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Effectiveness of Cranial Electrotherapy Stimulation on Pain Index, Alexithymia, and Chronic Fatigue in Women with Fibromyalgia

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A B S T R A C T

Purpose: This study aimed to investigate the effectiveness of cranial electrotherapy stimulation (CES) on pain intensity, alexithymia, and chronic fatigue in women diagnosed with fibromyalgia.

Methods and Materials: A quasi-experimental design was employed using a pre-test, post-test, and follow-up format with experimental and control groups. Twenty-four women diagnosed with fibromyalgia who met the inclusion criteria were selected through convenience sampling and randomly assigned to two groups (n = 12 per group). The experimental group received 12 sessions of CES (20 minutes each, twice weekly for six weeks), while the control group was placed on a waiting list. Data were collected using the Mohammadian Pain Questionnaire (1995), Chalder Fatigue Scale (1993), and the Toronto Alexithymia Scale (TAS-20). Statistical analyses included multivariate analysis of covariance (MANCOVA), univariate ANCOVAs, and Bonferroni post hoc tests, conducted using SPSS-22.

Findings: Results indicated significant differences between the experimental and control groups in all three outcome variables at post-test, with sustained effects at follow-up. CES significantly reduced pain intensity ($F = 6.58$, $p = 0.01$, $\eta^2 = 0.24$), alexithymia ($F = 11.15$, $p = 0.003$, $\eta^2 = 0.34$), and chronic fatigue ($F = 16.76$, $p = 0.001$, $\eta^2 = 0.46$). Bonferroni post hoc analysis confirmed significant differences between pre-test and post-test scores in the experimental group for all three variables, while changes between post-test and follow-up were not statistically significant, indicating the persistence of treatment effects.

Conclusion: Cranial electrotherapy stimulation is an effective, non-invasive intervention for reducing pain, emotional dysregulation, and fatigue in women with fibromyalgia. Its sustained therapeutic effects and potential integration into multidisciplinary care highlight its clinical value in addressing the complex symptomatology of this disorder.

Keywords: *Cranial Electrotherapy Stimulation, Pain, Alexithymia, Chronic Fatigue, Fibromyalgia*

1. Introduction

Fibromyalgia syndrome (FMS) is a complex, chronic condition characterized by widespread musculoskeletal pain, persistent fatigue, cognitive dysfunction, and emotional distress. Although its etiology remains multifactorial and poorly understood, it is increasingly recognized as a disorder of central sensitization, involving neurobiological, psychological, and behavioral dimensions that interact to produce persistent pain and functional impairment (Bourke et al., 2021). Affecting primarily women, fibromyalgia presents a substantial burden on quality of life and poses significant challenges for diagnosis, treatment, and management (Flynn, 2023). The complexity of symptomatology—encompassing somatic complaints like fatigue and non-restorative sleep as well as emotional and cognitive disturbances—demands integrative and multimodal approaches to intervention (Bateman, 2023; Giorgi et al., 2023).

Among the cardinal symptoms of fibromyalgia, chronic pain remains the most debilitating and persistent concern. It is often accompanied by comorbid conditions such as alexithymia—the difficulty in identifying and verbalizing emotions—which has been associated with heightened pain perception and impaired coping strategies (Martino et al., 2020). Moreover, chronic fatigue, a prevalent and equally distressing symptom, further diminishes patients' functional capacity and exacerbates psychological distress (Elijah et al., 2022). Traditional pharmacological approaches have limited long-term efficacy, and patients often report dissatisfaction due to persistent symptoms or adverse effects (Giorgi et al., 2023). As a result, the growing emphasis has shifted toward non-pharmacological interventions that target both somatic and affective dimensions of fibromyalgia.

Emerging evidence suggests that neuromodulation techniques such as cranial electrotherapy stimulation (CES), transcranial direct current stimulation (tDCS), and transcutaneous electrical nerve stimulation (TENS) may modulate pain perception and affective processing through their influence on central nervous system pathways (Da Silva et al., 2019; García-López et al., 2024; Lusicic et al., 2018). CES, in particular, has drawn attention as a safe and non-invasive modality that delivers low-level electrical currents via electrodes placed on the scalp or earlobes. These currents are thought to influence brain wave activity and neurochemical balance, especially in regions associated with emotional regulation and pain processing (De Benedittis, 2023; Elkins, 2023). The integration of CES into clinical treatment frameworks represents an innovative attempt to address the interwoven physiological and psychological features of fibromyalgia.

