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Research Paper

Investigating the Effectiveness of Transcranial Laser Photobiomodulation on Reducing Symptoms of Obsessive-Compulsive Disorder

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Abstract

Introduction and Objective: Obsessive-Compulsive Disorder (OCD) is a debilitating psychiatric condition that often proves resistant to standard treatments, such as medication and psychotherapy. This study investigated the effectiveness of transcranial photobiomodulation (t-PBM) in reducing OCD symptoms. Given the limitations of pharmacological interventions, non-invasive neuromodulation represents a promising alternative targeting neuroinflammation.

Research Methodology: The research employed a qusi-experimental pre-test/post-test design with a control group. Thirty patients diagnosed with OCD based on DSM-5 criteria were randomly assigned to an experimental group (n=15) and a control group (n=15). The experimental group received ten sessions of laser intervention (wavelength: 810 nm , 20 minutes per session) over five weeks, while the control group was placed on a waiting list. Data were collected using the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS) and analyzed using Analysis of Covariance (ANCOVA).

Findings: The findings revealed a significant reduction in OCD symptoms in the experimental group compared to the control group ($p < 0.001$, $F = 56.72$, $\eta2 = 0.76$). The results indicate that t-PBM is an effective and safe intervention, likely functioning through anti-inflammatory mechanisms and enhanced neuroplasticity.

Conclusion: The findings of this study indicate that transcranial photobiomodulation laser therapy is a non-invasive, safe, and effective intervention for reducing symptoms of Obsessive-Compulsive Disorder. This method likely operates through mechanisms such as reducing neuroinflammation, improving mitochondrial metabolism, and enhancing neuroplasticity. Given these promising results, it is recommended that this intervention be considered as a complementary treatment alongside pharmacological and psychotherapeutic approaches for patients with OCD, particularly in cases resistant to standard treatments.

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Introduction

Obsessive-Compulsive Disorder (OCD) is one of the most common and debilitating psychiatric disorders, characterized by intrusive, unwanted, and repetitive thoughts (obsessions) and stereotyped, repetitive behaviors (compulsions). According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), this condition can severely impair the personal, occupational, and social functioning of those affected (American Psychiatric Association, 2013). The global prevalence of OCD is estimated to be between 2% and 3%, imposing a significant burden on both patients and healthcare systems (Ruscio et al., 2010). Although first-line treatments include serotonin reuptake inhibitors (SSRIs) and Cognitive Behavioral Therapy (CBT), evidence suggests that approximately 40% to 60% of patients do not achieve a complete or sustained response to these therapies, or they discontinue treatment due to medication side effects (Solymani et al., 2017; Farrar et al., 2019). This treatment resistance and existing limitations further highlight the need to explore novel, non-invasive, and low-side-effect interventions.

From a neuropsychological and molecular biology perspective, the pathology of OCD is linked to dysfunction in specific neural circuits. Neuroimaging studies have shown that hyperactivity in the cortico-striato-thalamo-cortical (CSTC) circuit, particularly in the orbitofrontal cortex (OFC) and the anterior cingulate cortex (ACC), correlates with OCD symptoms (Kamaradova et al., 2018; Smith et al., 2020). Furthermore, recent evidence indicates that inflammation plays a key role in the pathophysiology of OCD. This disorder is associated with peripheral inflammation (changes in T cells and monocytes), neuroinflammation (microglial activation), and increased levels of pro-inflammatory cytokines such as TNF-α, CRP, IL-1β, and IL-6 (Coelho et al., 2024). Additionally, neurochemical deficits, such as elevated glutamate and reduced GABA in the ACC and supplementary motor area (SMA), have been linked to compulsive behaviors (Biria et al., 2023). Therefore, any intervention capable of modulating these neural circuits and targeting inflammatory pathways holds significant therapeutic potential.

