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Effectiveness Of The Combined Use Of Low-Frequency Electrostimulation With Low-Frequency Ultrasound: A Case Study.

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Abstract:
Non-invasive aesthetic strategies for harmonic body contour redefinition increasingly incorporate systemic physiological manipulations rather than superficial modifications. This study investigates a dual-modality protocol that combines electrostimulation with low-frequency currents, better known as functional electrical stimulation (FES), and low-frequency ultrasound (LFUS) to modify body contour through the architecture of adipose and muscle tissue. The combination of techniques addresses both the metabolism of lipolysis/apoptosis substrates and the regional morphological configuration of muscles, i.e., hypertrophy. The study involves six women between 25 and 35 years old, all with regionalized adipose accumulation and muscle hypotonia. Over a period of six to eight weeks, participants undergo biweekly sessions, alternating between systemic stimulation via FES and local application of LFUS preceded by subcutaneous saline infiltration. FES induces muscle contractions in the abdominal and lower limb regions through low-frequency current. LFUS, operating at 40 kHz, directs acoustic energy to induce cavitation in adipocyte membranes, while saline acts as a conductive medium, increasing cavitation uniformity. Before-and-after photographic comparisons of the protocol demonstrate visible reductions in infra- and supra-umbilical lipid deposits, especially among individuals with initial hypotonia. Improvements in muscle tone, increased skin firmness, and decreased abdominal protrusion are observed. These responses reflect functional synchrony: muscle recruitment boosts metabolism systemically, while ultrasound-induced apoptosis reduces subcutaneous fat density. No adverse events were recorded, and participant compliance remained constant. The combination of neuromuscular activation and mechanical fragmentation produces effects across multiple dimensions. Adipose tissue loss occurs without caloric restriction, while posture is corrected through contractile engagement. The treatment goes beyond aesthetic purposes by generating adipocyte lysis and substrate consumption, restoring myofibrillar function. It offers a physiologically grounded alternative for individuals unable to adhere to conventional training or surgical interventions. This integrated model, while still in its infancy, outlines a procedural framework where structural remodeling and metabolic reprogramming coexist. Data support its applicability, positioning the protocol as a modular platform for future non-pharmacological interventions in aesthetic and metabolic care.
Key Word*: Body harmonization, dermal sagging, localized fat, functional electrostimulation (FES), electrostimulation, aesthetics, low frequency ultrasound, hydrolipoclasia*

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I. Introduction

The deposition of adipose tissue in specific anatomical regions remains a challenge in both metabolic regulation and aesthetic approaches. Lipogenesis, an enzyme-regulated anabolic process, converts excess energy substrates, such as glucose and free fatty acids, into triglycerides stored in the cytoplasm of adipocytes. This mechanism, intensified by physical inactivity and hormonal imbalances, culminates in regional adipose tissue hypertrophy, often resistant to isolated caloric restriction or moderate aerobic activity (Lima; Vieira, 2017). Although often overlooked as cosmetic imperfections, these accumulations impact energy homeostasis and endocrine-metabolic function (Àvila, 2025).

In this context, skeletal muscle tissue acquires a role beyond voluntary movement. Functional electrical stimulation (FES), by inducing artificial muscle contractions, engenders systemic biochemical effects. During contraction, AMPK, an enzyme sensitive to energy depletion, is activated, enabling the translocation of glucose transporters in an insulin-independent manner. Concomitantly, irisin, a myokine encoded by FNDC5, is released. Its action induces the phenotypic conversion of white adipocytes into beige cells via UCP1 expression, which intensifies thermogenesis and calorie expenditure (Pauli, 2009; Ruiz-Silva, 2023). Therefore, FES ceases to be a mere toning tool and begins to act as a metabolic modulator (Ruiz-Silva, 2025).

Localized application of FES in areas of hypotonia, such as the lower abdomen, offers complementary responses. In muscles with low basal activation, electrical stimulation increases regional perfusion and promotes the oxidative use of fatty acids released by lipolysis (Martins, 2021). This metabolic redistribution supports the inclusion of FES in body contouring protocols, especially in patients with restricted conventional exercise due to musculoskeletal limitations or chronic clinical conditions (Roberto, 2006).