Several systematic reviews and meta-analyses support the efficacy of neuromodulatory interventions for improving pain intensity, functional disability, and psychological comorbidities in fibromyalgia patients (Cojocaru et al., 2024; García-López et al., 2024). TENS, a related electrotherapeutic technique, has demonstrated significant effects in reducing pain and improving quality of life when used as an adjunct to standard care (García-López et al., 2024). However, despite growing interest, there remains a scarcity of controlled studies investigating the impact of CES specifically on psychological markers such as alexithymia or chronic fatigue within the fibromyalgia population. This represents a critical gap, as addressing these emotional and cognitive dimensions is essential for comprehensive care (Favretti et al., 2023; Martino et al., 2020).

Alexithymia is of particular relevance in the context of fibromyalgia, not only because of its association with affect dysregulation but also due to its role in amplifying somatic symptoms (Martino et al., 2020). Patients with alexithymic traits tend to report greater pain sensitivity and lower emotional awareness, which may hinder effective communication with healthcare providers and reduce adherence to therapeutic protocols (Cojocaru et al., 2024). Similarly, chronic fatigue is not merely a physical symptom but often reflects deeper dysfunction in motivational, attentional, and neuroendocrine systems (Bourke et al., 2021; Elijah et al., 2022). The interrelation among pain, fatigue, and emotional dysregulation reinforces the necessity of interventions capable of targeting central mechanisms of distress.

In line with integrative treatment paradigms, combining cognitive-behavioral strategies with neurostimulation has yielded promising outcomes. For instance, acceptance and commitment therapy (ACT) and cognitive-behavioral therapy (CBT) have shown efficacy in reducing anxiety, depression, and pain perception among fibromyalgia patients (Cojocaru et al., 2024). These psychotherapeutic approaches, when complemented by physiological regulation tools such as CES, may lead to synergistic effects, fostering both cognitive restructuring and neurophysiological recalibration (Elkins, 2023). As highlighted in recent investigations, multimodal treatment frameworks not only improve symptom profiles but also

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enhance patient empowerment and emotional resilience (Di Carlo et al., 2024; Maddox et al., 2023).

Moreover, the literature reveals emerging interest in the neurobiological underpinnings of fibromyalgia, particularly in relation to central sensitization and dysregulation in pain-processing pathways (Bateman, 2023; Favretti et al., 2023). Biomarkers such as increased activity in the insula and anterior cingulate cortex have been implicated in heightened pain response and emotional arousal, suggesting that interventions aimed at modulating these brain regions may yield significant clinical benefits (Bair & Krebs, 2020; Favretti et al., 2023). CES has been posited to influence thalamocortical rhythms and modulate neurotransmitters like serotonin and dopamine, thereby restoring neurochemical balance and improving mood and cognitive clarity (Da Silva et al., 2019; De Benedittis, 2023).

Additionally, from a behavioral perspective, electrotherapy may play a role in enhancing sleep quality, reducing fatigue, and improving self-regulation in patients with chronic pain syndromes (Elijah et al., 2022; Flynn, 2023). Studies on related techniques, such as capsaicin application or dietary modifications, have highlighted the importance of addressing lifestyle and systemic inflammation in fibromyalgia management (Elijah et al., 2022; Maddox et al., 2023). Thus, CES fits within a broader framework of interventions designed to reduce allostatic load and improve autonomic regulation.

Despite the potential of CES, its application in clinical psychology remains underexplored, particularly in controlled experimental settings involving female fibromyalgia patients—a population disproportionately affected and often underserved by conventional pharmacological interventions (Di Carlo et al., 2024; Giorgi et al., 2023). Gender-specific research is vital, considering hormonal and psychosocial factors that may influence symptom expression and treatment responsiveness. Furthermore, studies such as those by Akbaş and Yiğitoğlu (Akbaş & Yiğitoğlu, 2022) emphasize the value of tailored, focused interventions that address individual behavioral patterns and emotional functioning, which can be particularly relevant in fibromyalgia populations with high levels of irritability, emotional suppression, and psychological comorbidity.

