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Research Article

The Effectiveness of Transcranial Direct Current Stimulation (tDCS) on Severity of Obsessive-Compulsive Symptoms, Executive Functions and Rumination in People with Obsessive-Compulsive Symptoms: A Randomized Clinical Trial

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Abstract

Background: Medical and cognitive treatments for people with obsessive-compulsive symptoms have limitations. Concerns about obsessive-compulsive symptoms arise from evidence indicating that obsessive-compulsive disorder (OCD) can have severe psychological consequences.

Objectives: This study aimed to investigate the effectiveness of transcranial direct current stimulation (tDCS) on the severity of obsessive-compulsive symptoms, executive functions, and rumination in individuals with obsessive-compulsive symptoms.

Methods: This research was a randomized clinical trial with a pre-and post-test design involving two groups. The statistical population included all individuals with obsessive-compulsive symptoms who referred to the Golestan Hospital Psychiatry Clinic and the Jundishapur University of Medical Sciences Counseling Center in Ahvaz during 2022 - 2023. Thirty individuals who met the inclusion and exclusion criteria were randomly assigned to two groups. In this randomized controlled double-blind study, 30 participants with obsessive-compulsive symptoms (based on the Maudsley Questionnaire cut-off point of 11) were assigned to receive 10 sessions (one session per day) of either active tDCS (2 mA) or sham treatment. Of these, 15 participants received active tDCS, and 15 participants received sham treatment. At the beginning of the study and after the intervention, all subjects were assessed using the Maudsley Obsessional-Compulsive Questionnaire (MOCI), the Executive Functions Questionnaire, the Yale-Brown Obsessive Compulsive Scale (Y-BOCS), and the Mistake Rumination Scale. Data analysis included descriptive statistics and analysis of covariance, performed using SPSS-23 software.

Results: In the pre-test, the mean scores of MOCI, Y-BOCS, mistake rumination, and executive functions in the active tDCS group were 22.40 ± 2.09, 22.33 ± 7.72, 20.93 ± 4.16, and 86.40 ± 14.38, respectively, compared to 21.53 ± 1.80, 20.33 ± 6.89, 19.13 ± 5.34, and 83.06 ± 16.61 in the sham treatment group. In the post-test, the mean scores in the active tDCS group were 14.46 ± 3.06, 14.40 ± 2.99, 11.46 ± 2.13, and 102.86 ± 8.40, respectively, compared to 21.66 ± 1.54, 18.13 ± 6.99, 18.26 ± 4.89, and 86.93 ± 15.54 in the sham treatment group. Results showed that the active tDCS group exhibited a significantly greater reduction in obsessive-compulsive symptoms and rumination and a significant improvement in executive functions compared to the sham treatment group ($P < 0.05$).

Conclusions: The tDCS appears to have a significant effect on reducing obsessive-compulsive symptoms and rumination and improving executive functions in individuals with obsessive-compulsive symptoms. Longer treatment durations with a higher number of tDCS sessions may be necessary to achieve clinically significant responses. Additionally, determining the optimal electrode placement for OCD remains a critical and challenging issue.

Keywords: Obsessive-Compulsive Symptoms, tDCS, Executive Functions, Rumination, Effectiveness

1. Background

Obsessive-compulsive disorder (OCD) is a chronic mental illness characterized by repetitive behaviors (compulsions) and unwanted thoughts (obsessions). While repetitive actions are common in daily life, individuals with OCD experience these behaviors and thoughts more frequently and intensely, significantly impacting their lives almost constantly (1, 2). Obsessive-compulsive disorder is the fourth most common mental disorder globally (3). Its estimated lifetime prevalence is 2.3%, with a range of 1.1 - 3.3%, varying by factors such as location, age, and other demographic variables (1, 4). Individuals with OCD may display various symptom categories, including persistent unwanted or religious thoughts, frequent hoarding, symmetry, frequent checking, fixation with contamination and cleaning methods, and ordering. These symptoms and behaviors may fluctuate, become irregular, or change in manifestation over the course of the disorder (5, 6).

