



# A New Approach to Treating Irritable Bowel Syndrome: The Impact of Neurofeedback on Electrophysiological Markers and Patient Symptoms

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## Abstract

**Background and Objective:** Irritable bowel syndrome (IBS) is a prevalent functional gastrointestinal disorder with symptoms, such as abdominal pain, bloating, and altered bowel habits. Emerging evidence suggests that dysregulation of the brain-gut axis plays a central role in IBS pathophysiology. This study aimed to evaluate the effectiveness of neurofeedback therapy in modulating brain wave activity and alleviating IBS symptoms.

**Materials and Methods:** A quasi-experimental design with a pretest-posttest control group was employed. Thirty female patients with IBS, diagnosed using the Rome III diagnostic criteria, were randomly assigned to experimental (n = 15) and control (n = 15) groups. The experimental group underwent 20 neurofeedback sessions over six weeks. Quantitative electroencephalography assessed brain wave activity and validated symptom severity scales, measured clinical outcomes. Statistical analyses compared pre- and post-intervention results within and between groups.

**Results:** Neurofeedback therapy significantly normalized alpha and beta brain wave activities in the experimental group ( $P < 0.01$ ). Participants also reported substantial improvements in IBS symptom severity, including reduced abdominal pain, bloating, and irregular bowel habits ( $P < 0.01$ ). No significant changes were observed in the control group.

**Conclusions:** Neurofeedback therapy effectively regulates brain wave activity and reduces IBS symptoms, offering a promising complementary approach for managing this chronic disease. These findings suggest that neurofeedback can be incorporated into clinical practice as a non-invasive, adjunctive treatment for IBS. Further large-scale, long-term studies are recommended to confirm these findings and optimize treatment protocols.

**Keywords:** Biofeedback Therapy, Brain-Gut Axis, Electroencephalography, Irritable bowel syndrome, Neurofeedback

## Background

Irritable bowel syndrome (IBS) is a prevalent and complex functional gastrointestinal disorder characterized by recurrent abdominal pain, bloating, and changes in bowel habits that may manifest as diarrhea, constipation, or a combination of both. It is important to note that IBS differs from structural gastrointestinal diseases because it does not involve detectable organic abnormalities, making its diagnosis and treatment particularly challenging [1]. Epidemiological studies suggest that IBS affects approximately 11% of the global population, with a higher prevalence among women, particularly during their reproductive years [2]. This disorder significantly impacts patients' quality of life, contributing to increased healthcare utilization, decreased work productivity, and heightened psychological distress, including anxiety and depression [3, 4].

Despite its high prevalence, the precise etiology of

IBS remains unclear. However, it is widely recognized as a multifactorial condition involving genetic predisposition, psychosocial stressors, gut microbiota symbiosis, and altered gut motility [5]. The pathophysiology of IBS is thought to involve dysregulation of the brain-gut axis—a bidirectional communication system linking the central nervous system with the enteric nervous system. Disruption of this communication network can lead to visceral hypersensitivity, abnormal gut motility, and an exaggerated emotional response to gastrointestinal symptoms, all contributing to the clinical manifestations of IBS [6].

In addition to gastrointestinal disturbances, IBS is often associated with various psychiatric comorbidities, including anxiety, depression, and somatization [7]. The emotional component of IBS symptoms is particularly noteworthy, as psychological distress can exacerbate

gastrointestinal symptoms, creating a vicious cycle that impairs the patient's overall well-being [8]. Psychological factors, such as stress and anxiety, influence the functioning of the brain-gut axis, intensifying the perception of abdominal pain and discomfort [9]. Given the complexity of IBS, management typically includes dietary modifications, pharmacotherapy, and psychological interventions. However, these approaches often provide only limited or transient symptom relief, underscoring the need for novel therapeutic strategies [10].

Recently, there has been growing interest in non-invasive therapies targeting the brain-gut axis, offering potential benefits beyond traditional treatment approaches. One such emerging therapy is neurofeedback, a specialized form of biofeedback that provides real-time feedback on brain wave activity, enabling individuals to modulate and optimize neural function through self-regulation [11]. Neurofeedback has been widely utilized in managing psychiatric and neurological conditions, such as anxiety, attention deficit hyperactivity disorder, and migraines, with promising results [12]. Given the pivotal role of neurophysiological factors in IBS, neurofeedback may hold promise as a therapeutic intervention for patients with this disorder, addressing both gastrointestinal symptoms and associated psychological distress [13].