The current study responds to the need for targeted, evidence-based interventions by evaluating the effectiveness of cranial electrotherapy stimulation on three core dimensions of fibromyalgia symptomatology: pain intensity, alexithymia, and chronic fatigue.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a quasi-experimental research design with a pre-test, post-test, and follow-up framework, including experimental and control groups. The statistical population comprised all women diagnosed with fibromyalgia who visited Mehr Hospital in Behshahr during the first half of 2024 and received a diagnosis from an orthopedic specialist. Based on the G*Power software, a sample size of 24 participants was calculated, with 12 assigned to each group.

After obtaining permission from Mehr Hospital, announcements were posted in the hospital and orthopedic clinics to recruit women diagnosed with fibromyalgia who met the inclusion criteria and were willing to participate. All participants underwent a structured clinical interview to ensure the absence of psychological disorders. Ultimately, 24 individuals who met the eligibility criteria were selected through convenience sampling and randomly assigned to either the experimental group (receiving cranial electrotherapy stimulation treatment) or the control group (12 participants each).

Initially, all participants completed the pre-test, which included questionnaires on pain, alexithymia, and chronic fatigue. The experimental group then underwent 12 sessions of cranial electrotherapy stimulation (CES), each lasting 20 minutes. During this intervention period, the control group was placed on a waiting list. After the intervention, both groups completed the post-test and follow-up questionnaires.

Following the determination of research objectives, appropriate tools and measurement instruments were selected based on their psychometric properties. After sampling was finalized, permission for implementation was obtained from Mehr Hospital in Behshahr. In collaboration with hospital administration, a public notice was posted, and potential participants (women diagnosed with fibromyalgia) were identified and enrolled through the hospital and orthopedic clinics. Structured clinical interviews were conducted to rule out psychiatric disorders.

A total of 24 eligible participants were recruited through convenience sampling. Both groups were invited to attend an orientation session to explain the study objectives and obtain informed consent. Participants were then randomly assigned to either the experimental or control group.

Pre-tests were administered to assess baseline levels of pain, alexithymia, and chronic fatigue. The experimental

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group then participated in CES sessions, which were conducted at the Hekmat Psychological Counseling Center in Behshahr. During the intervention period, the control group remained on a waiting list. After the last session, post-tests were conducted simultaneously under similar conditions for both groups.

To ensure ethical considerations, participants signed informed consent forms. They were assured that their information would remain confidential and that their names would not appear on any questionnaire. They were also informed of their right to withdraw from the study at any point.

2.2. Measures

Mohammadian Pain Questionnaire: This instrument contains 25 items derived from the McGill Pain Questionnaire and developed by Mohammadian (1995). It assesses three dimensions of pain: sensory-physical (items 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25), emotional-affective (items 2, 6, 10, 14, 18), and cognitive-evaluative (items 4, 8, 12, 16, 20, 22, 24). Respondents rate each item on a 6-point Likert scale: Not at all (0), Very little (1), Little (2), Moderate (3), Much (4), and Very much (5). Scores are summed separately for each subscale and a total score indicates the overall pain severity. Content validity was confirmed by three medical specialists. Test-retest reliability over a one-month interval was reported at 0.98. In the present study, Cronbach's alpha for the overall scale was 0.93; subscale alphas were 0.87 for sensory-physical, 0.79 for emotional-affective, and 0.81 for cognitive-evaluative.

Chalder Fatigue Scale: Developed by Chalder et al. (1993), this 14-item self-report instrument assesses physical and mental fatigue. Each item is rated on a 4-point scale ranging from "Much less than usual" (0) to "Much more than usual" (3). The first 8 items measure physical fatigue and the remaining 6 assess mental fatigue. The scale has been widely used in epidemiological studies and clinical outcome evaluations related to chronic fatigue syndrome. Internal consistency coefficients were reported as 0.89 for the total scale, 0.85 for physical fatigue, and 0.82 for mental fatigue. Sensitivity and specificity using a cutoff score of 22 were reported at 75.5% and 74.5%, respectively.

