FUS, both combined with intermittent pneumatic compression (IPC) for the treatment of EFP in female thighs. *Methods*. A randomized intrasubject assessor-blind trial was conducted (NCT03474523) on 40 lower limbs of 20 women with EFP grades I, II, or III according to the Nürnberger & Müller scale. Each lower limb was randomly assigned to receive either seven RFD sessions or seven FUS sessions, both combined with IPC. Measurements were collected at baseline and post-treatment, including lower limb circumferences at different levels, weight, grade of EFP, and physical activity level. *Results*. Both RFD and FUS treatments, both combined with IPC, showed significant intragroup reduction in thigh circumference measurements for RFD at 15 cm ($p = 0.001$), 20 cm ($p = 0.024$), and midpoint ($p = 0.008$) and for FUS at 15 cm ($p = 0.001$), 20 cm ($p = 0.010$), midpoint ($p = 0.008$), 30 cm ($p = 0.020$), and 40 cm ($p = 0.048$). No statistically significant differences were observed between the two treatments. Weight did not change with treatment, and physical activity levels did not significantly affect EFP improvement. *Conclusion*. Both RFD and FUS, combined with IPC, were effective noninvasive methods for treating EFP. This study found that there was no significant difference between RFD and FUS in terms of efficacy in reducing EFP in the thighs. Therefore, both techniques can be used to treat EFP from a clinical perspective. Further studies with objective measurements are required to confirm these results and to guide clinical decision-making. This trial is registered with NCT03474523.

1. Introduction

Edematous fibrosclerotic panniculopathy (EFP), commonly known as cellulite, is a multifactorial condition affecting 80–90% of postpubertal women [1]. Its pathogenesis remains poorly understood, but clinical evidence indicates a central role for fibrous septae in EFP pathophysiology [2]. It is believed that an important factor in the development of EFP is the number and type of septae since clinical studies targeting collagen-rich fibrous septae in EFP dimples using mechanical, surgical, or enzymatic approaches have shown promising results in improving skin topography and reducing the appearance of EFP. It is considered a major cosmetic problem for women in our society, where an esthetic body is associated with beauty and social acceptance [3–5]. It can have a negative impact on the emotional and

social development of women who internalize this idea [2, 6, 7]. Thus, the treatment of this condition is a major concern for improving the well-being of women.

Radiofrequency diathermy (RFD) and focused ultrasound (FUS) are used as options for noninvasive interventions against EFP [8]. RFD devices deliver electromagnetic energy to heat the skin and subcutaneous tissue, while FUS devices deliver mechanical energy to produce cavitation and acoustic effects. Both techniques induce collagen remodeling, adipocyte apoptosis, increased blood flow, and reduced edema [8].

RFD has different effects on the dermis and subcutaneous tissues, stimulating new collagen and elastin fiber synthesis by thermal effects, causing local hyperemia, and inducing adipocyte apoptosis [8, 9]. Van der Lugt et al. [10] analyzed biopsy connective tissue samples of the dermis immediately after RFD application and found lysis of the adipocyte membrane. Otherwise, FUS uses mechanical energy through a rhythmic succession of compression and expansion waves focused on the subcutaneous area, collapsing cavities, and degrading adipocytes [11–14]. After the application of both techniques, it is of vital importance to improve the drainage and vascularization of the treated area. Intermittent pneumatic compression (IPC) is a widely used technique for this purpose. According to current scientific evidence [15], IPC provokes fluid movement after 3 h, 1 h, and even 1–3 minutes. Current IPC devices attempt to mimic manual techniques of the therapist's hands using low pressure with short repetitive applications that move progressively along a limb to stimulate drainage [16]. Synthesis of the available research indicates that RF and FUS treatments represent a promising avenue for reducing EFP. Studies examining different RF modalities, including bipolar, subcutaneous microneedle, and unipolar devices, consistently report significant reductions in circumference and EFP severity, with sustained improvements over time [17–19]. In addition, FUS is also emerging as a promising treatment, offering efficacy in improving body contouring and skin tightening [20]. However, to the best of our knowledge, no studies have compared RFD with FUS, both combined with IPC, in the treatment of EFP. Therefore, the main aim of this study was to evaluate the efficacy of RFD combined with IPC versus FUS combined with IPC in the treatment of EFP in female thighs.

2. Materials and Methods

2.1. Trial Design. This study was a longitudinal randomized intrasubject assessor-blind trial in which both experimental groups corresponded to the lower limbs of the same subject randomly assigned to each group. One lower limb received RFD combined with IPC treatment, and the contralateral limb received FUS combined with IPC. Both treatments were simultaneously administered to the subjects. The study was performed in compliance with the Helsinki Declaration of Human Rights and approved by the Research Ethics Committee of the province of Cádiz, Spain (0989-N-15, 09/06/2017). This study was reported according to the CONSORT 2010 statement for reporting within-person randomized trials [21] and was registered in the Clinical Trials database (NCT03474523).