Neurofeedback trains individuals to regulate their brain wave activity, promoting balanced brain function. Brain wave activity is classified into five primary frequency bands: delta, theta, alpha, beta, and gamma [14]. Each of these waves is associated with distinct cognitive and emotional states; for instance, alpha waves are associated with relaxation, while beta waves are associated with heightened alertness and stress [15]. Research indicates that patients with IBS often exhibit abnormal brain wave patterns, including excessive beta activity, which correlates with increased stress and anxiety [16]. In this context, neurofeedback aims to restore optimal brain wave dynamics, potentially alleviating IBS symptoms by enhancing relaxation and reducing visceral hypersensitivity [17].

Recent studies have emphasized the potential of neurofeedback in treating IBS. For example, Tabatabaei et al. (2021) found that neurofeedback therapy could improve autonomic regulation and reduce visceral hypersensitivity in patients with IBS, thereby decreasing symptom severity [18]. Ebrahimian et al. (2018) suggested that neurofeedback might alleviate stress-related symptoms in IBS patients, thus enhancing overall emotional resilience [19]. The non-invasive nature of neurofeedback, combined with its ability to

modulate the brain-gut axis and promote relaxation, makes it an attractive alternative to pharmacological treatments, which often have side effects and provide only temporary relief [20].

Moreover, neurofeedback offers a patient-centered approach, encouraging individuals to actively participate in their treatment. This involvement may increase treatment adherence and long-term effectiveness. Unlike traditional treatments that primarily focus on symptom management, neurofeedback strives to address the underlying neurophysiological mechanisms of IBS, presenting the potential for a more sustainable approach to managing this disorder [21].

However, despite promising preliminary findings, the evidence supporting neurofeedback's efficacy in IBS remains limited, necessitating further research to establish its clinical effectiveness. Several studies have highlighted the importance of larger, randomized controlled trials to validate the impact of neurofeedback on IBS symptoms and to explore the mechanisms underlying its effects [22, 23]. Particularly, there is a need for studies examining the long-term effects of neurofeedback therapy on both gastrointestinal symptoms and psychological distress in patients with IBS [24].

This study aims to assess the effectiveness of neurofeedback therapy in modulating brain wave activity and alleviating IBS symptoms. Using a quasi-experimental design, this study will evaluate whether neurofeedback can reduce the severity of IBS symptoms, improve brain wave regulation, and enhance the overall quality of life of patients with IBS. By addressing the neurophysiological mechanisms underlying IBS and its associated psychological distress, this study seeks to contribute to the development of integrative, sustainable treatment strategies for this complex disorder.

Despite promising preliminary findings from small-scale studies on biofeedback and related psychological interventions for IBS, the specific application of electroencephalography (EEG)-based neurofeedback targeting brain wave dysregulation remains underexplored. Existing evidence is largely limited to older or smaller trials, often without detailed quantitative EEG (QEEG) assessments of specific markers, such as alpha wave power and frontal alpha asymmetry, which are implicated in stress regulation and emotional processing along the brain-gut axis [18, 19]. Moreover, recent systematic reviews and meta-analyses of brain-gut behavioral therapies for IBS have primarily focused on hypnotherapy, cognitive behavioral therapy, or pharmacological neuromodulators, with minimal inclusion or emphasis on neurofeedback protocols [e.g., references to recent reviews on gut-directed

hypnotherapy or behavioral therapies]. The current study addresses this gap by employing a quasi-experimental design to evaluate the effects of a structured 20-session neurofeedback protocol on both electrophysiological markers (via QEEG) and clinical symptoms in female patients diagnosed with Rome III diagnostic criteria. This approach not only provides novel insights into the potential of neurofeedback to modulate specific brain wave patterns linked to visceral hypersensitivity and psychological distress in IBS but also highlights its feasibility as a non-invasive, adjunctive therapy, particularly in populations with higher prevalence, such as women.

### Objectives

This study aimed to evaluate the efficacy of neurofeedback therapy in modulating brain wave activity, reducing IBS symptom severity, and improving quality of life among female patients using a quasi-experimental design.

### Materials and Methods

#### Study Design

This study employed a quasi-experimental design with a pretest-posttest control group to assess the effectiveness of neurofeedback therapy on brain wave activity and symptom severity in patients with IBS. Participants were evaluated at baseline and post-intervention using validated measures for brain activity and IBS symptoms.

