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Resonance-Based Vibrotactile Stimulation for Primary Dysmenorrhea: Preliminary Outcomes of a Randomized, Sham-Controlled Pilot Study

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Research Article

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Resonance-Based Vibrotactile Stimulation for Primary Dysmenorrhea: Preliminary Outcomes of a Randomized, Sham-Controlled Pilot Study

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Abstract

Background: The clinical effectiveness of vibrotactile stimulation for primary dysmenorrhea has not been established. We evaluated preliminary patient-reported outcomes in an unregistered randomized pilot study comparing active mechanical stimulation with an acoustic sham.

Methods: This single-center, randomized, acoustic-sham-controlled pilot study included 60 participants (observed age range 17–34 years), 30 in each arm, over three intervention cycles with 3-month follow-up. The primary reported outcome was 100-mm visual analog scale (VAS) pain at Cycle 3. Baseline-adjusted OLS ANCOVA used HC3 robust standard errors; additional outcomes were NRS, SDS, and responder proportions. Complete participant-level outcome records were available for the 60 participants. The study was not registered.

Results: All 60 participants had baseline and four follow-up measurements in the supplied participant-linked workbook (30 active; 30 acoustic sham). At Cycle 3, mean VAS was 34.93 ± 23.43 mm versus 75.97 ± 11.26 mm; baseline-adjusted active-minus-sham difference was −46.34 mm (95% CI −57.23 to −35.45; HC3 $P<0.001$). At least 50% reduction from individual baseline occurred in 20/30 versus 0/30 participants (Fisher $P<0.001$). After cessation, pain returned toward baseline; the 3-month adjusted difference was −6.02 mm (95% CI −9.22 to −2.82) despite the unadjusted follow-up group difference of +5.93 mm.

Conclusions: Active vibrotactile stimulation was associated with lower reported menstrual pain during treatment than acoustic sham. Findings are exploratory because participants could distinguish tactile stimulation, baseline pain differed substantially, and the trial was not publicly registered. The observations may inform design and funding of a future prospectively registered, adequately powered trial.

Keywords: primary dysmenorrhea; mechanical vibration; nonpharmacological analgesia; randomized pilot study; menstrual pain; acoustic sham

1. Introduction

Primary dysmenorrhea (PD) is defined as painful, spasmodic uterine cramping occurring in the absence of identifiable pelvic pathology [1, 2]. Affecting between 45% and 95% of women of reproductive age worldwide, PD represents a major cause of recurrent academic and occupational absenteeism, reduced physical productivity, and diminished health-related quality of life [3, 4]. The disorder is frequently accompanied by mood disturbances, including elevated anxiety and depressive symptoms, which can exacerbate central pain processing .

The underlying pathogenesis is primarily mediated by increased endometrial prostaglandin production and cyclic hyper-release of prostaglandins (PGF2α and PGE2) during menstruation [5, 6]. Prostaglandins trigger sustained myometrial hypercontractility, uterine vasoconstriction, tissue ischemia, and visceral sensory sensitization [7, 8]. Although nonsteroidal anti-inflammatory drugs (NSAIDs) and oral contraceptives serve as standard first-line therapies, a notable subset of women experience incomplete pain relief, report significant gastrointestinal side effects, or present contraindications [9]. Consequently, non-invasive, non-pharmacological modalities remain an important clinical priority.

Vibrotactile stimulation delivers mechanical oscillations to somatic tissues. Vibratory analgesia has been investigated experimentally, providing a rationale to explore this nonpharmacological intervention [10, 11]. The present trial did not measure neural pathways, autonomic activity, uterine perfusion or prostaglandins; these mechanisms cannot be established from its clinical outcomes.

This exploratory randomized study compared active vibrotactile stimulation with an acoustic sham intervention across three menstrual cycles. Pain and other reported clinical outcomes were evaluated, and treatment schedules were compared descriptively. Schedule comparisons also reflect differences in total treatment exposure. Evidence from physical therapy and self-care intervention reviews supports further controlled investigations in this population [12, 13].