Low-frequency ultrasound (LFUS), typically operating at 40 kHz, represents a non-thermal alternative for intervening in subcutaneous adipose tissue. Unlike high-frequency devices (1–3 MHz), LFUS produces acoustic cavitation, oscillating microbubbles that collapse under pressure variations, generating localized shear forces that disrupt adipocyte membranes. This disruption does not result in immediate necrosis; rather, it triggers programmed apoptosis pathways, preserving adjacent structures such as vessels and collagen matrix (Palumbo et al., 2011). Saline infiltration prior to the procedure improves acoustic conductivity and enhances the propagation of mechanical microinjuries.

Histological analyses of ex vivo human adipose tissue validate these findings. Pugliese et al. (2013) identified cytoplasmic condensation, cell membrane fragmentation, and homogenization of the fibrillar network after 15-minute applications of 5 W/cm², especially in previously hydrated samples. The evidence points to mechanically induced apoptosis, with no signs of a delayed inflammatory response, configuring LFUS as a selective alternative to invasive lipid destruction methods.

From a biochemical perspective, the effects of ultrasound are also measurable. Honda et al. (2016) observed a significant increase in plasma free fatty acids (NEFA) immediately after unfocused ultrasound sessions, suggesting rapid mobilization of intracellular triglycerides. This increase was not accompanied by changes in total or LDL cholesterol, suggesting that the lipolytic response is transient and metabolizable, without overloading the circulating lipid system.

The convergence between FES and LFUS articulates cellular, hemodynamic, and bioenergetic dimensions. While FES recruits muscle as a metabolic and secretory axis, ultrasound acts directly on the adipocyte structure. The combined application enhances substrate utilization, remodels subcutaneous tissue, and increases basal energy expenditure. Current literature supports the coherence of this therapeutic combination, although long-term follow-up studies are needed to map its sustained efficacy and physiological safety.

II. Material And Methods

This study adopts a clinical case series design, based on the technical documentation of six female participants between the ages of 25 and 35. Each volunteer presented with complaints related to localized fat concentration and tissue sagging, assessed by visual inspection and prior analysis of their aesthetic history. Interventions occurred over six to eight weeks under controlled outpatient conditions, with two weekly sessions. One session focused on systemic stimulation through functional electrical stimulation (FES); the other prioritized a local approach, with tumescent saline infiltration followed by the application of low-frequency ultrasound (LFUS).

FES was administered with a current-generating device set to operate at 30 Hz, using wave parameters configured to simulate the physiological recruitment of muscle fibers. Each contraction cycle featured rising and falling ramps of 5 to 8 seconds, sustained contraction phases of 20 to 30 seconds, and passive intervals of 10 to 12 seconds. The treated areas included the abdomen, anterior thigh, posterior thigh, and calves. Each muscle group was stimulated individually for 20 minutes, totaling approximately 60 minutes per patient, with the intensity adjusted according to the visual effectiveness of the contraction and subjective tolerance.

To promote acoustic cavitation, non-aspirative hydrolipoclasia was performed with a subcutaneous injection of 0.9% sterile saline solution, administered at a rate of 1 mL per anatomical quadrant. The selection of areas followed criteria based on adipose tissue density and areas of discomfort reported by the patients, avoiding infiltration in areas close to the umbilical ring. 13 x 0.45 mm (26G) hypodermic needles attached to 10 mL syringes were used, ensuring volumetric precision and standardization of the procedure. After infiltration, LFUS was applied with a 40 kHz transducer set at 2.5 W/cm², scanning an area corresponding to two dimensions of the head (ERAS). Each segment received 5 to 7 minutes of continuous sonication in a linear trajectory, optimizing energy propagation within the hydrated adipose tissue. This configuration aimed to accentuate mechanical shear forces at cellular interfaces, favoring membrane destabilization and the subsequent activation of apoptotic pathways, as observed in ex vivo adipose models (Palumbo et al., 2011).