2.2. Participants. The subjects included in the study met the following eligibility criteria: (i) female, (ii) aged between 18 and 40 years, and (iii) grade of EFP I, II, or III on the Nürnberger & Müller classification scale [22]. All contraindications according to the techniques used were considered, and patients were excluded. Data were collected at the Faculty of Nursing and Physiotherapy from the University of Cádiz, Cádiz (Spain) from October 2017 to April 2018. All patients signed and provided informed consent after being informed of the study protocol.

2.3. Interventions. Two experienced physiotherapists in the treatment of EFP performed the interventions. The sessions were performed simultaneously on both lower limbs, with 40 min of RFD and 45 min of FUS, during seven treatment sessions twice a week. IPC was applied using a Pulstar S2 device (Enraf-Nonius, Rotterdam, The Netherlands), always applied at the end of the treatment session in the preestablished "cellulite" mode, consisting of 30 min with 35 mmHg pressure, 35 s time compression, 15 s delay, and speed 9, and applied from distal to proximal. The maximum speed is 10, which corresponds to the speed at which the accessories inflate, and the pressure gradient increases. The higher the speed, the higher the gradient.

2.4. Radiofrequency Diathermy. RFD was applied using a Biodiatermia Lavatron 250 device (Indesa Innovation and Sanitary Development SL, Madrid, Spain) at a frequency of emission of 470 kHz ± 10% and a maximum output power of 250 W ± 10%. We used the device for bipolar and continuous emission with a large return electrode placed on the opposite side, that is, the abdominal region in the prone position for posterior thigh and buttock treatment and the mid-lower back in the supine position for anterior thigh treatment. Both active resistive and capacitive electrodes were used in manual mode, first in a circular motion to warm the area and then in a longitudinal motion from distal to proximal. The session duration was 40 min at approximately 70% intensity level, distributed between the anterior, lateral, medial, and posterior sides of the thigh as well as the buttock. A resistive electrode was used in manual mode for the first 30 min, followed by the capacitive electrode in automatic mode for the last 10 min. The temperature was maintained between 40 and 43 degrees Celsius because the device has a sensor that automatically regulates it in real time. The intervention comprised seven treatment sessions twice a week for one lower limb.

2.5. Focused Ultrasound. During the same treatment session, we applied FUS with the Multicell Plus device (Indesa Innovation and Sanitary Development SL, Madrid, Spain) at a resonance frequency of 34 kHz ± 4.75 kHz acoustic waves on the other lower limb. First, we applied the plane head in

the continuous mode to act in depth. The maximum output power of the device was 100 Wp (watt-peak) ± 2%. We started with 50% intensity and worked to 70% once the patient was accustomed, dedicating 5 min for each 10 cm^2 area, without exceeding a 40–45 min session time. In the last 10 min, we replaced this with the focal head for a more superficial action. Skin folds were prepared for better application. By creating a fold in the skin, ultrasound energy is concentrated in this specific area, allowing for greater precision in the EFP treatment. This means that specific areas can be treated more effectively while avoiding damage to surrounding tissues. The intervention comprised seven treatment sessions twice a week for the opposite lower limb.

2.6. Outcomes. Anthropometric measures were registered from the participants, such as age, weight, height, and body mass index (BMI). Weight measurements were performed using standardized weighing scales that were regularly calibrated for accuracy. The participants were instructed to remove their shoes and heavy clothing before weighing. Height measurements were performed using a stadiometer. The participants were asked to stand straight without shoes, with their backs against the stadiometer. Finally, the BMI was calculated for each participant by dividing the weight in kilograms by the square of the height in meters.

The EFP grade was evaluated according to the Nürnberger and Müller scale [22] over the thigh and gluteal region by a blinded assessor at the beginning and end of the intervention. In addition, the blinded assessor collected thigh circumference measurements. Three measurements were taken at each point, and the average was calculated to obtain the final measurement for each marker. Measurements were similarly performed with the patient in the anatomical position pre- and postintervention. The markers were set as follows: (a) circumference 15 cm below the anterior superior iliac spine (ASIS) toward the patella's upper pole, (b) circumference 20 cm below the ASIS toward the patella's upper pole, (c) circumference at the midpoint between the ASIS and the patella's upper pole, (d) circumference 30 cm below the ASIS toward the patella's upper pole, and (e) circumference 40 cm below the ASIS toward the patella's upper pole.

Finally, the International Physical Activity Questionnaire-short form (IPAQ-SF) was reported. It is a self-report measure of physical activity used to assess physical activity levels in adults, which has acceptable reliability and validity [23, 24].

Throughout the process, trained research staff supervised the measurements and ensured adherence to standardized protocols. Data obtained from each participant were recorded accurately and securely for subsequent analysis.

2.7. Sample Size. The sample size for this study was determined using EPIDAT 4.2. [25]. It was based on a priori power analysis to ensure sufficient statistical power to detect the expected difference between treatments. Based on an expected minimum difference of 1.71 cm and a standard deviation (SD) of 2.20 cm [26], a confidence level of 95%, and a statistical power of 90%, 18 pairs (36 lower limbs) were required. A correlation coefficient between the initial and final measurement of 0.8 was established, and a follow-up loss rate of 20% was estimated. A nonprobabilistic consecutive sampling approach was used to select the sample while checking the inclusion criteria.