2. Materials and Methods

2.1 Ethical Approval, Institutional Oversight, and Trial Registration

The study was conducted at the Institute of Neurology and Neurosurgery, Havana, Cuba, a national referral institution specializing in clinical neurology and neurosciences. The study protocol received institutional ethical approval from the Institute's Ethics Committee (Protocol ID: IRB_2023-05).

Written informed consent was obtained from adult participants and from the parents or legally authorized guardians of participants aged 17 years, in accordance with the approved protocol and applicable ethical requirements.

The study was conducted under institutional ethical oversight. However, no prospective or retrospective registration was obtained in a publicly accessible clinical trial registry. This limitation is explicitly acknowledged. The findings are presented as preliminary clinical evidence intended to support the design and funding of a future, adequately powered, prospectively registered randomized controlled trial.

2.2. Participants and Eligibility Criteria

The participant workbook includes women aged 17–34 years with primary dysmenorrhea. The source protocol lists eligibility criteria that included regular menstrual cycles, VAS ≥50 mm at entry, and no recent analgesic use; the source manuscript further described exclusions for secondary dysmenorrhea, pregnancy, selected comorbidities, and recent hormonal treatment. Eligibility and assent/parental authorization for participants under 18 require confirmation against original screening and consent records.

2.3. Sample Size and Randomization

The participant-linked workbook included 60 individuals assigned to six groups (A1–A3 active and B1–B3 acoustic sham; n=10 in each). The original study text describes stratified, computer-generated block randomization; the allocation sequence and concealment mechanism have not been independently recovered. No formal sample-size calculation was available. The intervention schedules were:

1. Premenstrual-only regimen: Five consecutive daily 10-minute sessions during the five days preceding anticipated menstruation.
2. Menstrual-only regimen: Five consecutive daily 10-minute sessions during menstrual days one to five.
3. Combined regimen: Ten 10-minute sessions per cycle (five premenstrual and five menstrual days).

2.4. Interventions and Blinding Considerations

The active device (Rezzimax Tuner Pro II, Rezzimax LLC, Smithfield, UT, USA) is a handheld, battery-powered therapeutic vibrator (operating motor speed 6,000–7,400 rpm; 3-mm displacement stroke; four automated algorithms). Each 10-minute session was delivered under direct clinical supervision at the outpatient department across five standardized anatomical regions (~2 minutes per site): posterior cervical spine, anterior neck, bilateral plantar feet, hypogastrium, and lumbosacral region. We set intensity to the highest comfortably tolerated level.

The sham control device possessed identical outer casing, mass, operator interface, workflow, and operational motor sound. However, we removed the internal eccentric counterweight, allowing motor activation without generating therapeutic mechanical oscillation. Because active mechanical oscillation produces an unmistakable somatosensory sensation, complete participant blinding was inherently limited; therefore, the study is categorized as an evaluator-blind, sham-controlled pilot trial. Outcome assessors and data analysts were strictly blinded to group allocation.

2.5. Outcome Measures and Statistical Analysis

The prespecified primary endpoint reported in the source manuscript was menstrual pain on a 100-mm VAS at Cycle 3. Repeated assessments included baseline, intervention Cycles 1–3, and 3-month follow-up. Secondary outcomes analyzed here were NRS, SDS, and the proportion meeting at least 30% or 50% reduction in VAS relative to each participant's own baseline. The workbook contains anxiety entries labeled SAS but includes totals below the possible raw score minimum for the 20-item Zung scale; these entries were excluded from validated clinical outcomes and inferential testing. The original questionnaire and scoring key are needed to interpret them.