Research in the past few decades has significantly expanded our understanding of the phenomenology and treatment of OCD. Numerous mechanisms and factors contribute to the etiology of OCD, leading to its chronic nature. Recent years have seen increased attention on the neuropsychology of OCD. This disorder is linked to neuropsychological impairments, particularly in areas such as attention, memory, and executive functions (7, 8). Based on the neurological mechanisms implicated in OCD, it is believed that the disorder involves deficiencies in two primary inhibitory processes: (1) Cognitive inhibition process: Associated with obsessive symptoms; (2) behavioral inhibition process: Associated with compulsive symptoms (9).

Deficiencies in these two inhibitory systems explain not only the cognitive and behavioral symptoms of OCD but also many neuropsychological deficits observed in this disorder, such as impairments in attention, memory, planning, and decision-making (7, 9).

There is substantial evidence linking OCD to brain dysfunction and cognitive abnormalities (10). Neuropsychological studies consistently reveal that individuals with OCD perform worse compared to other populations and clinical samples (11).

Underlying factors often accelerate the progression of diseases, and in the case of OCD, rumination appears to be a significant contributing factor. Memory interference can lead to rumination, which is frequently observed in individuals with OCD and generalized anxiety disorder (12). Research confirms that rumination plays a role in exacerbating psychological disturbances (13). This style of thinking is also prevalent in several emotional disorders, including depression, OCD, generalized anxiety disorder, and post-traumatic stress disorder (14).

The clinical literature on OCD highlights cognitive behavioral therapy (CBT), particularly in the form of exposure and response prevention (ERP), as the first-line treatment for this disorder (15). However, despite significant advances in OCD treatment, some patients either do not respond to treatment or show minimal improvement (16). While certain patients experience partial recovery, residual symptoms persist, leading to significant functional impairment and a reduced quality of life. Additionally, some patients are unwilling or unable to tolerate the anxiety associated with ERP, while others abandon or refuse the treatment altogether (17). Consequently, the treatment of OCD remains a challenging area in psychological therapy.

The ongoing search for more effective treatment methods continues to drive extensive and varied research in this field. Among the emerging therapeutic techniques is brain stimulation, which has gained attention in recent years as a safe and effective non-invasive intervention. In particular, transcranial direct current stimulation (tDCS) has shown promising results (18).

Harika-Germaneau et al. (19) studied the efficacy of 10 sessions of tDCS in treating treatment-resistant OCD. In this study, 80 treatment-resistant outpatients with OCD were randomly assigned to receive either active or sham tDCS. Patients were assessed at baseline, at the end of the treatment, and during one- and three-month follow-ups. A significant interaction between time and treatment was observed. However, the primary endpoint — change in Yale-Brown Obsessive Compulsive Scale (Y-BOCS) scores after two weeks—was not achieved. In contrast, the secondary endpoint, which measured changes in Y-BOCS scores after three months, was successfully met (19). These findings underscore the importance of studying the placebo effect in tDCS interventions and the necessity of long-term follow-up to evaluate the optimal effects of the treatment. Similarly, Brunelin et al. (20) concluded that despite methodological limitations and variability in stimulation parameters, tDCS appears to be a promising tool for alleviating OCD symptoms.

Obsessive-compulsive disorder is a complex disorder, recognized as the tenth leading cause of disability among patients. It is also one of the most prevalent mental health conditions in Iran, with an estimated prevalence ranging from 11.7% to 43.2% (21). Given that conventional psychological and pharmacological treatments do not consistently result in recovery and that a significant proportion of patients are resistant to these interventions, researchers have increasingly focused on novel treatment approaches. These include neurobiological methods that offer the potential for neurological adjustments (22).

2. Objectives

Considering the limited research on the efficacy of such interventions, this study was designed to evaluate the effectiveness of tDCS in improving executive functions, reducing the severity of obsessive-compulsive symptoms, and addressing rumination in individuals with OCD symptoms.

3. Methods

The current research falls under the category of applied research in terms of its goal and experimental designs regarding its data collection method. This study was a randomized clinical trial with a pre-and post-test design, consisting of two groups. The statistical population included all individuals with obsessive-compulsive symptoms who visited the psychiatric clinic of Golestan Hospital and the Counseling Center of Jundishapur University of Medical Sciences in Ahvaz during 2022 - 2023. Thirty participants meeting the inclusion and exclusion criteria were randomly assigned to two groups. In this double-blind, controlled, randomized study, 30 patients with obsessive-compulsive symptoms (determined by a score higher than 11 on the Maudsley Questionnaire) were assigned to receive 10 sessions (one session per day) of either active tDCS (2 mA) or sham treatment, each lasting 20 minutes. Of these, 15 patients received active tDCS, and 15 received sham treatment.