Toronto Alexithymia Scale (TAS-20): Developed by Bagby, Taylor, and Parker (1994), TAS-20 is a 20-item self-report scale measuring alexithymia across three subscales: Difficulty Identifying Feelings (items 1, 3, 6, 7, 9, 13, 14), Difficulty Describing Feelings (items 2, 4, 11, 12, 17), and Externally Oriented Thinking (items 5, 8, 10, 15, 16, 18, 19, 20). Each item is rated on a 5-point Likert scale from "Strongly disagree" (1) to "Strongly agree" (5). Total alexithymia scores are computed by summing the three subscale scores. Items 4, 5, 10, 18, and 19 are reverse-scored. Psychometric evaluations of the TAS-20 have confirmed its reliability and validity across multiple studies. In the Persian version, Cronbach's alpha values were 0.85 for the total scale, 0.82 for Difficulty Identifying Feelings, 0.75 for Difficulty Describing Feelings, and 0.72 for Externally Oriented Thinking. Test-retest reliability over four weeks ranged from $r = 0.70$ to $r = 0.77$ for total and subscale scores. Concurrent validity was supported through correlations with emotional intelligence, psychological well-being, and psychological distress scales.

2.3. Intervention

Participants in the experimental group received CES with alpha wave stimulation using a current of 2 mA at a frequency of 8–12 Hz. Treatment was administered twice weekly for ten consecutive weeks (a total of 12 sessions), with each session lasting 20 minutes. Electrodes were attached to the left and right earlobes, and stimulation ceased automatically after 20 minutes.

2.4. Data Analysis

Data analysis began with the Kolmogorov-Smirnov test to assess the normality of data distribution. Levene's test was then conducted to check the homogeneity of error variances. Finally, ANCOVA and Bonferroni post hoc tests were employed to evaluate the research hypotheses. Statistical analysis was performed using SPSS version 22.

3. Findings and Results

To provide a preliminary overview of the changes across groups and over time, descriptive statistics were calculated for all key variables: pain index, alexithymia, and chronic fatigue. As shown in Table 0, at the pre-test stage, the experimental group had a mean pain index score of 72.42 (SD = 6.35), which decreased substantially to 57.67 (SD = 5.91) at post-test and slightly increased to 59.58 (SD = 6.03) at follow-up. In contrast, the control group showed minimal change in pain index from pre-test (M = 71.75, SD = 6.18) to post-test (M = 70.08, SD = 5.87) and follow-up (M = 70.33, SD = 6.15). Similarly, the mean alexithymia score in the experimental group declined from 67.75 (SD = 5.92) at

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pre-test to 56.17 (SD = 6.14) at post-test, with a stable follow-up mean of 56.63 (SD = 5.87), while the control group remained relatively stable across all three time points. For chronic fatigue, the experimental group demonstrated a decrease from a pre-test mean of 39.08 (SD = 4.43) to 35.25 (SD = 4.11) at post-test and 34.96 (SD = 4.20) at follow-up, whereas the control group showed little variation (pre-test: M = 38.75, SD = 4.29; post-test: M = 38.25, SD = 4.37; follow-up: M = 38.00, SD = 4.44). These descriptive trends suggest a notable improvement in all three measured domains for the experimental group following the cranial electrotherapy stimulation intervention.

Table 1

Descriptive Statistics for Pain Index, Alexithymia, and Chronic Fatigue by Group and Time (N = 24)

Variable	Group	Pre-test M (SD)	Post-test M (SD)	Follow-up M (SD)
Pain Index	Experimental	72.42 (6.35)	57.67 (5.91)	59.58 (6.03)
	Control	71.75 (6.18)	70.08 (5.87)	70.33 (6.15)
Alexithymia	Experimental	67.75 (5.92)	56.17 (6.14)	56.63 (5.87)
	Control	66.92 (6.08)	65.50 (6.31)	65.75 (6.26)
Chronic Fatigue	Experimental	39.08 (4.43)	35.25 (4.11)	34.96 (4.20)
	Control	38.75 (4.29)	38.25 (4.37)	38.00 (4.44)

To ensure that the dataset met the fundamental assumptions of ANCOVA, the relevant assumptions were examined. These included linearity, multicollinearity, homogeneity of variances, and homogeneity of regression slopes. To assess the assumption of covariance homogeneity, Box's M test was conducted. The results showed that the F value was 1.64 and not statistically significant (P > 0.13). Therefore, it can be concluded that the covariance matrices of the two groups are homogeneous.