All 60 enrolled participant IDs were linked across baseline and the four follow-up sheets of the supplied workbook, with no missing VAS, NRS, or SDS outcomes. Group means and sample SDs were recalculated directly. At each follow-up, the active-versus-sham contrast was estimated by ordinary least squares ANCOVA with a binary treatment indicator and the corresponding baseline scale as the sole covariate; two-sided HC3 robust confidence intervals used normal critical values (1.96). The model was fitted separately for VAS, NRS, and SDS at each time point. Fisher exact tests were performed for ≥30% and ≥50% reduction from individual baseline VAS. Hedges g used the pooled sample SD and small-sample correction. Schedule-specific ANCOVA used the same baseline-adjusted model on the corresponding 20 participants. All secondary, subgroup, and longitudinal tests are exploratory and were not corrected for multiplicity. This analysis is consistent with the

source model specification; allocation concealment and prospective endpoint selection could not be independently verified.

3. Results

3.1. Participant Flow and Baseline Characteristics

The supplied workbook contains baseline data for all 60 randomized participants, with one outcome record per ID at each of the three menstrual-cycle assessments and the 3-month follow-up. Thus VAS, NRS, and SDS measurements were complete in the available dataset. This does not independently verify session-by-session attendance or protocol adherence.

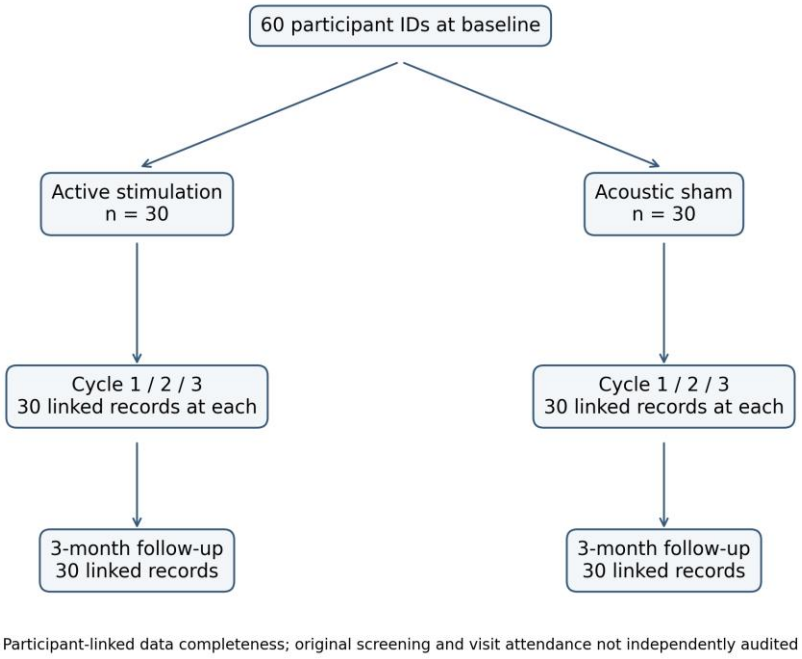


Figure 1. Participant-linked outcome record completeness: 60 baseline records (30 active, 30 acoustic sham), and all 60 IDs represented at Cycles 1, 2, 3 and follow-up. The original screening denominator and attendance logs were not available for verification.

Table 1 shows the recalculated baseline characteristics. VAS was markedly higher in the active arm than the acoustic sham arm (91.30 ± 10.90 vs 76.57 ± 11.14 mm; standardized mean difference 1.34). Adjustment for measured baseline values does not resolve possible imbalance due to allocation methods, regression-to-the-mean effects, or differential expectancy.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants

Characteristic	Active Rezzimax (n = 30)	Sham Control (n = 30)	SMD
Age (years)	26.40 ± 5.39	27.20 ± 5.38	-0.15
Pregnancies (count)	1.53 ± 1.57	0.83 ± 0.95	0.54
Abortions (count)	0.67 ± 0.96	0.33 ± 0.66	0.40
Cesarean sections (count)	0.47 ± 0.82	0.20 ± 0.48	0.40
Deliveries (count)	0.40 ± 0.72	0.30 ± 0.53	0.16
VAS Pain Intensity (mm)	91.30 ± 10.90	76.57 ± 11.14	1.34
Numeric Rating Scale (NRS)	8.80 ± 1.27	7.33 ± 1.15	1.21
Self-Rating Depression Scale (SDS)	55.50 ± 12.00	48.53 ± 11.33	0.60

Values are mean ± SD. SMD: Standardized Mean Difference; VAS: Visual Analog Scale.