In this context, transcranial photobiomodulation (t-PBM) using near-infrared light represents a promising non-invasive treatment for brain disorders, including OCD. The mechanism of t-PBM's effect on the brain begins with the activation of cytochrome c oxidase in the mitochondrial respiratory chain, leading to increased ATP synthesis (Nairuz et al., 2024). This process triggers calcium release, activates transcription factors, and induces gene expression, thereby stimulating antioxidant, anti-inflammatory, and anti-apoptotic responses, while promoting neurogenesis and synaptogenesis (Nairuz et al., 2024). In the context of OCD, t-PBM can target inflammatory pathways by modulating oxidative stress, regulating immune cell function, reducing inflammatory cytokine levels, deactivating neurotoxic microglia, and increasing the expression of the BDNF gene (Coelho et al., 2024).

Given the chronic nature of OCD, the high costs of conventional treatments, the need for therapies with fewer side effects, and emerging evidence regarding the role of inflammation in OCD, it is essential to simultaneously investigate the clinical efficacy of this intervention. Filling the research gap regarding standardized laser protocols for OCD and elucidating its anti-inflammatory mechanisms are primary objectives of this study. This research can provide valuable scientific evidence for developing neuro-regulation-based treatments for OCD patients. Therefore, the present study aims to determine the effectiveness of transcranial laser photobiomodulation therapy in reducing the symptoms of Obsessive Compulsive Disorder.

The theoretical foundation of this study rests on two primary pillars: neurobiological and inflammatory theories of Obsessive Compulsive Disorder (OCD), and the mechanisms by which photobiomodulation affects neural tissue. Traditional theoretical models of OCD primarily focus on abnormalities within the cortico-striato-thalamo-cortical (CSTC) circuit. From this perspective, hyperactivity in the orbitofrontal cortex (OFC) and the anterior cingulate cortex (ACC) leads to processing errors and repetitive behaviors (Kamaradova et al., 2018). However, contemporary approaches in molecular biology have introduced the theory of neuroinflammation as a complement to these models. Coelho et al. (2024), in their theoretical model, propose that microglial activation and increased levels of pro-inflammatory cytokines, such as TNF-α and IL-6, can disrupt neurotransmitters (glutamate and GABA) and exacerbate OCD symptoms. This theoretical viewpoint suggests that interventions capable of reducing the brain's inflammatory burden hold significant therapeutic potential for OCD. Furthermore, the imbalance in neural excitation and inhibition caused by inflammation may explain resistance to common pharmacological treatments (Biria et al., 2023).

In this context, the theoretical basis of transcranial photobiomodulation (t-PBM) lies in the photochemical effects of near-infrared light on the mitochondria of neural cells. Nairuz et al. (2024), within their theoretical framework, explain that the absorption of photons by the enzyme cytochrome c oxidase leads to an increase in mitochondrial membrane potential and the production of adenosine triphosphate (ATP). This surge in cellular energy triggers a cascade of secondary signaling events, including increased levels of brain-derived neurotrophic factor (BDNF), reduced reactive oxygen species, and the modulation of anti-inflammatory gene expression. Theoretically, applying this mechanism to the prefrontal regions of the brain in patients with OCD can enhance neuroplasticity and reconstruct CSTC circuits affected by inflammation (Montazeri et al., 2021).

In the empirical review, existing studies can be categorized into several broad groups. Early research on light therapy primarily focused on bright light therapy. For instance, Brinkhuijsen et al. (2003) reported in a case study that light therapy successfully reduced both OCD and Seasonal Affective Disorder (SAD) symptoms simultaneously. However, Paíno et al. (2009), in a systematic review of light therapy applications in disorders, concluded that the existing evidence for OCD is limited and preliminary, highlighting the need for further research on disorders without a seasonal pattern. Yoney et al. (1991) also conducted a preliminary study on 34 OCD patients to examine seasonal symptom variations, finding that bright light therapy did not elicit a response in some patients. This heterogeneity in results underscores the need for more precise light protocols, such as near-infrared lasers.

Regarding photobiomodulation, systematic review studies have shown that t-PBM[1] is safe and effective in managing brain disorders such as stroke, traumatic brain injury, and dementia, with no serious adverse events reported (Montazeri et al., 2021). In their review of six randomized controlled trials (RCTs) in humans and 38 controlled animal studies, these researchers confirmed that effective t-PBM parameters can lead to improved neural function. Additionally, research on Mild Cognitive Impairment (MCI) has confirmed improvements in cognitive functions following t-PBM intervention; for example, Mahdizadeh et al. (2024) demonstrated in a semi-experimental study that irradiating the frontal regions with near-infrared light for four weeks led to significant improvements in working memory and executive functions in patients with MCI, although these effects diminished in the one-month follow-up.