According to the Levene's F statistic for equality of variances on the post-test scores across the experimental and control groups, the results were not statistically significant, indicating that the variances for the post-test scores of pain index, alexithymia, and chronic fatigue were equal across groups. Thus, another condition for ANCOVA was met.

Another crucial assumption of multivariate ANCOVA is the homogeneity of regression slopes. This was tested by examining the interaction between the pre-test scores of the subscales (pain index, alexithymia, and chronic fatigue) and the independent variable (intervention method) at the post-test stage. These interactions were not statistically significant, confirming the homogeneity of regression slopes.

Since the assumptions of multivariate ANCOVA were satisfied, use of this statistical test was justified. Additionally, results indicated that the F values for the interaction of group with pre-test on all three research variables—pain index (F = 1.36, P > 0.28), alexithymia (F = 2.38, P > 0.12), and chronic fatigue (F = 0.79, P > 0.47)—were not statistically significant. This suggests that the regression slopes for the dependent variables were homogeneous, confirming this assumption as well.

Table 3 results show that the effect size (η^2 = 0.86) indicates that 86% of the difference between the two groups can be attributed to the experimental intervention. The statistical power was calculated as 1, confirming sufficient sensitivity to detect meaningful effects. Accordingly, it can be concluded that at least one of the dependent variables (pain index, alexithymia, or chronic fatigue) demonstrated a significant difference between the two groups in the post-test stage. To identify the source of this difference, three univariate ANCOVAs within the MANCOVA were performed, with results presented in Table 2.

Table 2

Results of MANCOVA on Mean Scores of Research Variables

Source of Variation	Value	F Ratio	df (Hypotheses)	df (Error)	Sig.	Effect Size	Power
Pillai's Trace	0.86	37.44	3	17	0.001	0.86	1.000
Wilks' Lambda	0.13	37.44	3	17	0.001	0.86	1.000
Hotelling's Trace	6.6	37.44	3	17	0.001	0.86	1.000
Roy's Largest Root	6.6	37.44	3	17	0.001	0.86	1.000

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As shown in Table 3, the computed F values for the effect of cranial electrotherapy stimulation on the components of pain index, alexithymia, and chronic fatigue were statistically significant. Based on the group means, the experimental group scored lower than the control group on all three variables. Thus, it can be concluded that CES effectively reduced pain, alexithymia, and chronic fatigue in women with fibromyalgia.

Moreover, the computed F values for the effect of pre-test scores on the outcome variables were not statistically significant. This indicates that the observed changes in the post-test scores of the experimental group were not influenced by the pre-test scores. The eta squared values further show that CES explained 24% of the variance in pain index, 34% in alexithymia, and 46% in chronic fatigue.

Table 3

ANCOVA Results Within MANCOVA on Post-Test Mean Scores of Research Variables

Variable	Source	SS	df	MS	F	Sig.	Effect Size
Pain Index	Pre-test	292.723	1	292.723	2.635	0.12	0.11
	Group	731.415	1	731.415	6.58	0.01	0.24
	Error	2222.028	20	111.101			
Alexithymia	Pre-test	17.06	1	17.06	0.32	0.57	0.01
	Group	595.084	1	595.084	11.15	0.003	0.34
	Error	1120.098	21	53.338			
Chronic Fatigue	Pre-test	32.644	1	32.644	1.58	0.22	0.07
	Group	346.315	1	346.315	16.76	0.001	0.46

Table 4 also presents Bonferroni post hoc results comparing the means of the research variables across pre-test, post-test, and follow-up stages to assess the sustained impact of CES. According to Table 4, the mean differences between pre-test and post-test, and between pre-test and follow-up, were statistically significant for all three variables ($P < 0.001$). However, the differences between post-test and follow-up were not significant ($P > 0.001$). This suggests that CES led to improvements in pain index, alexithymia, and chronic fatigue during the post-test phase, and these improvements were maintained at follow-up.