3.2. Primary Outcome: Menstrual Pain Trajectory

Observed VAS pain means declined over three treatment cycles in the active group while remaining relatively stable in acoustic sham (Table 2, Figure 2). Reanalysis of the 60 participant-linked records reproduced the source baseline-adjusted ANCOVA estimates: Cycle 1, −19.46 mm (95% CI −25.02 to −13.91); Cycle 2, −31.50 mm (−40.22 to −22.77); and Cycle 3, −46.34 mm (−57.23 to −35.45). At 3-month follow-up, the adjusted contrast was −6.02 mm (−9.22 to −2.82), whereas the unadjusted group means were 87.57 and 81.63 mm; the sign reversal reflects the baseline covariate adjustment and is not an arithmetic error. Follow-up treatment effects should not be interpreted as sustained analgesia.

Table 2. Visual analog scale (VAS) outcomes: recalculated group summaries, baseline-adjusted active-minus-sham contrasts, and unadjusted Hedges g

Time Point	Active Mean ± SD	Sham Mean ± SD	Adjusted Diff	95% CI	p-value	Hedges g
Cycle 1	67.60 ± 14.50	75.97 ± 10.87	-19.46	-25.02 to -13.91	<0.001	-0.64
Cycle 2	53.10 ± 17.94	75.27 ± 11.99	-31.50	-40.22 to -22.77	<0.001	-1.43
Cycle 3 (Primary)	34.93 ± 23.43	75.97 ± 11.26	-46.34	-57.23 to -35.45	<0.001	-2.20
3-Month Follow-Up	87.57 ± 10.07	81.63 ± 11.06	-6.02	-9.22 to -2.82	<0.001	+0.55

All means, SDs, baseline-adjusted effects, 95% CIs, P values and Hedges g were recomputed from the 60 participant-level records. Adjusted contrasts are from independent follow-up OLS models including treatment and baseline VAS, with HC3

robust standard errors. Unadjusted Hedges g has the sign of active-minus-sham pain, and is not the standardized adjusted ANCOVA coefficient.