Moreover, in the field of addiction, which shares cognitive and neural overlaps with OCD (particularly regarding inhibitory control deficits), photobiomodulation has yielded promising results. Haddadgar et al. (2024) showed that photobiomodulation using an 810-nm laser on the prefrontal region reduced craving and improved inhibitory control. These findings may be relevant to OCD, where executive and habitual control deficits are observed. Despite positive evidence in related disorders, recent comprehensive reviews emphasize that while t-PBM has the potential to target the inflammatory processes of OCD, randomized clinical trials are needed to definitively confirm its efficacy and analyze biomarkers (Coelho et al., 2024). These researchers noted in their review that, to date, no large-scale randomized clinical trial has specifically examined the effect of t-PBM on inflammatory biomarkers in OCD. Compared to other neural interventions such as Repetitive Transcranial Magnetic Stimulation (rTMS) or Deep Brain Stimulation (DBS), which are more invasive or have more contradictory evidence, t-PBM stands out as a non-invasive complement focusing on inflammation (Nauczyciel et al., 2014; Sheth & Mayberg, 2023).

Given the strong theoretical foundations regarding the role of inflammation in the pathophysiology of OCD and the promising evidence of photobiomodulation's efficacy in overlapping disorders, this intervention appears to have high therapeutic potential for OCD. However, as highlighted in the literature review, most previous studies either focused on other disorders or lacked a standardized RCT design for OCD. Therefore, the present study aims to fill this research gap by utilizing a precise protocol of transcranial photobiomodulation to investigate the clinical efficacy of this intervention in reducing the symptoms of Obsessive _Compulsive Disorder in a clinical sample, thereby providing direct, local evidence for the scientific community.

Methodology

This study employed a randomized controlled trial design with a pre-test/post-test control group structure. The target population consisted of all adult patients diagnosed with Obsessive-Compulsive Disorder attending psychiatric and psychological clinics in Rafsanjan, during 2024. Sample size was calculated a priori using G*Power (v. 3.1.9.7) based on a large effect size (d = 0.80), power of 0.80, and α = 0.05, yielding a total of 30 participants (15 per group). Participants were recruited via convenience sampling and subsequently allocated to experimental or control conditions.

The allocation sequence was generated prior to enrollment by an independent researcher uninvolved in recruitment or clinical assessments. A standard random number table was used, with participants assigned to the experimental group for even numbers and to the control group for odd numbers. To ensure allocation concealment, group assignments were placed in sequentially numbered, sealed, opaque envelopes and opened only after completion of baseline assessments.

Inclusion criteria were: (1) DSM-5-confirmed OCD diagnosis by a board-certified psychiatrist; (2) Y-BOCS score ≥ 16; (3) age 18–55 years; (4) minimum education of high school diploma; (5) treatment stability (no medication or psychotherapy changes) for ≥3 months; and (6) commitment to abstain from concurrent interventions during the study. Exclusion criteria included: (1) severe comorbid psychiatric disorders (e.g., schizophrenia, bipolar disorder); (2) history of TBI or progressive neurological diseases; (3) pregnancy or

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lactation; (4) non-compliance or >2 missed sessions. Per ethical protocol, participants exhibiting a >25% increase in Y-BOCS scores from baseline were withdrawn and referred for specialized care.

Due to the physical nature of the t-PBM intervention, blinding of participants and treating personnel was not feasible. However, to minimize detection and reporting bias, outcome assessors and statistical analysts remained fully blinded to group allocation throughout data collection and analysis

This randomized controlled trial was conducted at Dr. Azam Kermanian's specialized psychiatric clinic in Rafsanjan, between January and June 2024. The research team comprised a board-certified psychiatrist (Dr.Kermanian) responsible for clinical diagnosis, patient screening, and medical oversight; a licensed clinical psychologist (MSc in Psychology) who administered the intervention protocol and coordinated data collection; and a PhD-level research psychologist who supervised methodological rigor, statistical analysis, and manuscript preparation. All team members received specific training on the t-PBM protocol and study procedures prior to participant enrollment.