Patients were photographed in anterior and lateral views before and after treatment. Comparison between cases revealed noticeable changes in fat distribution and muscle tone, particularly in individuals with initial hypotonia. The abdominal wall, frequently targeted due to postural weakness, showed improved contour and reduced projection. These changes indicate both metabolic utilization of substrates and localized muscle restructuring, consistent with the mechanisms associated with AMPK activation and GLUT-4 translocation (Pauli et al., 2009).

The experimental protocol combined systemic and local intervention strategies. FES was used to enhance basal metabolism through induced muscle contractions, while LFUS aimed to mechanically disrupt adipocyte compartments. Saline infiltration prior to sonication acted as a conduction medium and simultaneously facilitated cavitational homogeneity. Histopathological studies support this method, as demonstrated by Pugliese et al. (2013), who observed cytoplasmic condensation, membrane rupture, and collagen homogenization, all signs consistent with apoptosis.

During the intervention period, no adverse events were recorded. Participants tolerated the procedures without reporting prolonged discomfort or skin reactivity. These safety indicators corroborate the findings of Honda et al. (2016), who demonstrated lipid mobilization induced by non-focused ultrasound, without harmful changes in total cholesterol or low-density lipoprotein levels. The absence of inflammatory responses after the treatments reinforces the coherence and stability of the adopted therapeutic approach.

Figure 1 illustrates the infiltration of 0.9% saline solution. Red quadrant: protection area of approximately 1 centimeter around the umbilical region. Black quadrants: application sites of 0.9% saline solution, with a volume of 1 mL per site.

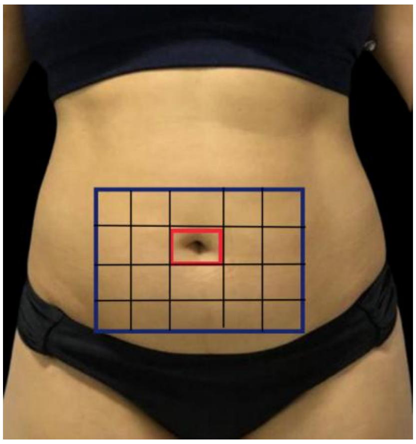

Figure 1 – Schematic representation of the infiltration of 0.9% saline solution into the abdomen

After infiltration, low-frequency ultrasound (40KHz) was applied using the **MaxShape equipment (Bioset**). The dose used was 2.5 W/cm², or 10 watts in the equipment, and the application time was 5 to 7 minutes for each area corresponding to two ERAS (head dimensions), with horizontal scanning movements.

III. Results

Figure 2 – Clinical case 1: (A) Photographic record in anterior view of the patient before the intervention, showing concentration of adipose tissue in the infraumbilical region and skin sagging in the supraumbilical segment. (B) Image obtained six weeks after the protocol, demonstrating morphological changes resulting from the treatment.

Figure 2 – Clinical case 1: Source: the Author (2025)

Figure 3 – Clinical case 2: (A) Photographic records in anterior and lateral views obtained before the intervention, with evidence of adipose accumulation in the infra- and supraumbilical regions, associated with abdominal projection due to muscular hypotonia. (B) Images captured eight weeks after treatment, revealing post-protocol structural modifications.