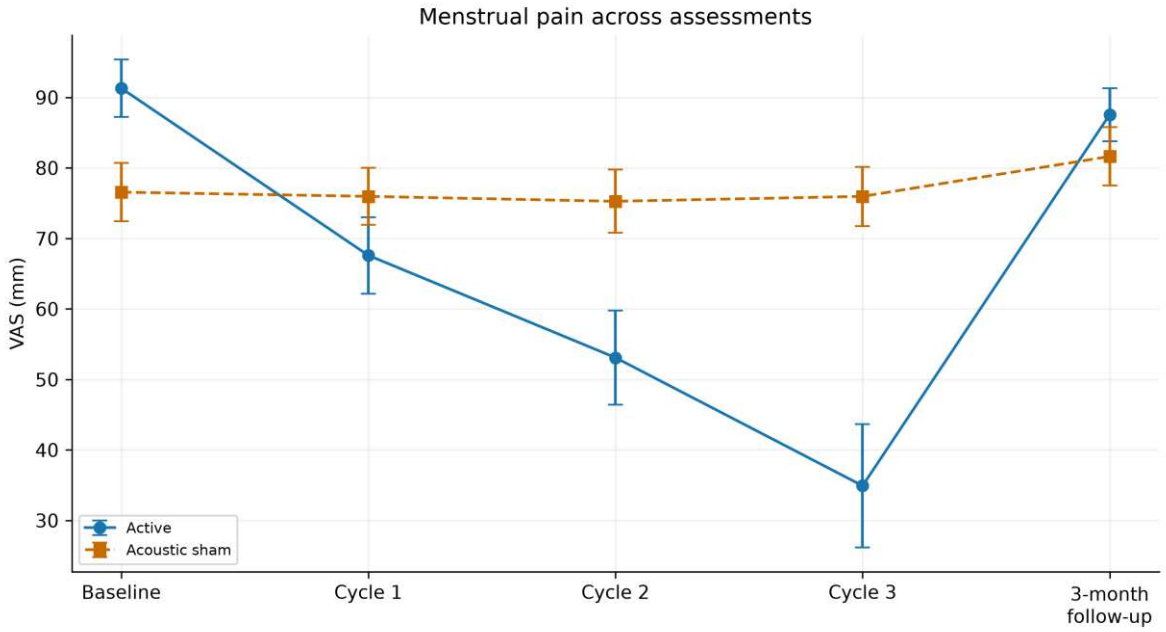


Figure 2. Unadjusted observed mean VAS at baseline, three treatment cycles and follow-up; error bars represent approximate pointwise 95% confidence intervals. These are not the baseline-adjusted ANCOVA contrasts.

3.3. Clinical Responder Analysis

Individual-level responder proportions were recalculated relative to each participant's baseline VAS (Table 3). By Cycle 3, ≥30% reduction occurred in 25/30 (83.3%) active and 0/30 acoustic-sham participants; ≥50% reduction occurred in 20/30 (66.7%) versus 0/30 (two-sided Fisher exact P<0.001). No participant reached ≥30% reduction at 3-month follow-up. These exploratory comparisons are unadjusted for multiplicity.

Table 3: Clinical Responder Proportions Across Assessment Time Points

Time Point	Threshold	Active Rezzimax (n = 30)	Sham Control (n = 30)	Risk Diff (%)	Fisher's p
Cycle 1	≥ 30% Reduction	10 (33.3%)	0 (0.0%)	33.3%	<0.001
Cycle 1	≥ 50% Reduction	2 (6.7%)	0 (0.0%)	6.7%	0.492
Cycle 2	≥ 30% Reduction	21 (70.0%)	0 (0.0%)	70.0%	<0.001
Cycle 2	≥ 50% Reduction	12 (40.0%)	0 (0.0%)	40.0%	<0.001
Cycle 3	≥ 30% Reduction	25 (83.3%)	0 (0.0%)	83.3%	<0.001
Cycle 3	≥ 50% Reduction	20 (66.7%)	0 (0.0%)	66.7%	<0.001
3-Month Follow-Up	≥ 30% Reduction	0 (0.0%)	0 (0.0%)	0.0%	1.000

Fisher's exact test used for responder comparisons between active and sham arms.

3.4. Timing Regimen Subgroup Analysis

The subgroup means in Table 4 exactly reconcile with the overall active and acoustic-sham means when weighted by the equal subgroup sizes. For each schedule, baseline-adjusted Cycle 3 coefficients and HC3 confidence intervals were recomputed from individual records; the previously reported subgroup confidence intervals were inconsistent with the specified model and have been replaced. The combined schedule provided ten rather than five sessions per cycle, so timing and cumulative treatment exposure cannot be disentangled. Subgroups included only 10 participants per arm and these analyses are exploratory.

Table 4: Exploratory Subgroup Analysis by Treatment-Timing Regimen at Cycle 3

Regimen	Active Base → C3	Sham Base → C3	Adjusted Diff (mm)	95% CI	p-value
Premenstrual-only (5 sessions)	88.00 → 61.20	81.10 → 82.40	-25.01	-30.85 to -19.16	<0.001
Menstrual-only (5 sessions)	91.50 → 33.80	71.00 → 67.90	-45.13	-55.61 to -34.66	<0.001
Combined (10 sessions)	94.40 → 9.80	77.60 → 77.60	-76.78	-92.15 to -61.40	<0.001

n=10 per arm per schedule. Adjusted effects and 95% confidence intervals were independently recomputed using OLS (treatment + baseline VAS), HC3 standard errors and normal critical values. Schedule-specific estimates are exploratory; combined treatment involved twice the session count.