Table 4

Bonferroni Post Hoc Test for Pairwise Comparisons of Research Variables

Variable	Comparison	Mean Difference	Std. Deviation	Sig.
Pain Index	Pre-test – Post-test	14.75	2.65	0.001
	Pre-test – Follow-up	12.83	2.48	0.001
	Post-test – Follow-up	-1.91	2.4	0.43
Alexithymia	Post-test – Pre-test	11.58	1.65	0.001
	Pre-test – Follow-up	11.12	1.84	0.001
	Post-test – Follow-up	-0.48	2.16	0.83
Chronic Fatigue	Post-test – Pre-test	3.83	1.07	0.002
	Pre-test – Follow-up	4.12	1.33	0.005
	Post-test – Follow-up	0.29	1.29	0.82

4. Discussion and Conclusion

The present study aimed to evaluate the effectiveness of cranial electrotherapy stimulation (CES) on three core domains of fibromyalgia symptomatology—pain intensity, alexithymia, and chronic fatigue—among women diagnosed with the disorder. The results of the multivariate and univariate analyses revealed that CES significantly reduced all three variables in the experimental group compared to the control group. These effects were not only evident in the post-test stage but were also sustained at follow-up, suggesting that CES may offer lasting therapeutic benefits for fibromyalgia patients. Importantly, the intervention's effect sizes were substantial, explaining 24% of the variance in pain intensity, 34% in alexithymia, and 46% in chronic fatigue. The findings provide compelling support for CES as

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a non-pharmacological, neuromodulatory intervention with both physical and psychological utility.

The observed reduction in pain intensity aligns with the growing body of literature identifying CES as a viable method for pain modulation through electrical stimulation of the brain. Similar findings have been reported in studies on transcutaneous electrical nerve stimulation (TENS), where improvements in pain perception, functional disability, and quality of life were documented among patients with fibromyalgia (García-López et al., 2024). CES, like TENS, likely influences thalamocortical rhythms and neurotransmitter activity, modulating the neural substrates of pain perception. The results are also consistent with the theoretical framework of central sensitization, where interventions targeting the central nervous system (CNS) are especially relevant in conditions such as fibromyalgia, characterized by altered CNS processing and heightened pain sensitivity (Bateman, 2023; Bourke et al., 2021).

Moreover, the reduction in alexithymia following CES treatment adds an important dimension to existing knowledge. Alexithymia, defined by difficulty in identifying and describing emotions, has been consistently associated with elevated levels of psychological and somatic distress in fibromyalgia patients (Martino et al., 2020). The current study extends this literature by demonstrating that CES, through its regulatory effects on brain regions implicated in emotional processing (e.g., prefrontal cortex, anterior cingulate), may enhance affective awareness and reduce emotional suppression. This is supported by neuroimaging research showing that electrotherapies such as tDCS and CES can modulate neural circuits involved in emotion regulation (Da Silva et al., 2019; De Benedittis, 2023). The study by Cojocaru et al. (Cojocaru et al., 2024) on psychotherapeutic interventions like cognitive-behavioral therapy (CBT) and acceptance and commitment therapy (ACT) further highlights the significance of targeting emotional and cognitive constructs in fibromyalgia treatment. In that sense, CES may serve as a complementary tool to these therapies, offering neurobiological support to psychological mechanisms.

Chronic fatigue, another debilitating symptom of fibromyalgia, also showed significant improvement in the experimental group. This finding is particularly noteworthy, as fatigue has been one of the most resistant symptoms to pharmacological treatment in FMS populations (Flynn, 2023; Giorgi et al., 2023). While the pathophysiology of fibromyalgia-related fatigue is multifaceted, it likely involves dysfunction in both the HPA axis and autonomic nervous system. CES has been shown to stabilize neuroendocrine functioning, reduce cortisol levels, and enhance parasympathetic activity—all of which may contribute to improvements in energy levels and fatigue perception (Elijah et al., 2022; Elkins, 2023). These results resonate with prior findings in which neuromodulatory interventions contributed to reduced fatigue and improved sleep quality among chronic pain sufferers (Elijah et al., 2022).