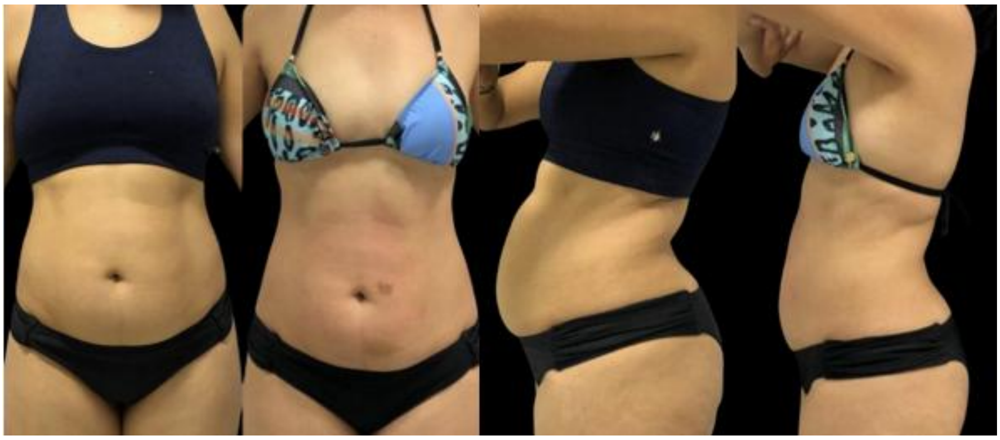

Figure 3 – Clinical case 2: Source: the Author (2025)

In figure 4, Clinical case 3: Patient with (A) Anterior view before treatment, patient presenting localized adiposity and tissue sagging. (B) Six weeks post-treatment.

Figure 4 – Clinical case 3: Source: the Author (2025)

In Figure 5, Clinical case 4, patient with: (A) Lateral view before treatment, patient presenting localized adiposity and muscular hypotonia in the abdomen. (B) Eight weeks post-treatment.

Figure 5 – Clinical case 4: Source: the Author (2025)

Figure 6 – Clinical case 5: (A) Anterior view record obtained before the intervention, showing concentration of adipose tissue in the infra and supraumbilical regions. (B) Image captured six weeks after treatment, demonstrating morphological changes resulting from the applied protocol.

Figure 6 – Clinical case 5: Source: the Author (2025)

Figure 7 – Clinical case 6: (A) Lateral view record prior to the intervention, with evidence of regionalized adiposity and muscle hypotonia in the abdominal region. (B) Image obtained eight weeks after treatment, indicating tissue modification and improvement in local tone.

Figure 7 – Clinical case 6: Source: the Author (2025)

IV. Discussion

Visual comparisons between pre- and post-intervention photographic records reveal evident reductions in subcutaneous fat volume, especially in the infra- and supra-umbilical regions. Patients with initial muscle hypotonia demonstrate noticeable improvements in abdominal contour and skin tension, reporting complete satisfaction with the results. These outcomes reflect not only local structural remodeling but also systemic metabolic reorientation promoted by electrically induced muscle contraction. Previous reports identify FES-triggered AMPK activation and subsequent GLUT-4 mobilization as central processes in enhancing insulin-independent glucose uptake and fatty acid oxidation (Paul 2009), mechanisms likely replicated in this group.

Figure 3 shows a lateral and anterior view of the patient before the intervention, demonstrating a concentration of adipose tissue in the infra- and supra-umbilical regions, as well as abdominal protrusion resulting from muscle hypotonia. Eight weeks after treatment, a reduction in subcutaneous volume, improvement in abdominal contour, and postural alignment are observed. The postural correction obtained in hypotonic individuals indicates that electrostimulation works beyond acetylcholine metabolism and energy expenditure. By recruiting deep transverse musculature, it promotes trunk stability and reduces abdominal protrusion, often mistakenly interpreted as adipose accumulation. The therapeutic value lies in this combined action: volumetric fat reduction and muscle tone reconditioning. The improvement in tissue firmness, captured in photographic evidence, confirms the endocrine-mechanical role of skeletal muscle, especially under artificial stimulation.

The results of low-frequency ultrasound application, followed by saline infiltration, show consistent adipocyte attenuation. This effect is consistent with cavitational fragmentation previously described in controlled ex vivo models (Palumbo et al., 2011). Current visual evidence, although lacking histological verification, aligns with the expected morphological patterns of apoptotic remodeling: smoother transitions between tissue planes, reduced bulging, and decreased localized lipid accumulation. These changes, although subtle, suggest that mechanical fragmentation occurs at the cellular level, without visible inflammation or dermal compromise.