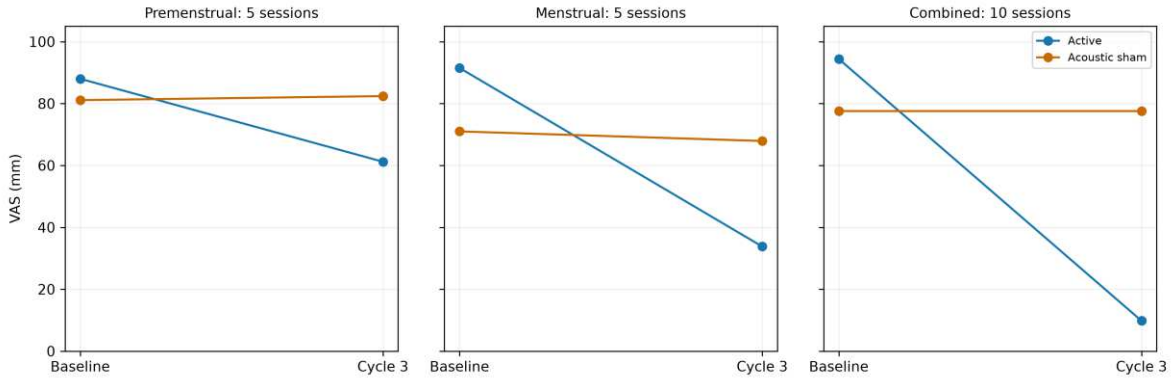


Figure 3. Observed mean VAS at baseline and Cycle 3 within the three treatment schedules (10 participants per arm/schedule). Combined-treatment participants received twice the number of sessions as either single-period group.

3.5. Secondary Clinical Outcomes (NRS and SDS)

NRS and SDS estimates in Table 5 were fully recalculated from participant-level records using baseline-adjusted HC3 ANCOVA. The recorded anxiety fields reproduce the earlier published aggregate SAS figures but contain scores below 20, invalid for the conventional raw 20-item Zung SAS. Without a validated scoring key, the anxiety outcome is excluded rather than altered. All cycle and follow-up sheets recorded “None” for adverse events, but the workbook does not establish how events were solicited or adjudicated.

Table 5. Recalculated secondary clinical outcomes (NRS and SDS) from participant-linked data

Outcome & Time Point	Active Rezzimax (n = 30)	Sham Control (n = 30)	Adjusted Diff	95% CI	p-value
Numeric Rating Scale (NRS)					
Baseline	8.80 ± 1.27	7.33 ± 1.15	—	—	—
Cycle 1	6.17 ± 1.64	6.97 ± 1.25	-1.87	-2.47 to -1.27	<0.001
Cycle 2	4.77 ± 1.87	6.90 ± 1.30	-3.04	-3.86 to -2.22	<0.001
Cycle 3	3.10 ± 2.29	6.87 ± 1.14	-4.37	-5.48 to -3.25	<0.001
3-Month Follow-Up	8.57 ± 1.04	7.80 ± 1.19	-0.36	-0.73 to 0.02	0.064
Self-Rating Depression Scale (SDS)					
Baseline	55.50 ± 12.00	48.53 ± 11.33	—	—	—
Cycle 1	48.93 ± 10.35	47.07 ± 11.04	-4.15	-5.93 to -2.37	<0.001
Cycle 2	45.93 ± 10.17	46.17 ± 10.87	-6.01	-8.21 to -3.80	<0.001
Cycle 3	43.00 ± 9.33	45.67 ± 10.86	-7.93	-10.67 to -5.20	<0.001
3-Month Follow-Up	52.07 ± 10.23	47.23 ± 11.01	-1.18	-2.98 to 0.63	0.202

Means and SDs, adjusted active-minus-sham contrasts, 95% confidence intervals, and HC3 P values were recalculated. Each adjusted estimate is from a model with treatment group and the corresponding baseline outcome as predictors. These analyses are exploratory; no multiplicity adjustment was applied. Anxiety score entries were excluded pending instrument verification.