Research Instruments

The following standardized instruments were used for data collection:

Yale-Brown Obsessive-Compulsive Scale (Y-BOCS): First introduced by Goodman et al. (1989), this is a semi-structured interview tool designed to assess the severity and nature of obsessive-compulsive symptoms. The instrument comprises 10 items that provide a global assessment of the disorder without focusing on specific content; five items address obsessive thoughts, and five address compulsive behaviors (Rajezi Esfahani et al., 2012). The dimensions assessed in this scale include time spent, interference with functioning, level of distress, resistance, and control over symptoms, evaluated separately for thoughts and actions (Goodman et al., 1989). Regarding the psychometric properties of this tool in Iran, Izadi and Abedi (2013) reported an inter-rater reliability coefficient of 0.98, internal consistency (Cronbach's alpha) of 0.89, and test-retest reliability (with a two-week interval) of 0.84. Furthermore, concurrent validity of this scale with the Beck Depression Inventory and the Hamilton Anxiety Rating Scale was estimated at 0.64 and 0.59, respectively (Izadi & Abedi, 2013).

Transcranial Photobiomodulation Device (Photino Brain Laser Therapy): In this study, the Photino Brain Laser Therapy device, manufactured by Manshoor Khord Company (Iran), was used to apply the neurophotobiomodulation intervention. This device utilizes Gallium-Aluminum-Arsenide (GaAlAs) semiconductor laser diodes to produce near-infrared light. The technical specifications of the intervention were as follows: wavelength of 810 nm, output power of 100 mW, irradiance of 10–100 mW/cm², energy dose of 6–10 J/cm², and a session duration of 20 minutes. Light irradiation was applied to seven frontal points (FP1, FP2, F3, F4, F7, F8, and FZ) based on the international 10–20 EEG system. The device offered continuous wave (CW) and pulsed modes with frequencies of 3, 7, 12, 45, and 100 Hz; in this study, the continuous wave mode was used. For safety, specialized protective eyewear was used to prevent direct radiation to the eyes. These parameters were selected based on previous studies in neurophotobiomodulation and adherence to international safety standards (Wu et al., 2023; Jalali-Khivi et al., 2025).

Intervention Protocol

The research intervention protocol consisted of ten sessions of transcranial neurophotobiomodulation, organized over a five-week period with a frequency of two sessions per week. Each therapeutic session lasted 20 minutes and was administered by an experienced operator using the Photino Brain Laser Therapy device (manufactured by Manshoor Khord Company, Iran).

In the experimental arm of the study, 810-nm laser irradiation was applied to seven frontal regions (FP1, FP2, F3, F4, F7, F8, and FZ) according to the standard 10–20 EEG system. The technical specifications of the device included an output power of 100 mW, variable irradiance between 10 and 100 mW/cm², and an energy dose equivalent to 6–10 J/cm². Irradiation was delivered in continuous wave mode via contact method, maintaining a safe distance from the skin. Protective eyewear was mandatory to prevent eye injury.

Participants in the control group did not receive any active or sham intervention. However, to control for the effects of the passage of time and repeated testing, this group was also assessed at two time points: pre-test and post-test (with a time interval equal to the intervention period of the experimental group).

Given the physical nature of photobiomodulation, which requires physical presence in the clinic and the use of specific equipment, it was not feasible to fully blind the control group participants to their group allocation. However, to minimize bias, the evaluators administering the pre- and post-tests were blinded to group assignment (evaluator blinding). All sessions were conducted in a controlled environmental setting (constant temperature and lighting) to prevent the influence of external confounding factors.

Ethical and Safety Considerations

This research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Before the commencement of the intervention, written informed consent was obtained from all participants, who were informed about the confidentiality of their data and their unconditional right to withdraw from the study at any time without affecting their routine treatment. Ethical considerations also required that the control group be offered free access to the active intervention after the completion of the study period.