In all six cases evaluated, volumetric reduction manifested without any recorded adverse cutaneous or circulatory effects. The convergence of FES and LFUS methods appears to simultaneously exploit distinct energetic pathways: electrical for metabolic activation and ultrasonic for localized adipocyte lysis. The strategic alternation of systemic and regional stimuli generates a cumulative physiological response, shifting energy balance, degrading lipid stores, and strengthening muscle structure. This combined approach challenges dichotomous models of fat reduction that separate physical exercise from assistive technologies.

Participant tolerance remains high in all cases. No patient discontinued the protocol due to discomfort or clinical complications. The absence of dropouts reinforces the credibility of the procedure, particularly considering the intensity and regularity of the sessions. The consistency of individual responses, combined with the progressive reduction in measurements, suggests that the simultaneous application of both techniques transcends placebo effects or occasional responses. Although the photographic method does not provide metric precision, the repeatability of visual results strengthens the interpretive reliability.

Comparative studies support the methodological framework. Pugliese et al. (2013) describe histological fragmentation of adipocyte membranes under similar sonic protocols, while Honda et al. (2016) associate the use of LFUS with a transient increase in free fatty acids (NEFA) without altering lipid profiles. These parallel findings support the hypothesis that controlled ultrasonic destruction promotes adipose apoptosis within physiological limits. Current clinical observations, although initial, resonate with these conclusions and provide an empirical basis for subsequent studies. Beyond the aesthetic effects, the data raise questions about energy distribution and the communication between muscle and fat tissue in sedentary individuals. If FES-induced contraction simulates physical training at a biochemical level, and if LFUS triggers programmed cell death without necrosis, then the combination of these resources offers a therapeutic paradigm for body contouring that goes beyond cosmetics. The intervention may affect metabolic flexibility, adipokine expression, and regional thermogenesis—areas that require further investigation into their mechanistic underpinnings.

V. Conclusion

The final configuration of this intervention outlines a therapeutic architecture that simultaneously addresses structural and metabolic domains, without resorting to pharmacological means or invasive methods. By activating skeletal muscle through external stimulation and associating it with the mechanical disintegration of adipocytes, the approach establishes a dual pathway: one biochemical in nature, the other morphological. Although operating autonomously, these approaches merge within the same protocol to produce effects that are not limited to aesthetic alteration, but also systemic reprogramming.

The intervention triggers a reconfiguration of peripheral energy flows through the synchronization of muscle contractions and subcutaneous perturbation. This synchronization converts areas of localized tissue inertia into zones of active renewal. Regions previously marked by lipid retention or hypotonia reveal measurable changes, not due to a mere catabolic increase, but rather through the selective activation of latent physiological pathways. This functional shift highlights the body's ability to reorganize itself when exposed to non-endogenous stimuli.

Patient response profiles, both subjectively and visually, support the argument for the protocol's tolerance and permanence. The detectable improvements in contour and firmness are not accompanied by inflammatory markers, dermal damage, or vascular alterations. On the contrary, these modifications reveal a coherent adaptation—load redistribution, volume reduction, and postural repositioning—that expresses the intertwining of neuromuscular stimulation and adipose morphology.

From an operational perspective, the technique demonstrates plasticity in the face of individual anatomical and functional variations. Its modularity—the ability to target and treat specific areas without interfering with systemic integrity—allows its application beyond clinical extremes. The methodology extends to subclinical conditions, borderline manifestations, and aesthetic motivations without submitting to the hierarchical structure imposed by traditional medicine.

Conceptually, this convergence dissolves classic dichotomies between structural intervention and metabolic manipulation. It reinterprets body contouring as an active dialogue between mechanical stimulation and tissue reactivity. In doing so, it reveals that non-pharmacological and non-surgical approaches can produce effects previously attributed exclusively to physical exercise or excision. What emerges is not a shortcut, but a parallel physiological pathway—designed, quantifiable, and replicable.

While it does not prescribe fixed scales, the protocol proposes a framework from which scalable models can be developed. It will require adjustments in duration, intensity, and cadence, but its operating principle—sequential activation and substrate clearance—remains intact. In this consistency lies its potential: a reimagined intersection between voluntary inactivity and induced activation, where function is restored not by effort but by orchestration.

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