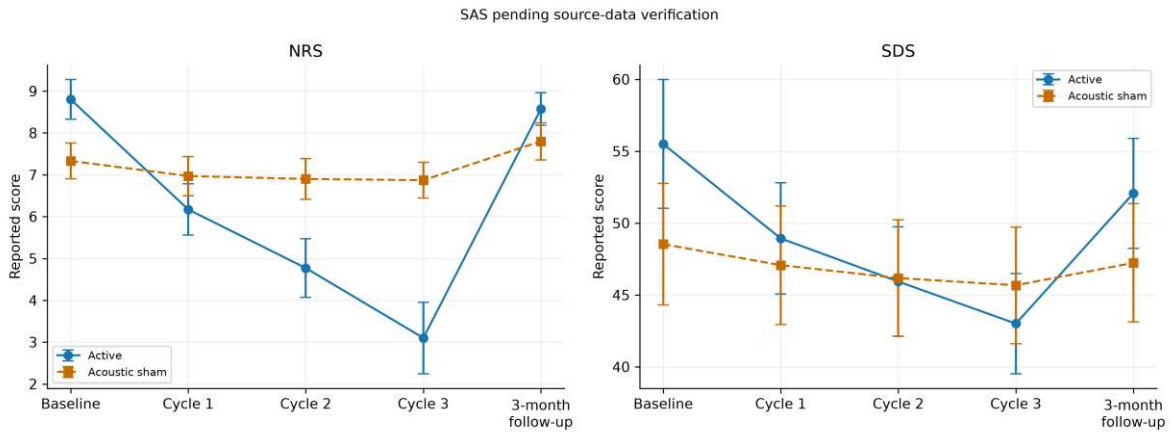


Figure 4. Unadjusted NRS and SDS group means and approximate pointwise 95% confidence intervals (n=30 per arm). Anxiety questionnaire entries were excluded owing to unresolved scoring.

4. Discussion

The participant-level reanalysis reproduced the overall ANCOVA results for VAS, NRS and SDS and confirmed a substantial difference in reported pain during treatment (Tables 2–5). This association is preliminary, as outcome reporting may be influenced by allocation awareness, regression to the mean, and other trial design limitations. The acoustic comparator did not reproduce the active tactile sensation.

The progressive reduction in reported pain does not identify a biological mechanism. Neural modulation is one hypothesis, but expectancy, repeated clinical contact and other contextual effects may also contribute. No physiological biomarkers were collected to distinguish these explanations.

The combined schedule had the lowest observed Cycle 3 pain score, but it also provided twice as many sessions. This finding cannot isolate a premenstrual timing effect from total treatment exposure. A future trial would need comparable exposure across schedules to address this question.

Pain scores returned toward baseline at the post-treatment follow-up. This observation does not establish the efficacy, safety or necessity of a continued maintenance regimen, which was not evaluated.

4.1. Methodological Considerations and Limitations

This study has important limitations: no public trial registration; a large baseline VAS imbalance; limited participant masking because acoustic sham lacked active tactile stimulation; small schedule strata; unequal treatment exposure across regimens; lack of independent verification of original allocation concealment, attendance and minor-participant consent procedures; and limited evidence of systematic adverse-event surveillance. All postbaseline regression analyses were reproduced using participant-level data, but baseline adjustment cannot remove these design constraints. One purported SAS variable was not a validated Zung raw score and was omitted. Inferences from multiple secondary and subgroup analyses are exploratory.