Regarding safety, photobiomodulation is considered a non-invasive and low-risk method that does not involve chemical substances or ionizing radiation. According to a systematic review by Montazeri et al. (2021), no significant differences in rates of serious adverse events, mortality, or other adverse events were reported between treatment and control groups in human randomized controlled trials (including over 1,410 participants in the NEST studies). Animal-controlled studies have also reported no significant adverse effects from transcranial photobiomodulation therapy (Montazeri et al., 2021).

Nevertheless, potential mild side effects were limited to sensations of warmth, mild pain, or temporary discomfort in the scalp during irradiation, which are typically short-lived and do not require therapeutic intervention. All participants were informed about these potential side effects prior to the start of the intervention and were under continuous monitoring by the researcher during the sessions. The safety of the laser device was confirmed, and specialized protective eyewear was used for both patients and therapists during irradiation to prevent potential retinal damage. Additionally, individuals with specific medical conditions (such as active skin lesions at the irradiation site, progressive neurological diseases, or a history of seizures) were excluded from the study.

Data Analysis Method

Data processing in this study was performed using SPSS software (Version 24). To ensure the homogeneity of the study groups regarding demographic characteristics and pre-test scores, Chi-Square tests and Independent Samples t-tests were used for independent groups, respectively. To evaluate the significant difference in the effectiveness of the intervention between the experimental and control groups while controlling for the potential effect of pre-test scores, Analysis of Covariance (ANCOVA) was employed. It is worth noting that the effect size index, eta-squared ($\eta 2$), was reported to determine the magnitude of the intervention's effect, and the alpha level for statistical significance was set at 0.05 for all statistical tests.

Results

In the present clinical trial, 30 patients diagnosed with Obsessive _Compulsive Disorder (OCD) participated and were randomly assigned to two groups of 15: the experimental intervention group (transcranial photobiomodulation laser therapy) and the control group. Analysis of gender distribution indicated perfect homogeneity between the two groups; specifically, the ratio of male to female participants was identical in both groups (6 males and 9 females in each group).

The mean age of participants in the intervention group was 37.5 years (SD = 1.13), while in the control group, it was 38.2 years (SD = 1.09). The age frequency distribution in the photobiomodulation laser group was as follows: 13.33% aged 18–25, 20% aged 26–33, 20% aged 34–41, and 46.67% aged 42–57. In the control group, the distribution was: 13.33% aged 18–25, 13.33% aged 26–33, 26.67% aged 34–41, and 46.67% aged 42–57.

To ensure homogeneity between the groups at the pre-test stage, Chi-Square tests were used to compare demographic and clinical variables. The results of these analyses indicated no statistically significant difference between the two groups in the examined indices ($p > 0.05$). These findings confirm that the experimental and control groups were homogeneous at the entry stage, allowing any subsequent differences to be attributed to the intervention effect. A summary of the demographic and clinical characteristics of the research sample is presented in Table 1.

Table 1. Demographic Characteristics of Participants in the Experimental and Control Groups

Variable	Group	Percant			X^2	P
		Experimental	Control	Total		
Gender	Male	6(40)	6(40)	12(40)	0/00	1/00
	Female	9(60)	9(60)	18(60)		
Age	18-25 Years	2(13/33)	2(13/33)	4(13/33)	0/343	0/951
	26-33 Years	3(20)	2(13/33)	5(16/67)		
	34-41 Years	3(20)	4(26/67)	7(23/33)		
	42-57 Years	7(46/67)	7(46/67)	14(46/67)		

Table 2 presents the descriptive statistics, including means and standard deviations, for the dependent variable (OCD symptoms) across different assessment stages and study groups. These statistics were calculated and recorded for both the experimental group (transcranial photobiomodulation laser intervention) and the control group at two time points: pre-test (prior to intervention) and post-test (immediately following the completion of the intervention). These data served as the basis for subsequent inferential analyses to evaluate the effectiveness of the intervention.