3.1. Inclusion Criteria

Participants had to obtain a score higher than 11 on the Maudsley Obsessional-Compulsive Questionnaire (MOCI), be willing to participate in the research, not receive simultaneous psychological treatments such as group therapy, cognitive-behavioral therapies, mindfulness, muscle relaxation, or stress management, be aged between 18 and 60 years, and complete a written consent form.

3.2. Exclusion Criteria

Individuals were excluded if they had a history of psychotic disorders, serious head injuries, substance abuse, acute suicidal ideation, or implanted metal or devices in the brain. Pregnant women were also excluded. Additionally, patients previously exposed to tDCS could not participate. Other exclusion criteria included unavailability during the research period, severe physical illnesses such as cancer, the use of a cardiac pacemaker, severe organic brain disorders based on patient and family history or psychiatric examination, the presence of evident bipolar or psychotic symptoms, and absence from tDCS sessions.

After coordinating and obtaining the code of ethics from Ahvaz University (IR.AJUMS.HGOLESTAN.REC.1400.152) and the clinical trial code (IRCT20220220054069N1), the researcher entered the research environment with permission. The research was conducted at the Golestan Hospital Psychiatry Clinic and the Counseling Center of Ahvaz University of Medical Sciences. Before the preliminary evaluations, all conditions for participating in the research were explained to the applicants, allowing them to proceed with the evaluation process if they wished. Full explanations about the purpose of the project were provided to participants before obtaining consent and completing the questionnaire. After explaining the research, its conditions, and other ethical matters, participants were asked to complete the informed consent form.

Regarding sample selection, it should be noted that in experimental methods, each subgroup should consist of at least 15 people to ensure the sample is a true representative of the community and that the research maintains high external validity (23, 24). A total of 38 individuals were evaluated for eligibility. Eight people did not participate, leaving a total of 30 participants who completed the study. Of these, 15 patients received active tDCS, and 15 patients received sham treatment. In this randomized double-blind controlled study, 30 patients with obsessive-compulsive symptoms were assigned to receive 10 sessions (one session per day) of active tDCS (2 mA) or sham treatment. Pre-test