2.8. Randomization. Random group assignment of each lower limb (right or left) to the RFD and FUS groups was performed using EPIDAT [25] considering 20 right lower limbs. The opposite treatment was applied to the corresponding left limb. We then contacted each volunteer for the first appointment to explain the procedure and provide informed consent. Once all documents were signed, we proceeded with data collection.

2.9. Blinding. To minimize bias, an assessor-blinded design was used in this study. Because patients received both interventions simultaneously, it was not possible to blind them or therapists. However, the assessor who evaluated the outcomes was blinded to the treatment group allocation, which reduced the risk of biased assessments and ensured the reliability and validity of the study results. A unique identification number was assigned to each patient, and the assessor was not provided any information about the treatment received by each patient.

2.10. Statistical Analysis. Statistical analyses conducted in this study were performed using SPSS 24.0. Descriptive analysis was performed to summarize the data and provide mean and SD values for continuous variables and percentages for categorical variables. The dependent Student's *t*-test examined within-group differences pre- and postintervention, with Cohen's *d* used to determine effect sizes. The independent Student's *t*-test was used to assess differences between independent groups, while the Mann–Whitney test was used to handle nonparametric data. The Kolmogorov–Smirnov test was used to determine normality. Rank-biserial correlation was used to analyze the association between dichotomous variables. Correlations explored the relationships between age, height, weight, BMI, and differences in thigh circumference. Finally, a chi-squared contrast was used to examine the association between EFP grade and physical activity level. All statistical tests were two-tailed, and the results were considered significant at $p \leq 0.05$.

3. Results

3.1. Descriptive Analysis. The analyzed data comprised 20 women evaluated using the Nürnberger & Müller scale for determining the grade of EFP (Figure 1). The mean age of the participants was 25.35 years (SD = 7.34), with an average weight of 59.27 kg (SD = 7.93), height of 1.63 meters (SD = 0.05), and BMI of 22.20 (SD = 2.49). According to the EFP grade, 50% of the sample had Grade II, and only 10% had Grade III. Furthermore, 45% reported moderate activity

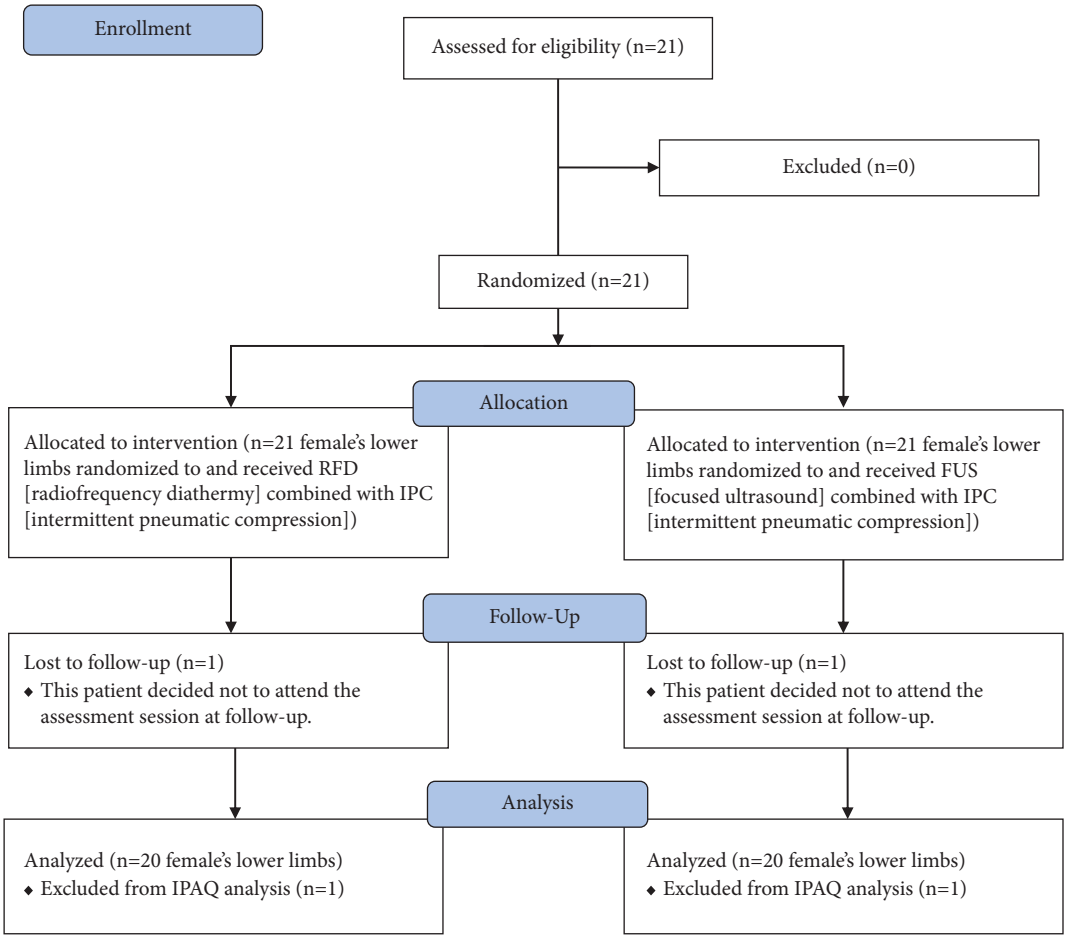

Figure 1: Flow diagram according to the CONSORT 2010 statement for reporting within-person randomized trials.

and 35% reported high levels (Table 1). However, it should be noted that there was a loss in the collection of IPAQ data, so for this variable, there would be 19 women.