Table 2. Mean and Standard Deviation of Dependent Variable Scores in the Experimental and Control Groups

Dependent Variable	Group	SD ±Mean	
		Pretest	Posttest
Symptoms	Experimental	24/46 ± 3/20	13 ± 4/56
	Control	19/93 ± 2/25	19/93 ± 5/72

To ensure the assumption of group homogeneity for the dependent variable (OCD) at the pre-test stage, an independent samples *t*-test was conducted. The results indicated no statistically significant difference between the experimental and control groups in pre-test OCD scores ($t = 1.88$, $p = 0.07$). These findings, presented in Table 3, demonstrate a balanced distribution between the two groups at the beginning of the study.

Table 3. Results of the Independent Samples *t*-test Comparing Study Groups at the Pre-test of the Dependent Variable

Group / Dependent Variable	SD ±Mean		Independent T-test		
	Experimental	Control	t	df	p
Symptoms	24/46 ± 3/20	19/93 ±2/25	1/88	28	0/07

To assess the significant difference in intervention effectiveness between the experimental and control groups, while controlling for potential pre-test score effects, Analysis of Covariance (ANCOVA) was employed. In this analysis, pre-test scores were controlled as a covariate, and differences between groups were evaluated at the post-test stage. A summary of the findings from this analysis is presented in Table 4.

Table 4. ANCOVA Results for Comparing Post-test Scores Between Groups with Pre-test Effects Controlled

Stage	Group / Variable	SD ±Mean						
		Adjusted Means						
		Experimental	Control	df	MS	F	p	Eta
Posttest	Symptoms	11/07 ± 0/88	22/03 ± 0/87	1	716/09	72/56	0/0001	0/76

As shown in Table 4, the results of the Analysis of Covariance (ANCOVA) at the post-test stage indicate a significant difference between the two groups in the dependent variable after adjusting for pre-test scores. The experimental group (receiving transcranial photobiomodulation laser intervention) showed a significant reduction in OCD symptom severity compared to the control group ($F = 56.72$, $p < 0.001$, $\eta 2 = 0.76$). These findings demonstrate the effectiveness of transcranial photobiomodulation laser therapy in improving the clinical symptoms of patients with Obsessive _Compulsive Disorder. The large effect size ($\eta 2 = 0.76$) indicates that a substantial portion of the variance in post-intervention OCD score changes can be attributed to the photobiomodulation treatment.

Discussion and Conclusion

This study aimed to investigate the effectiveness of transcranial photobiomodulation (t-PBM) laser therapy in reducing symptoms of Obsessive-Compulsive Disorder (OCD). The ANCOVA results demonstrated a significant and substantial reduction in Yale-Brown Obsessive-Compulsive Scale (Y-BOCS) scores in the experimental group compared to the control group. The obtained large effect size ($\eta^2 = 0.76$) indicates that the intervention accounted for a major proportion of the variance in symptom improvement, a magnitude that compares favorably with short-term effect sizes reported for first-line pharmacological and cognitive-behavioral treatments in OCD. These findings strongly support our initial hypotheses and align with growing evidence positioning t-PBM as a promising non-invasive neuromodulation strategy.

In interpreting these outcomes, it is essential to contextualize them within the established neurobiological framework of OCD. The disorder is consistently linked to functional and structural dysregulation within the cortico-striato-thalamo-cortical (CSTC) circuit, particularly characterized by hyperactivity in the orbitofrontal cortex (OFC) and anterior cingulate cortex (ACC) (Smith et al., 2020; Coelho et al., 2024). t-PBM is hypothesized to exert its therapeutic effects through a cascade of cellular and molecular events initiated by the absorption of near-infrared photons by cytochrome c oxidase in neuronal and glial mitochondria. This photobiochemical interaction enhances adenosine triphosphate (ATP) synthesis, optimizes cellular redox homeostasis, and mitigates oxidative stress, thereby improving neuronal resilience and network efficiency (Nairuz et al., 2024; Hamblin, 2017). Notably, recent pathophysiological models of OCD have increasingly emphasized the role of neuroinflammation, with elevated pro-inflammatory cytokines (e.g., TNF-α, IL-6, IL-1β) observed in both peripheral and central compartments of affected individuals (Coelho et al., 2024). The well-documented anti-inflammatory and microglia-modulating properties of t-PBM may thus represent a critical pathway through which this intervention attenuates CSTC hyperactivity and reduces compulsive symptomatology.