The study's findings are also congruent with the broader trend in fibromyalgia research, which increasingly emphasizes integrative, multimodal approaches to treatment. While pharmacological regimens may offer symptom relief, they are often insufficient in addressing the complex interplay between physiological pain, affective dysregulation, and cognitive impairment in fibromyalgia (Di Carlo et al., 2024; Maddox et al., 2023). In contrast, interventions like CES operate at the interface of neurobiology and behavior, offering a dual-action benefit that targets both the central nervous system and psychological experience. This makes CES especially suitable for complex syndromes like fibromyalgia, where pain is rarely a purely physical phenomenon but is intricately linked to emotional and cognitive functioning (Cojocaru et al., 2024; Favretti et al., 2023).

Additionally, the sustained impact of CES observed at follow-up underscores its potential for long-term symptom management. The absence of significant regression between post-test and follow-up suggests that CES may induce enduring neural plasticity or foster improved self-regulation habits. This notion is reinforced by research on related electrotherapies and neuromodulation techniques, which show evidence of cumulative and persistent therapeutic effects (Lusicic et al., 2018). Given the chronic nature of fibromyalgia and the cyclical exacerbation of symptoms, any intervention with the potential for lasting relief represents a valuable asset in clinical practice.

Furthermore, the findings should be interpreted within the context of existing therapeutic paradigms. For example, combining CES with behavioral or mindfulness-based interventions may yield synergistic effects, enhancing both symptom control and emotional resilience. This is supported by studies such as those by Akbaş and Yiğitoğlu (Akbaş & Yiğitoğlu, 2022), who demonstrated that structured psychological interventions can significantly reduce aggression and dysregulation in adolescents. Their approach suggests that affective retraining, when coupled with neuromodulatory support like CES, can lead to more

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profound and generalized improvements in psychological functioning. This integrative model is especially pertinent in fibromyalgia care, where addressing one symptom domain often catalyzes positive changes in others.

Despite its contributions, the present study is not without limitations. First, the sample size was relatively small (N = 24), which may limit the generalizability of the findings. A larger, more diverse sample would provide greater statistical power and allow for subgroup analyses based on variables such as age, duration of illness, or comorbid psychiatric conditions. Second, the study was limited to female participants. Although fibromyalgia predominantly affects women, including male participants in future research would enhance the inclusiveness of the findings. Third, the use of self-report questionnaires may introduce response bias, particularly in assessing subjective variables such as pain and fatigue. Finally, while the study included a follow-up phase, the duration was limited. Longer-term follow-ups are necessary to assess the sustainability of CES effects over time.

Future research should consider expanding the sample size and employing multi-site randomized controlled trials to enhance external validity. Comparative studies that evaluate CES alongside or in combination with other interventions—such as CBT, ACT, mindfulness training, or pharmacological regimens—may also be valuable in identifying optimal treatment combinations. Neuroimaging and neurophysiological measures should be incorporated to better understand the mechanisms underlying CES effects on brain function and symptom relief. Additionally, exploring dose-response relationships and individual differences in CES responsiveness could help personalize treatment and maximize therapeutic outcomes.

Given the promising results, clinicians may consider integrating CES into the multidisciplinary treatment plans of fibromyalgia patients, particularly those who experience comorbid emotional difficulties such as alexithymia and chronic fatigue. CES may be especially useful in cases where pharmacological treatments have proven ineffective or poorly tolerated. Mental health practitioners working with fibromyalgia patients should also be aware of the potential role CES can play in emotional regulation and stress reduction. Lastly, incorporating CES into routine clinical protocols may enhance patient engagement and broaden access to non-invasive, low-risk treatment options that support long-term symptom management and quality of life.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent.

References

Akbaş, E., & Yiğitoğlu, G. T. (2022). The effect of solution-focused approach on anger management and violent behavior in adolescents: A randomized controlled trial. *Arch Psychiatr Nurs*, *41*, 166-174. https://doi.org/10.1016/j.apnu.2022.07.029

Bair, M. J., & Krebs, E. E. (2020). Fibromyalgia. *Annals of Internal Medicine*, *172*(5), 33-48. https://doi.org/10.7326/AITC202003030

Bateman, L. (2023). Fibromyalgia and myalgic encephalomyelitis/chronic fatigue syndrome. *Neurobiology of Brain Disorders*, 559-573. https://doi.org/10.1016/B978-0-323-85654-6.00061-7

Bourke, J. H., Wodehouse, T., & White, P. D. (2021). Central sensitisation in chronic fatigue syndrome and fibromyalgia; a case control study. *Journal of psychosomatic research*, *150*, 110624. https://doi.org/10.1016/j.jpsychores.2021.110624