3.2. Differences Intra- and Intergroup. The results in Table 2 show statistically significant improvements in both treatments compared with the baseline measurements. At circumferences of 15 cm, 20 cm, and the midpoint, both RFD combined with IPC and FUS combined with IPC showed statistically significant intragroup differences ($p < 0.05$), indicating their effectiveness in improving EFP. At 30 and 40 cm circumferences, only RFD combined with IPC exhibited a statistically significant intragroup difference. Weight and BMI measurements were available for the baseline and RFD post-treatment groups, and no statistically significant differences were detected ($p > 0.05$).

3.3. Correlations between Outcomes. Table 3 shows the correlation coefficients (Rho values) between the variables (age, height, weight, and BMI) and differences (post-treatment-baseline) in thigh circumference measurements. The differences in thigh circumference showed a consistent pattern of changes across different levels and with both treatments. Notably, there were significant correlations between the differences in thigh circumference and BMI, indicating that changes in thigh circumference may be associated with variations in BMI.

3.4. Level of Physical Activity. No statistically significant differences were observed in physical activity levels, baseline parameters, or post-treatment (Table 4).

3.5. Adverse Events. Finally, concerning adverse events, minor bruises appeared in some participants' thighs after the first FUS session but disappeared in a few days and did not reappear. Other patients noted slight darkening of skin pigmentation on the RFD application area, such as sun tanning, which disappeared from one session to another.

4. Discussion

Our results showed that both RFD combined with IPC and FUS combined with IPC were effective in the treatment of EFP, although no statistically significant intergroup differences were observed. Nevertheless, FUS combined with IPC showed better significant results than RFD combined with IPC. Although RFD combined with IPC obtained significant findings in thigh circumference measurements at higher

Table 1: Baseline information ($N = 20$ women).

Age [Mean ± SD]		25.35 ± 7.34
Weight [Mean ± SD]		59.27 ± 7.93
Height [Mean ± SD]		1.63 ± 0.05
BMI [Mean ± SD]		22.20 ± 2.49
Grade of EFP [*N* (%)]	Grade I	8 (40%)
	Grade II	10 (50%)
	Grade III	2 (10%)
IPAQ [*N* (%)]	Low	3 (15%)
	Moderate	9 (45%)
	High	7 (35%)
	Lost	1 (5%)

SD: standard deviation; *N*: sample; BMI: body mass index; IPAQ: International Physical Activity Questionnaire; EFP: edematous fibroblastic panniculopathy.

Table 2: Intra- and intergroup differences for RFD combined with IPC and FUS combined with IPC.

Thigh circumferences	Baseline $N = 20$		Post-treatment $N = 20$		Intragroup differences				Intergroup differences	
	RFD	FUS	RFD	FUS	RFD		FUS		*P*	EF
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	*P*	EF	*P*	EF		
15 cm	57.78 ± 4.53	57.52 ± 4.99	56.80 ± 4.42	56.45 ± 4.47	**0.001**[a]	0.927[b]	**0.001**[a]	0.983[b]	0.789[c]	0.085[b]
20 cm	55.66 ± 4.77	55.35 ± 4.93	54.96 ± 4.47	54.53 ± 4.44	**0.024**[a]	0.547[b]	**0.010**[a]	0.637[b]	0.776[c]	0.091[b]
Midpoint	54.42 ± 4.27	54.23 ± 4.44	53.81 ± 4.10	53.55 ± 3.88	**0.008**[a]	0.660[b]	**0.008**[a]	0.666[b]	0.793[c]	0.083[b]
30 cm	48.00 ± 4.08	48.04 ± 4.27	47.43 ± 3.77	47.18 ± 3.82	0.098[a]	0.389[b]	**0.020**[a]	0.568[b]	0.538[c]	0.196[b]
40 cm	39.96 ± 0.61	40.01 ± 2.92	39.52 ± 2.67	39.35 ± 2.82	0.156[a]	0.330[b]	**0.048**[a]	0.472[b]	0.632[c]	0.153[b]
Weight	59.27 ± 8.04		60.02 ± 8.34		—	—	—	—	0.300[c]	0.245[b]
BMI	22.20 ± 2.53		21.35 ± 5.6		—	—	—	—	0.709[d]	0.100[e]

N: sample; BMI: body mass index; SD: standard deviation; RFD: radiofrequency diathermy; FUS: focused ultrasound therapy; EF: effect size. [a]Dependent Student's *t*-test; [b]Cohen's d; [c]independent Student's *t*-test; [d]Mann–Whitney test; [e]rank biserial correlation. *Note.* Significant results ($p < 0.05$) were shown in bold.

levels (15 cm and 20 cm below ASIS) and at the midpoint, FUS combined with IPC showed significant changes at all measurement levels.