#### Participants

The study involved 30 female patients aged 20–50 years who were diagnosed with IBS according to the Rome III diagnostic criteria. Participants were recruited from specialized gastroenterology clinics in Tabriz City, Iran.

The sample size of 30 participants (15 per group) was determined based on similar pilot/quasi-experimental neurofeedback studies in IBS and related disorders, which typically use 20–40 participants and report large effect sizes (e.g., Cohen's  $d > 0.8$ ) for symptom reduction and EEG changes (15). Post-hoc power analysis confirmed adequate power ( $> 0.80$ ) to detect large effects observed in our results.

#### Inclusion Criteria:

The inclusion criteria included a confirmed diagnosis of IBS, moderate to severe IBS symptoms based on a standardized severity scale, and no prior experience with neurofeedback therapy.

#### Exclusion Criteria:

- The exclusion criteria included the presence

of psychiatric disorders, including major depression and anxiety, use of psychotropic medications, pregnancy or lactation, and neurological conditions or other chronic gastrointestinal diseases.

Participants were randomly assigned to two groups: an experimental group ( $n = 15$ ) receiving neurofeedback therapy and a control group ( $n = 15$ ) receiving no intervention.

#### Intervention

The experimental group underwent neurofeedback therapy comprising 20 sessions, delivered three times per week over six weeks. Each session lasted 30–45 minutes.

#### Neurofeedback Equipment:

Neurofeedback sessions used a certified EEG-based system capable of real-time monitoring of brain wave activity. Sensors were placed on the scalp to record alpha, beta, theta, and delta brain wave frequencies.

#### Procedure:

During each session, participants received visual and auditory feedback based on their brain wave activity. The objective was to reduce excessive beta wave activity and enhance alpha-wave production to promote relaxation and self-regulation. Adjustments were made according to individual progress. The control group did not receive any neurofeedback or alternative interventions during the study.

#### Outcome Measures

##### 1. Brain Wave Activity:

Brain wave activity was measured using QEEG before and after the intervention, focusing on changes in alpha and beta wave frequencies, which are implicated in stress and relaxation mechanisms.

##### 2. Irritable Bowel Syndrome (IBS) Symptom Severity:

Symptom severity was assessed using the IBS Severity Scoring System, which evaluates abdominal pain, bloating, bowel habit dissatisfaction, and quality of life on a scale of 0–500. A reduction of  $\geq 50$  points was considered clinically significant.

#### Demographic and Clinical Characteristics:

Baseline characteristics, such as age, body mass index, symptom duration, and medication use, were recorded for all participants.

#### Statistical Analysis

Data were analyzed using SPSS (version 26). Descriptive statistics (mean  $\pm$  standard deviation) summarized baseline characteristics. The data

distribution was assessed for normality using the Shapiro-Wilk test. Parametric tests (paired/independent t-tests, analysis of covariance [ANCOVA]) were used as data met normality assumptions; otherwise, non-parametric equivalents would have been applied. Paired t-tests and independent sample t-tests compared pre- and post-intervention outcomes within and between groups. Analysis of variance evaluated the interaction effects of group and time on brain wave activity and symptom severity. A *P*-value of less than 0.05 was considered statistically significant.

### Ethical Considerations

The study was approved by the Ethics Committee of the Islamic Azad University, Tabriz Branch, Iran (IR.IAU.TABRIZ.REC.1402.406). Written informed consent was obtained from all participants after explaining the study's objectives, procedures, potential benefits, and risks. Participants were

assured of confidentiality and their right to withdraw from the study at any time.

### Results

This study examined the effectiveness of neurofeedback therapy on brain waves and symptoms in women with IBS. The findings are presented in two sections: descriptive statistics and inferential results.

#### Descriptive Statistics

The participants consisted of 30 women diagnosed with IBS, randomly assigned to experimental and control groups (15 in each group). The groups were matched based on demographic variables, including age and education. The mean age of the experimental group was  $33.87 \pm 7.82$  years, while the control group had a mean age of  $34.41 \pm 6.94$  years. The majority of participants in both groups had high school diplomas (46.7%) (Table 1).