The acoustic sham did not reproduce the tactile sensation of active stimulation. Participant awareness of allocation could influence self-reported pain even if assessors were blinded. Blinding credibility was not reported, so the absence of sham responders cannot be attributed to a specific mechanism. Multiple secondary and subgroup comparisons are exploratory. Objective physiological biomarkers were not collected.

The participant-level data show a preliminary between-arm difference in reported menstrual pain during treatment; the observed effect declined substantially after treatment stopped. These results do not demonstrate definitive clinical efficacy or a specific neurophysiological mechanism. A larger prospectively registered study with improved tactile sham, balanced treatment exposure and prespecified efficacy and safety assessment is required.

Implications for future research. The observed dispersion, patient-level pain trajectories and responder rates provide useful planning inputs for a future adequately powered, prospectively registered study. The future protocol should establish an allocation-concealment procedure, a credible tactile comparator, dose-equated schedule groups, structured adverse-event ascertainment, and prospectively defined analysis and follow-up.

Declarations

Data Availability Statement

De-identified participant-level clinical outcome data and the analysis scripts supporting the findings of this study are available from the corresponding author upon reasonable academic request, subject to institutional ethics approval and applicable data-sharing requirements. Identifying information will not be shared.

Ethical Approval and Informed Consent

The Institutional Ethics Committee of the Institute of Neurology and Neurosurgery, Havana, Cuba, approved the study protocol (IRB_2023-05). Written informed consent was obtained from all adult participants before enrollment. For participants aged 17 years, written informed consent was obtained from their parents or legally authorized guardians prior to participation, in accordance with the ethics-approved procedures and applicable requirements. The study was conducted in accordance with the Declaration of Helsinki.

Trial Registration and Institutional Regulatory Authorization

This randomized, sham-controlled pilot clinical study was conducted at the Institute of Neurology and Neurosurgery, Havana, Cuba, a leading national tertiary-level referral institution and a center of excellence in clinical neurology, neurosurgery, and neuroscientific research within the Cuban National Health System.

The Institute operates under the authority and regulatory framework of the Cuban Ministry of Public Health (MINSAP) and is institutionally authorized to conduct clinical research in accordance with applicable national regulations. The study protocol received formal approval from the Institutional Ethics Committee (Protocol ID: IRB_2023-05).

The pilot investigation was conducted under the Institute's institutional research authorization and ethical oversight, within the regulatory framework established by MINSAP. Its exploratory design aimed to generate preliminary clinical evidence to support the methodological development, scientific justification, and potential funding of a subsequent larger, adequately powered randomized controlled trial.

Consent for Publication: Not applicable. No individual personal details, patient photographs, or identifiable data are included in this manuscript; all reported values reflect aggregated, de-identified group data.

Declaration of Interest: The authors declare no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Rezzimax LLC provided the Rezzimax Tuner Pro II devices used in the study but, according to the authors, did not participate in study design, data collection, statistical analysis, interpretation, manuscript writing, or the decision to submit the article.

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Authors' Contributions: YM and MC contributed to patient screening, clinical intervention delivery, and data curation. CM conceptualized and designed the study, performed statistical analyses, created figures and tables, and drafted the manuscript. All authors reviewed, revised, and approved the final manuscript.

Preprint Publication: The authors report an earlier preprint on Research Square; its exact bibliographic details must be confirmed in the submission system.

Use of Generative AI and AI-Assisted Technologies in the Writing and Analysis Process: During preparation of this manuscript, the authors used AI-assisted tools to improve language clarity and grammar and to assist in developing and debugging data-analysis scripts and document-production workflows. These tools were not used to generate, simulate, fabricate, or impute empirical observations or clinical outcomes. The authors reviewed and validated the analyses, code, and manuscript content and take full responsibility for the accuracy and integrity of the work.

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