Our results are consistent with those of De la Casa-Almeida et al. [27, 28] and Albornoz-Cabello et al. [3], who reported the effects of RFD on thigh circumference. The first one used bipolar static RFD local application on the thighs, followed by bipolar RFD segmental static, showing that both produced statistically significant changes at higher levels (at 15 cm and 20 cm below the ASIS) with no significant difference between the two types of application. The second one applied monopolar RFD and measured the circumferences at the trochanter areas and at 15, 20, and 25 cm below the ASIS. They obtained significant improvements only in the trochanter. These authors concluded that De la Casa-Almeida et al. [27, 28] obtained better improvements because of the bipolar static application modality, which had a systemic effect. The penetration when using a bipolar electrode is more superficial than on a monopolar application, so the action could be focused on EFP [10]. Regarding the effectiveness of FUS use, to our knowledge, no studies have analyzed thigh circumference reduction, but there is a study [14] that measured a reduction in abdominal fat, reporting a reduction of 8.21 cm in abdominal circumference. Therefore, this technique appears to be effective in reducing EFP.

FUS combined with IPC showed significant differences in all thigh circumferences. The differential effects of FUS and RFD on different circumferences of the thighs for EFP reduction could be attributed to their different mechanisms of action and penetration depths. In this way, FUS works by delivering high-intensity ultrasound waves to targeted areas beneath the skin [20]. The energy from ultrasound can penetrate deep into the subcutaneous fat layer, reaching the fibrous bands responsible for EFP formation throughout the entire thigh [29], allowing for a more comprehensive treatment that addresses EFP. Furthermore, RFD employs electromagnetic waves to generate heat within the skin [30]. However, the penetration depth of RFD waves is relatively shallow compared to that of FUS. Energy tends to be more concentrated in the upper layers of the skin [28], specifically targeting superficial fat and collagen fibers.

Analyses of the correlations between age, height, weight, BMI, and differences (post-treatment vs. baseline) in circumference measurements revealed a consistent pattern of changes in thigh circumference at different levels and with both treatments. No significant correlation was found between weight and differences in thigh circumferences. Similarly, De la Casa-Almeida et al. [27] did not find a relationship between weight loss and EPF improvement after RFD application. The same authors in another study [28] found a significant correlation between pre- and

Table 3: Correlation between physical activity level and pre- and postintervention thigh circumference measurements.

		Age	Height	Weight	BMI	Difference 15 cm RFD	Difference 20 cm RFD	Difference midpoint RFD	Difference 30 cm RFD	Difference 40 cm RFD	Difference 15 cm FUS	Difference 20 cm FUS	Difference midpoint cm FUS	Difference 30 cm FUS	Difference 40 cm FUS
Age	Rho	—													
	P	—													
Height	Rho	−0.139	—												
	P	0.558	—												
Weight	Rho	−0.187	**0.484**	—											
	P	0.430	**0.030**	—											
BMI	Rho	−0.099	0.091	**0.867**	—										
	P	0.679	0.704	**<0.001**	—										
Difference 15 cm RFD	Rho	0.063	0.041	−0.202	−0.276	—									
	P	0.793	0.864	0.394	0.239	—									
Difference 20 cm RFD	Rho	−0.157	0.427	−0.049	−0.310	**0.605**	—								
	P	0.508	0.060	0.838	0.183	**0.005**	—								
Difference midpoint RFD	Rho	−0.273	0.387	−0.077	−0.368	**0.694**	**0.820**	—							
	P	0.245	0.092	0.748	0.111	**<0.001**	**<0.001**	—							
Difference 30 cm RFD	Rho	−0.050	0.395	−0.184	**−0.448**	**0.561**	**0.785**	**0.780**	—						
	P	0.834	0.085	0.439	**0.049**	**0.010**	**<0.001**	**<0.001**	—						
Difference 40 cm RFD	Rho	0.090	**0.457**	−0.035	−0.307	**0.490**	**0.756**	**0.682**	**0.892**	—					
	P	0.705	**0.043**	0.885	0.188	**0.028**	**<0.001**	**<0.001**	**<0.001**	—					
Difference 15 cm FUS	Rho	−0.275	0.069	−0.096	−0.186	**0.546**	**0.504**	0.402	0.364	0.414	—				
	P	0.241	0.771	0.689	0.429	**0.013**	**0.025**	0.079	0.115	0.071	—				
Difference 20 cm FUS	Rho	−0.246	0.402	−0.214	**−0.550**	**0.630**	**0.740**	**0.762**	**0.738**	**0.674**	**0.645**	—			
	P	0.296	0.079	0.366	**0.013**	**0.003**	**<0.001**	**<0.001**	**<0.001**	**0.002**	**0.003**	—			
Difference midpoint cm FUS	Rho	0.025	0.118	−0.366	**−0.469**	**0.571**	**0.605**	**0.513**	**0.562**	**0.496**	**0.650**	**0.668**	—		
	P	0.916	0.621	0.113	**0.038**	**0.009**	**0.006**	**0.021**	**0.011**	**0.028**	**0.002**	**0.002**	—		
Difference 30 cm FUS	Rho	−0.128	0.235	−0.343	**−0.574**	**0.593**	**0.764**	**0.736**	**0.844**	**0.693**	**0.450**	**0.690**	**0.493**	—	
	P	0.590	0.319	0.139	**0.009**	**0.006**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.048**	**0.001**	**0.029**	—	
Difference 40 cm FUS	Rho	0.090	0.349	−0.332	**−0.608**	**0.653**	**0.657**	**0.708**	**0.753**	**0.647**	0.337	**0.743**	**0.602**	**0.842**	—
	P	0.705	0.131	0.152	**0.005**	**0.002**	**0.002**	**< 0.001**	**< 0.001**	**0.003**	0.147	**< 0.001**	**0.006**	**< 0.001**	—