**Table 1.** Age Distribution of Participants

| Age Group (y) | Experimental Group (No. %) | Control Group (No. %) |
|---------------|----------------------------|-----------------------|
| 20–25         | 1 (6.7)                    | 1 (6.7)               |
| 26–30         | 4 (26.7)                   | 2 (13.3)              |
| 31–35         | 4 (26.7)                   | 6 (40)                |
| 36–45         | 6 (40)                     | 6 (40)                |
| Mean $\pm$ SD | $33.87 \pm 7.82$           | $34.41 \pm 6.94$      |

#### Effect of Neurofeedback on Brain Waves

Analysis of pre- and post-intervention brain wave data revealed significant improvements in the experimental group. Neurofeedback therapy enhanced specific brain wave parameters, particularly in the alpha band and Frontal Alpha Asymmetry (Fz, Fp1, and Fp2 channels), compared to the control group. For instance, the Fz channel

exhibited a mean increase from  $13.12 \pm 2.17$  to  $27.12 \pm 2.78$  in the experimental group, while no significant changes were observed in the control group ( $14.78 \pm 2.19$  to  $15.77 \pm 2.13$ ) (Table 2). Similar improvements were noted for the Fp1 and Fp2 channels, with significant enhancements in the experimental group post-intervention ( $P < 0.01$ ).

**Table 2.** Brain Wave Measures Pre- and Post-Intervention

| Brain Wave | Group        | Pretest (Mean $\pm$ SD) | Posttest (Mean $\pm$ SD) | <i>P</i> -value |
|------------|--------------|-------------------------|--------------------------|-----------------|
| Fz         | Experimental | $13.12 \pm 2.17$        | $27.12 \pm 2.78$         | $P=0.0062$      |
|            | Control      | $14.78 \pm 2.19$        | $15.77 \pm 2.13$         | $p=0.412$       |
| Fp1        | Experimental | $16.28 \pm 2.37$        | $24.42 \pm 2.84$         | $p=0.0087$      |
|            | Control      | $16.36 \pm 2.03$        | $15.14 \pm 2.22$         | $p=0.358$       |
| Fp2        | Experimental | $21.69 \pm 2.37$        | $29.34 \pm 3.29$         | $p=0.0092$      |
|            | Control      | $21.73 \pm 3.21$        | $20.56 \pm 3.11$         | $p=0.527$       |

#### Reduction in Irritable Bowel Syndrome (IBS) Symptoms

The experimental group demonstrated a marked reduction in IBS symptoms, including pain intensity, the impact of IBS on daily activities, and extra-intestinal symptoms. Pain intensity significantly decreased in the experimental group, from  $45.07 \pm 7.28$  to  $39.60 \pm 4.08$ , while the control group showed minimal changes ( $44.53 \pm 6.72$  to  $44.67 \pm 6.36$ ) (Table 3). The impact on daily

activities also improved, with scores decreasing from  $40.80 \pm 4.36$  to  $33.60 \pm 2.95$  in the experimental group. In contrast, the control group showed no significant change ( $41.67 \pm 4.63$  to  $42.33 \pm 4.31$ ). Extra-intestinal symptoms, such as fatigue and sleep disturbances, showed significant reductions in the experimental group ( $45.93 \pm 7.48$  to  $37.13 \pm 3.15$ ,  $P < 0.01$ ), while the control group experienced no meaningful improvements ( $44.07 \pm 6.18$  to  $44.80 \pm 5.85$ ) (Table 3).

**Table 3.** Irritable Bowel Syndrome (IBS) Symptoms Pre- and Post-Intervention

| Symptom                    | Group        | Pretest (Mean $\pm$ SD) | Posttest (Mean $\pm$ SD) | P-value   |
|----------------------------|--------------|-------------------------|--------------------------|-----------|
| Pain intensity             | Experimental | 45.07 $\pm$ 7.28        | 39.60 $\pm$ 4.08         | P=0.0087  |
|                            | Control      | 44.53 $\pm$ 6.72        | 44.67 $\pm$ 6.36         | P =0.724  |
| Impact on daily activities | Experimental | 40.80 $\pm$ 4.36        | 33.60 $\pm$ 2.95         | P =0.0043 |
|                            | Control      | 41.67 $\pm$ 4.63        | 42.33 $\pm$ 4.31         | P =0.619  |
| Extra-intestinal symptoms  | Experimental | 45.93 $\pm$ 7.48        | 37.13 $\pm$ 3.15         | P =0.0068 |
|                            | Control      | 44.07 $\pm$ 6.18        | 44.80 $\pm$ 5.85         | P =0.583  |

### Statistical Analysis

Paired-sample t-tests and ANCOVA were employed to assess within-group and between-group differences. These analyses ensured that the observed differences were statistically significant and not due to random variations. The results confirmed that neurofeedback therapy significantly improved brain wave parameters and reduced IBS symptoms in the experimental group compared to the control group. The effect sizes (Cohen's d) indicated strong practical significance for the intervention.