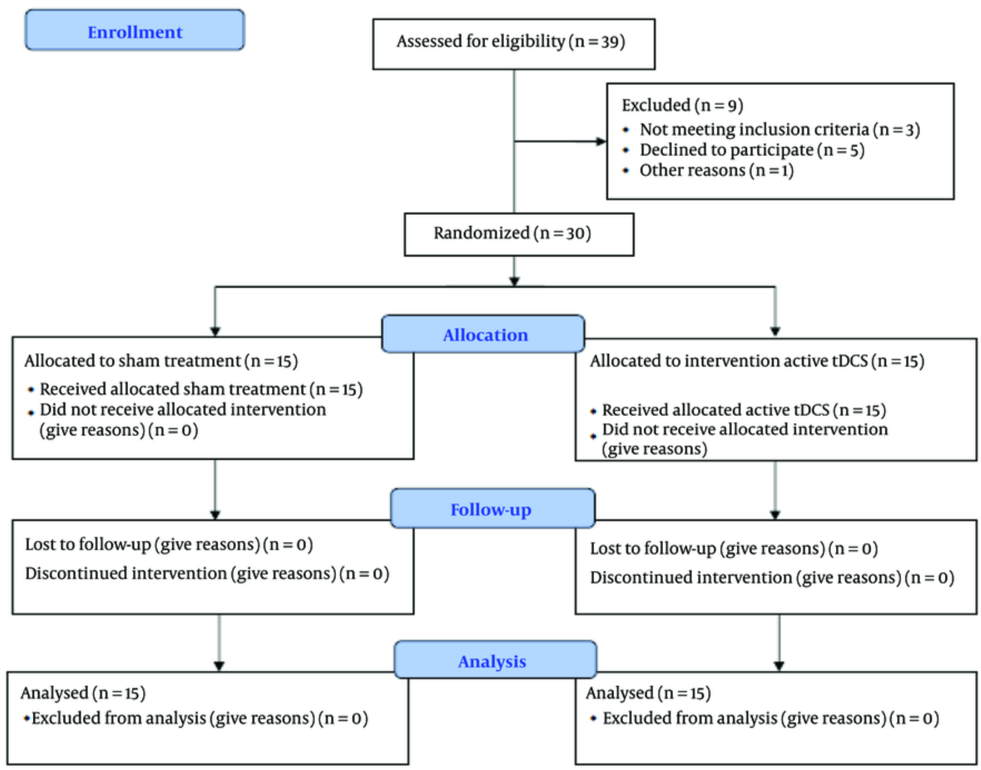

Figure 1. Flow chart of the 2010 CONCORT process

evaluations were conducted, and after the treatment concluded, re-evaluations were performed.

It should be noted that no costs were imposed on the participants in this study. At the beginning of the research and after the intervention, all participants were assessed using the MOCI, the Executive Functions Questionnaire, the Y-BOCS, and the Mistake Rumination Scale. As shown in CONSORT Figure 1, the sample size was based on previous research indicating a high effect size according to Cohen's criteria for the studied treatments. With a test power of 0.80 and a significance level of 0.95, 15 participants were allocated to each group.

Regarding sample selection, it is important to reiterate that in experimental methods, each subgroup should consist of at least 15 participants to ensure the sample is representative of the community and the research has high external validity (23, 24). To analyze the findings, descriptive statistics, analysis of covariance, independent *t*-tests, and chi-square tests were employed. All analyses were performed using SPSS-23 software.

3.3. Measures

The MOCI: This is a 30-item tool with true and false responses. It provides a total score and seven sub-scores. The cutoff point for this scale is eleven. In Iran, the reliability of this instrument was reported as 0.85 using the test-retest method, and the reliability coefficient for the entire test was 0.84 (25).

Executive Functions Questionnaire: This is a 35-item scale used to measure executive functions. Participants respond using a five-point Likert scale ranging from never to always. This scale has demonstrated good psychometric properties (26). The reliability of the subscales, calculated using the omega coefficient, ranged from 0.82 to 0.94 (26).

3.3.1. Yale-Brown Obsessive Compulsive Scale

Developed by Goodman et al. (27), this scale is used to determine the symptoms and severity of obsessive-compulsive symptoms. It contains 10 items - 5 items evaluate obsessive thoughts, and 5 items assess compulsions. Responses are scored on a 5-point Likert scale ranging from very severe (4) to subclinical (0). The total score ranges from 0 to 40, indicating the intensity of obsession and compulsion (27). In Iran, findings showed significant internal consistency for both the symptom and severity subscales, with coefficients of 0.97 and 0.95, respectively, and a test-retest reliability of 0.99 (28).

3.3.2. The Mistake Rumination Scale

This seven-item scale measures the tendency to ruminate about past personal mistakes. It has a single-factor structure and high internal consistency. Responses range from not at all to very high. The scale has demonstrated good psychometric properties (29, 30), with a Cronbach's alpha coefficient of 0.93 (30).

3.3.3. Transcranial Direct Current Stimulation

The tDCS is a non-invasive brain stimulation technique that applies a weak direct current (1 - 2 mA) between two electrodes placed on the scalp. Neurophysiological studies indicate that the polarity of the electrode and the intensity of the current determine the effects of tDCS. Specifically, anodal tDCS may increase the excitability of the cerebral cortex near the electrode, while cathodal tDCS may reduce excitability. The effects of tDCS extend beyond the targeted electrode area, influencing cortical networks and subcortical regions connected to the target areas. It is worth noting that the details of microscopic brain processes and the molecular mechanisms underlying tDCS effects on brain function remain largely unknown (31). This study evaluated the efficacy of tDCS, with the cathode applied to the orbitofrontal cortex (OFC) and the anode applied to the right cerebellum, in reducing OCD symptoms.