BMI: body mass index; RFD: radiofrequency diathermy; FUS: focused ultrasound therapy. *Note.* Significant results ($p < 0.05$) were shown in bold.

Table 4: Association between the grades of EFP and level of physical activity.

	Baseline $N = 19$				Post-treatment $N = 19$			
	IPAQ Low	IPAQ Medium	IPAQ High	P	IPAQ Low	IPAQ Medium	IPAQ High	P
No EFP	0	0	0	0.355[a]	1	1	2	0.956[a]
Grade I	0	3	4		1	4	2	
Grade II	2	5	3		1	3	2	
Grade III	1	1	0		0	1	1	

N: sample; EFP: edematous fibrosclerotic panniculopathy; IPAQ: International Physical Activity Questionnaire. [a]Chi-square contrast.

postintervention weight, but this was associated with the variable cellulite severity scale. Furthermore, no correlation between body weight and cellulite treatment was found by Adatto et al. [31] for acoustic wave application, Fritz et al. [9] for simultaneous application of monopolar radiofrequency and local pressure, and Ferraro et al. [32] for shock waves and cryotherapy. Conversely, the differences in thigh circumference and BMI were significantly correlated, but they were not in concordance with the results reported by Moravvej et al. [14], who found no correlation between FUS and BMI. In our study, the results may be because BMI is calculated using a person's weight and height, which may better reflect body composition than weight.

Concerning the level of physical activity and grade of EFP, our study did not find a significant relationship between these levels, either before or after treatment. Thus, the main cause of cellulite is multifactorial, including altered sensitivity to estrogen, damage to the microvasculature of the dermis and subcutaneous tissue, and differences in the architecture of adipose tissue in men and women [33]. Therefore, it is reasonable that the level of physical activity by itself may not have such a large influence on the onset and decline of EFP. Conti et al. [34] stated that EFP is a complex condition and that some treatments, such as weight loss programs, have different effects on individuals; the majority experimented with an improvement, but the condition worsened for others. Therefore, further studies are needed to determine the relationship between physical activity and EFP.

4.1. Limitations and Strengths. The lack of treatment guidelines and comparative analyses between the two electrotherapy modalities analyzed were limitations. Furthermore, we used scales and questionnaires to measure the different outcomes; therefore, more objective measurements are needed to enrich our knowledge of these interventions. Other limitations were related to baseline differences that may exist in the amount of EFP in each lower extremity and the use of IPC in both groups, making it difficult to determine how much of the observed benefit was due to the isolated use of IPC and how much was added by the combination of RFD and FUS.

Conversely, a major strength of this study is its inclusive approach, as it targeted women between the ages of 18 and 40 years and included all grades of EFP and physical activity levels, which increases the generalizability of the findings. Moreover, this clinical trial stands out as a pioneering effort, as it is the first to compare two different electrotherapy treatments, RFD and FUS combined with IPC. It provides valuable insights into the efficacy of these interventions and serves as a basis for further research in this area.

5. Conclusions

In conclusion, the results of this study suggest that both RFD and FUS combined with IPC produce significant changes in the thigh circumference. However, no significant changes in weight or BMI were observed.

While no significant difference was found between the two treatments, it can be concluded that FUS significantly decreased circumferences at all levels of the thigh, whereas RFD only decreased circumferences in the upper thigh area. FUS can penetrate deeper into the skin, making it better suited for treating deeper layers of EFP. Furthermore, the level of physical activity did not appear to be significantly associated with the EFP grade, either before or after treatment.

Therefore, from a clinical point of view, both techniques can be chosen for the treatment of EFP, although it seems that FUS would be more suitable for the treatment of deeper layers. Nevertheless, our results do not shed light on the superiority of one technique over another. Considering these findings, future studies employing more objective assessment methods are needed to confirm the efficacy of the two treatments and to provide a better basis for clinical decision-making.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

The study was performed in compliance with the Helsinki Declaration of Human Rights and approved by the Research Ethics Committee of the province of Cádiz, Spain.