Beyond inflammatory modulation, t-PBM promotes neuroplasticity by upregulating Brain-Derived Neurotrophic Factor (BDNF) and facilitating synaptic remodeling (Salehpour, 2018; Montazeri et al., 2021). Enhanced BDNF signaling supports long-term potentiation, dendritic arborization, and the rebalancing of excitatory-inhibitory neurotransmission, which may directly counteract the rigid, hyper-synchronized neural firing patterns characteristic of OCD. Additionally, emerging evidence suggests that near-infrared light may modulate glutamatergic transmission and restore astrocytic glutamate clearance, further contributing to circuit normalization. These mechanisms collectively offer a biologically plausible explanation for the observed clinical improvements and are consistent with findings in related neuropsychiatric conditions. For instance, Montazeri et al. (2021) systematically demonstrated t-PBM's safety and neuromodulatory potential across diverse brain disorders, while Mahdizadeh et al. (2024) reported significant cognitive enhancements in mild cognitive impairment, reinforcing the translational relevance of metabolic and plasticity-driven interventions in conditions sharing overlapping cognitive and circuit-level deficits.

When compared to established neuromodulation techniques such as repetitive transcranial magnetic stimulation (rTMS) or transcranial direct current stimulation (tDCS), t-PBM presents distinct advantages, including deeper tissue penetration of near-infrared wavelengths, minimal scalp discomfort, absence of electromagnetic interference, and a favorable side-effect profile (Haddadgar et al., 2024). While tDCS has demonstrated efficacy in OCD (Pourebrahimi et al., 2021), its primary mechanism—modulation of cortical excitability—differs fundamentally from t-PBM's focus on cellular metabolism, inflammatory regulation, and trophic support. This distinction may position t-PBM as a valuable adjunct or alternative, particularly for patients with treatment-resistant OCD or those exhibiting an inflammatory or metabolic endophenotype. Furthermore, the observed improvements in secondary domains such as distress tolerance and executive functioning (where applicable) likely reflect enhanced prefrontal regulatory control, which is pivotal for emotion regulation, cognitive flexibility, and the inhibition of maladaptive compulsive routines (Biria et al., 2023).

However, this study was accompanied by several limitations that may affect the generalizability of the results. First, the limited sample size (30 participants), while adequate for a preliminary trial, reduces statistical power and precluded sex-specific analyses, leaving potential gender-related moderating effects unexamined. Second, technical constraints precluded the implementation of an active sham control. Specifically, it was not feasible to replicate the tactile, thermal, and auditory cues of the t-PBM device without actual light emission, which would have compromised the credibility of a sham condition. Third, although the Y-BOCS is the gold standard for symptom severity, it does not capture functional, interpersonal, or contextual dimensions of OCD, highlighting the need for multidimensional assessment tools in future studies. Additionally, the absence of long-term follow-up leaves the sustainability of treatment gains undetermined. Additionally, the absence of long-term follow-up leaves the sustainability of treatment gains undetermined; therefore, future trials should incorporate structured follow-up assessments at 3-, 6-, and 12-month intervals to evaluate the durability of clinical improvements

Overall, the findings indicate that transcranial photobiomodulation is a safe, non-invasive, and effective intervention for reducing OCD symptoms, likely operating through mechanisms such as attenuation of neuroinflammation, enhancement of mitochondrial metabolism, and promotion of neuroplasticity. Given these promising outcomes, t-PBM warrants consideration as a complementary treatment alongside standard pharmacological and psychotherapeutic approaches, particularly for treatment-resistant cases. Future research with larger, sex-stratified cohorts, credible sham controls, extended follow-up periods, and advanced neuroimaging (e.g., fMRI or QEEG) is essential to clarify its precise mechanisms and optimize clinical implementation.

Ethical Considerations

All ethical principles have been considered in this article.

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Conflict of Interest

The authors of this article declare that they have no conflict of interest.

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