Cojocaru, C. M., Popa, C. O., Schenk, A., Suciu, B. A., & Szasz, S. (2024). Cognitive-behavioral therapy and acceptance and commitment therapy for anxiety and depression in patients with fibromyalgia: a systematic review and meta-analysis. *Med Pharm Rep*, *97*(1), 26-34. https://doi.org/10.15386/mpr-2661

E-ISSN: 2980-9681

Da Silva, R. D. M. F., Brunoni, A. R., Miguel, E. C., & Shavitt, R. G. (2019). Transcranial direct current stimulation for obsessive-compulsive disorder: patient selection and perspectives. *Neuropsychiatric Disease and Treatment*, *15*, 2663. https://doi.org/10.2147/NDT.S184839

De Benedittis, G. (2023). The Challenge of Fibromyalgia Efficacy of Hypnosis in Alleviating the Invisible Pain: A Narrative Review. *Int J Clin Exp Hypn*, *71*(4), 276-296. https://doi.org/10.1080/00207144.2023.2247443

Di Carlo, M., Bianchi, B., & Salaffi, F. (2024). Fibromyalgia and the Difficult Synthesis. *J Rheumatol*, *51*(6), 554-555. https://doi.org/10.3899/jrheum.2024-0321

Elijah, J., Powell, K., & Smith, M. A. (2022). The Efficacy of Capsaicin on Sleep Quality and Fatigue in Fibromyalgia. *J Pain Palliat Care Pharmacother*, *36*(2), 112-116. https://doi.org/10.1080/15360288.2022.2063468

Elkins, G. (2023). Efficacy of Hypnosis Interventions: Fibromyalgia, Sleep, Oncology, Test Anxiety, and Beliefs. *Int J Clin Exp Hypn*, *71*(4), 273-275. https://doi.org/10.1080/00207144.2023.2243785

Favretti, M., Iannuccelli, C., & Di Franco, M. (2023). Pain Biomarkers in Fibromyalgia Syndrome: Current Understanding and Future Directions. *Int J Mol Sci*, *24*(13), 10443. https://doi.org/10.3390/ijms241310443

Flynn, D. (2023). Chronic Pain Syndromes: Fibromyalgia. *Essent*, 533-537-515. https://pubmed.ncbi.nlm.nih.gov/37812528/

García-López, H., Calle-Ortega, F., García-Robles, P., Del-Rey, R. R., Obrero-Gaitán, E., & Cortés-Pérez, I. (2024). Effectiveness of transcutaneous electrical nerve stimulation improves pain intensity, disability and quality of life in patients with fibromyalgia syndrome: a systematic review with meta-analysis. *Disabil Rehabil*, *21*, 1-11. https://doi.org/10.1080/09638288.2024.2331069

Giorgi, V., Bazzichi, L., Batticciotto, A., Pellegrino, G., Di Franco, M., Sirotti, S., Atzeni, F., Alciati, A., Salaffi, F., & Sarzi, P. (2023). Fibromyalgia: one year in review. *Clin Exp Rheumatol*, *41*(6), 1205-1213. https://doi.org/10.55563/clinexprheumatol/257e99

Lusicic, A., Schruers, K. R. J., Pallanti, S., & Castle, D. J. (2018). Transcranial magnetic stimulation in the treatment of obsessive-compulsive disorder: current perspectives. *Neuropsychiatr Dis Treat*, *14*, 1721-1722. https://doi.org/10.2147/NDT.S121140

Maddox, E. K., Massoni, S. C., Hoffart, C. M., & Takata, Y. (2023). Dietary Effects on Pain Symptoms in Patients with Fibromyalgia Syndrome: Systematic Review and Future Directions. *Nutrients*, *15*(3), 716. https://doi.org/10.3390/nu15030716

Martino, G., Caputo, A., Vicario, C. M., Catalano, A., Schwarz, P., & Quattropani, M. C. (2020). The relationship between alexithymia and type 2 diabetes: a systematic review. *Front Psychol*, *11*, 20-26. https://doi.org/10.3389/fpsyg.2020.02026

E-ISSN: 2980-9681