Consent

All patients signed and provided informed consent after being informed of the study and protocol.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors are grateful to the University of Cadiz for their support.

References

[1] S. Luebberding, N. Krueger, and N. S. Sadick, "Cellulite: an evidence-based review," *American Journal of Clinical Dermatology*, vol. 16, no. 4, pp. 243–256, 2015.

[2] L. S. Bass and M. S. Kaminer, "Insights into the pathophysiology of cellulite: a review," *Dermatologic Surgery*, vol. 46, no. 1, pp. S77–S85, 2020.

[3] M. Albornoz-Cabello, A. J. Ibáñez-Vera, and B. De la Cruz-Torres, "Efficacy of monopolar dielectric transmission radio frequency in panniculus adiposus and cellulite reduction," *Journal of Cosmetic and Laser Therapy*, vol. 19, no. 7, pp. 422–426, 2017.

[4] K. Altabas, V. Altabas, M. C. Berković, and V. Z. Rotkvić, "From Cellulite to smooth skin: is Viagra the new dream cream?" *Medical Hypotheses*, vol. 73, no. 1, pp. 118-119, 2009.

[5] M. De La Casa Almeida, C. S. Serrano, J. J. J. Rejano, J. R. Díaz, M. B. Lugo, and J. R. R. Roldán, "Reliability of texture analysis using co-occurrence matrices (glcm) on photographic image in the assessment of cellulite in a Spanish population," *Journal of the European Academy of Dermatology and Venereology*, vol. 29, no. 2, pp. 315–324, 2015.

[6] M. De La Casa Almeida, C. Suarez Serrano, J. J. Jiménez Rejano, R. Chillõn Martínez, E. M. Medrano Sánchez, and J. Rebollo Roldán, "Intra- and inter-observer reliability of the application of the cellulite severity scale to a Spanish female population," *Journal of the European Academy of Dermatology and Venereology*, vol. 27, no. 6, pp. 694–698, 2013.

[7] C. M. Da Silva, M. V. De Mello Pinto, L. G. Barbosa, S. D. D. S. Filho, L. L. V. Rocha, and R. V. Gonçalves, "Effect of ultrasound and hyaluronidase on gynoid lipodystrophy type II-An ultrasonography study," *Journal of Cosmetic and Laser Therapy*, vol. 15, no. 4, pp. 231–236, 2013.

[8] K. M. Coleman and J. Pozner, "Combination therapy for rejuvenation of the outer thigh and buttock: a review and our experience," *Dermatologic Surgery*, vol. 42, no. Supplement 2, pp. S124–S130, 2016.

[9] K. Fritz, C. Salavastru, and M. Gyurova, "Clinical evaluation of simultaneously applied monopolar radiofrequency and targeted pressure energy as a new method for noninvasive treatment of cellulite in postpubertal women," *Journal of Cosmetic Dermatology*, vol. 17, no. 3, pp. 361–364, 2018.

[10] C. Van Der Lugt, C. Romero, D. Ancona, M. Al-Zarouni, J. Perera, and M. A. Trelles, "A multicenter study of cellulite treatment with a variable emission radio frequency system: hottopics," *Dermatologic Therapy*, vol. 22, no. 1, pp. 74–84, 2009.

[11] D. Bani, A. Q. Li, G. Freschi, and G. L. Russo, "Histological and ultrastructural effects of ultrasound-induced cavitation on human skin adipose tissue," *Plastic and Reconstructive Surgery Global Open*, vol. 1, no. 6, pp. e41–e49, 2013.

[12] J. Moreno-Moraga, T. Valero-Altés, A. M. Riquelme, M. I. Isarria-Marcosy, and J. R. de la Torre, "Body contouring by non-invasive transdermal focused ultrasound," *Lasers in Surgery and Medicine*, vol. 39, no. 4, pp. 315–323, 2007.

[13] F. J. Mestre Navas, "Capítulo 13. Aplicación estética de los ultrasonidos," in *Aparatología Estética*, pp. 174–189, Editorial Videocinco, Madrid, 2013.

[14] H. Moravvej, Z. Akbari, S. Mohammadian, and Z. Razzaghi, "Focused ultrasound lipolysis in the treatment of abdominal cellulite: an open-label study," *Journal of Lasers in Medical Sciences*, vol. 6, no. 3, pp. 102–105, 2015.

[15] J. J. Phillips and S. J. Gordon, "Intermittent pneumatic compression dosage for adults and children with lymphedema: a systematic review," *Lymphatic Research and Biology*, vol. 17, no. 1, pp. 2–18, 2019.

[16] M. Volkan-Yazıcı, G. Yazici, and M. Esmer, "The effects of complex decongestive Physiotherapy applications on lower extremity circumference and volume in patients with lipedema," *Lymphatic Research and Biology*, vol. 19, no. 1, pp. 111–114, 2021.