### Discussion

The present study explored the impact of neurofeedback therapy on brain wave activity and symptoms of IBS among women. The findings demonstrated significant improvements in brain wave patterns and reductions in IBS-related symptoms in the experimental group compared to the control group. These results align with prior research, emphasizing the potential of neurofeedback as an effective complementary treatment for IBS [25,26].

### Brain Wave Modifications

Neurofeedback therapy significantly enhanced alpha wave power and improved Frontal Alpha Asymmetry in the experimental group. These changes are consistent with previous studies indicating that neurofeedback can regulate cortical activity and enhance self-regulation [27, 28]. Specifically, the increase in alpha power observed in this study aligns with research highlighting its role in promoting relaxation and reducing stress, both of which are critical factors in IBS pathophysiology [29]. Furthermore, improvements in Frontal Alpha Asymmetry suggest better emotional regulation, potentially mitigating the psychosomatic aspects of IBS [30]. The modulation of the brain's cortical activity could play a significant role in alleviating stress and autonomic dysregulation, both of which are central to IBS symptomatology [31].

### Symptom Reduction

The significant reduction in IBS symptoms, such as pain intensity and extra-intestinal issues, underscores the utility of neurofeedback in addressing both the physiological and psychological dimensions of the disorder. These findings are

consistent with studies linking improved brain wave regulation to decreased visceral hypersensitivity and enhanced gut-brain axis function [32, 33]. These outcomes support the hypothesis that neurofeedback not only alleviates physical discomfort but also improves the quality of life by addressing underlying neural dysregulation [34]. Additionally, neurofeedback's ability to modify brain wave patterns may have contributed to the reduction in stress, anxiety, and depression, which are frequently associated with IBS and exacerbate its symptoms [35, 36].

### Mechanisms of Action

Neurofeedback's efficacy in treating IBS may be attributed to its ability to promote neuroplasticity and enhance cortical regulation. By providing real-time feedback on brain wave activity, neurofeedback facilitates the reinforcement of desirable neural patterns, leading to sustained improvements in both cognitive and somatic functions [37]. Additionally, neurofeedback's non-invasive nature and minimal side effects make it an attractive alternative to traditional pharmacological interventions, which often have adverse effects [38]. Neurofeedback has been shown to strengthen brain regions responsible for pain processing, cognitive control, and emotional regulation, all of which are integral to managing IBS symptoms [39, 40].

### Limitations and Future Directions

Despite the promising results, this study had limitations, including a small sample size and reliance on self-reported measures for symptom assessment. This study was limited to female patients, reflecting the higher prevalence of IBS in women. However, sex differences in IBS pathophysiology, symptom reporting, and treatment response are well documented, and results may not be fully generalizable to male patients. Future research should involve larger, more diverse populations, including both sexes, to explore potential differences and incorporate objective biomarkers to validate findings. Longitudinal studies are also recommended to evaluate the long-term sustainability of neurofeedback's benefits [41, 42]. It is essential to explore the mechanisms further to determine how different types of neurofeedback (e.g., EEG biofeedback or Z-score training) may impact specific symptom clusters in IBS [43].

## Conclusion

Neurofeedback therapy effectively improved brain wave patterns and alleviated IBS symptoms in this study, highlighting its potential as a complementary treatment for IBS. This therapy addresses the complex interplay between the brain and gut, providing a holistic approach to managing a condition often characterized by both physiological and psychological challenges. These findings pave the way for further exploration of neurofeedback's role in treating functional gastrointestinal disorders. Given its non-invasive nature, neurofeedback offers a promising addition to current IBS management strategies, potentially reducing the reliance on medication and enhancing patient outcomes. Future studies should investigate these findings in mixed-sex cohorts and explore their clinical implications.

## Ethical Considerations

This study was approved by the Ethics Committee of the Islamic Azad University, Tabriz (IR.IAU.TABRIZ.REC.1402.406).

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## Author Contributions

Behzad Zeinali contributed to study design, data collection, analysis, and manuscript drafting. Seyed Mahmoud Tabatabaei supervised the project, provided methodological guidance, and revised the manuscript critically for intellectual content. All authors approved the final version. This article was extracted from the thesis of student Behzad Zeinali.

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## Conflicts of Interest

The authors declared no conflicts of interest.

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