[17] D. J. Goldberg, A. Fazeli, and A. L. Berlin, "Clinical, laboratory, and MRI analysis of cellulite treatment with a unipolar radiofrequency device," *Dermatologic Surgery*, vol. 34, no. 2, pp. 204–209, 2008.

[18] M. Alexiades, G. Munavalli, D. Goldberg, and D. Berube, "Prospective multicenter clinical trial of a temperature-controlled subcutaneous microneedle fractional bipolar radiofrequency system for the treatment of cellulite," *Dermatologic Surgery*, vol. 44, no. 10, pp. 1262–1271, 2018.

[19] R. Wanitphakdeedecha and W. Manuskiatti, "Treatment of cellulite with a bipolar radiofrequency, infrared heat, and pulsatile suction device: a pilot study," *Journal of Cosmetic Dermatology*, vol. 5, no. 4, pp. 284–288, 2006.

[20] M. Juhász, D. Korta, and N. A. Mesinkovska, "A review of the use of ultrasound for skin tightening, body contouring, and cellulite reduction in dermatology," *Dermatologic Surgery*, vol. 44, no. 7, pp. 949–963, 2018.

[21] N. Pandis, B. Chung, R. W. Scherer, D. Elbourne, and D. G. Altman, "CONSORT 2010 statement: extension checklist for reporting within person randomised trials," *BMJ*, vol. 357, p. j2835, 2017.

[22] F. Nürnberger and G. Müller, "So-called cellulite: an invented disease," *Journal of Dermatologic Surgery & Oncology*, vol. 4, no. 3, pp. 221–229, 1978.

[23] D. R. Bassett, "International physical activity questionnaire: 12-Country reliability and validity," *Medicine & Science in Sports & Exercise*, vol. 35, no. 8, p. 1396, 2003.

[24] P. H. Lee, D. J. Macfarlane, T. Lam, and S. M. Stewart, "Validity of the international physical activity questionnaire short form (IPAQ-SF): a systematic review," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 8, no. 1, p. 115, 2011.

[25] "C de S Xunta de G. Servicio de Epidemiología de la Dirección Xeral de Saúde Pública da EPIDAT4.2. Consellería de Sanidade (Xunta de Galicia),".

[26] W. Manuskiatti, C. Wachirakaphan, N. Lektrakul, and S. Varothai, "Circumference reduction and cellulite treatment with a TriPollar radiofrequency device: a pilot study," *Journal of the European Academy of Dermatology and Venereology*, vol. 23, no. 7, pp. 820–827, 2009.

[27] M. De la Casa-Almeida, C. Suárez-Serrano, J. Rebollo-Roldán, J. Jiménez-Rejano, M. Benítez-Lugo, and S. Cruz-Sicilia, "Eficacia de la diatermia capacitiva mediante radiofrecuencia en la reducción de la celulitis y los perimetros corporales: estudio piloto," *Cuest Fisioter*, vol. 41, no. 1, pp. 3–15, 2012.

[28] M. De La Casa Almeida, C. Suarez Serrano, E. M. Medrano Sánchez, E. Diaz Mohedo, G. Chamorro Moriana, and M. Rebollo Salas, "The efficacy of capacitive radio-frequency diathermy in reducing buttock and posterior thigh cellulite measured through the cellulite severity scale," *Journal of Cosmetic and Laser Therapy*, vol. 16, no. 5, pp. 214–224, 2014.

[29] Y. Kim, H. Rhim, M. J. Choi, H. K. Lim, and D. Choi, "High-intensity focused ultrasound therapy: an overview for radiologists," *Korean Journal of Radiology*, vol. 9, no. 4, p. 291, 2008.

[30] J. Y. Hong, E. J. Ko, S. Y. Choi et al., "Efficacy and safety of high-intensity focused ultrasound for noninvasive abdominal subcutaneous fat reduction," *Dermatologic Surgery*, vol. 46, no. 2, pp. 213–219, 2020.

[31] M. A. Adatto, R. Adatto-Neilson, P. Novak, A. Krotz, and G. Haller, "Body shaping with acoustic wave therapy AWT®/EPAT®: randomized, controlled study on 14 subjects," *Journal of Cosmetic and Laser Therapy*, vol. 13, no. 6, pp. 291–296, 2011.

[32] G. A. Ferraro, F. De Francesco, C. Cataldo, F. Rossano, G. Nicoletti, and F. D'Andrea, "Synergistic effects of cryolipolysis and shock waves for noninvasive body contouring," *Aesthetic Plastic Surgery*, vol. 36, no. 3, pp. 666–679, 2012.

[33] K. Bryś, B. O. Grabarek, P. Król, R. Staszkiewicz, M. Wierzbik-Strońska, and T. Król, "The thermal influence of an electromagnetic field with a radio frequency depending on the type of electrode used," *International Journal of Environmental Research and Public Health*, vol. 19, no. 18, p. 11378, 2022.

[34] G. Conti, N. Zingaretti, D. Amuso et al., "Proteomic and ultrastructural analysis of cellulite—new findings on an old topic," *International Journal of Molecular Sciences*, vol. 21, no. 6, p. 2077, 2020.