4. Results

4.1. Description of the Sample

In this research, 30 subjects with an age range of 17 - 51 years and an average age of 36.50 ± 8.94 participated. Among these 30 subjects, 15 were in the intervention group and 15 in the control group. Eight participants (26.7%) were male, and 22 participants (73.3%) were female. Nine participants (30.00%) were single, 19 were married (63.33%), and 2 (6.66%) were divorced. Regarding the educational qualifications of the participants: Four people (13.3%) had a middle school education, 1 person (3.3%) had a diploma, 2 people (6.7%) had postgraduate education, 15 people (50.0%) had a bachelor's degree, and 8 people (26.7%) had postgraduate education or higher.

Eighteen participants (60.0%) were employed, while 12 participants (40.0%) were unemployed. Five participants (16.7%) reported a history of drug use, while 25 participants (83.3%) reported no history of drug use. Two participants (6.6%) reported a medical history, while 28 participants (93.3%) reported no medical history.

The results of the chi-square test showed no significant difference in the education and gender variables between the two groups ($P > 0.05$). However, the results of the independent *t*-test indicated that the average age in the control group (39.93 ± 7.29) was higher than in the intervention group (33.06 ± 9.33), and this difference was statistically significant ($P < 0.05$).

As shown in Table 1, the mean post-test scores compared to the pre-test scores in the active tDCS group demonstrated a greater decrease in MOCI, Y-BOCS, and rumination variables compared to the sham treatment group. Additionally, there was a greater increase in the executive functions variable in the active tDCS group compared to the sham treatment group.

The assumptions of the covariance analysis method, including independence of observations, homogeneity of the variance-covariance matrix across groups, homogeneity of regression slopes, homogeneity of variances, and normality of the dependent variable distribution, were appropriate and observed.

According to Table 2, the effectiveness of tDCS on obsessive thoughts and compulsions in MOCI was significant at the 0.001 level, with an effect size of 0.752. This indicates that tDCS accounts for 75.27% of the variance in changes in obsessive thoughts and compulsions in MOCI from pre-test to post-test. The power of the statistical test in this analysis is 1.000, reflecting the high ability of the test to detect significant differences.

According to Table 3, the effectiveness of tDCS on obsessive thoughts and compulsions in the Y-BOCS was significant at the 0.001 level, with an effect size of 0.412. This means that tDCS explains 41.2% of the variance in changes in obsessive thoughts and compulsions in the

Table 1. The Mean ± Standard Deviation of the Variables of Obsessive-Compulsive Symptoms, Rumination and Executive Functions in the Pre-test and Post-test

Variables and Groups	Pre-test	Post-test
MOCI		
Active tDCS	22.40 ± 2.09	14.46 ± 3.06
Sham treatment	21.53 ± 1.80	21.66 ± 1.54
Y-BOCS		
Active tDCS	22.33 ± 7.72	14.40 ± 2.99
Sham treatment	20.33 ± 6.89	18.13 ± 6.99
Mistake Rumination Scale		
Active tDCS	20.93 ± 4.16	11.46 ± 2.13
Sham treatment	19.13 ± 5.34	18.26 ± 4.89
Executive Functions Questionnaire		
Active tDCS	86.40 ± 14.38	102.86 ± 8.40
Sham treatment	83.06 ± 16.61	86.93 ± 15.54

Abbreviations: MOCI, Maudsley Obsessional-Compulsive Questionnaire; tDCS, transcranial direct current stimulation; Y-BOCS, Yale-Brown Obsessive Compulsive Scale.

Table 2. Covariance Analysis Test on Maudsley Obsessional-Compulsive Questionnaire

Variable	Source of Change	SS	df	F	P-Value	Effect Size	Statistical Power
MOCI	Group	416.271	1	82.02	0.001	0.752	1.000

Abbreviation: MOCI, Maudsley Obsessional-Compulsive Questionnaire.

Y-BOCS from pre-test to post-test. The power of the statistical test in this analysis is 0.987, demonstrating the high power of the test in identifying significant differences.

According to Table 4, the effectiveness of tDCS on rumination was significant at the 0.001 level, with an effect size of 0.706. This suggests that tDCS accounts for 70.6% of the variance in rumination changes from pre-test to post-test. The power of the statistical test in this analysis is 1.000, indicating the high sensitivity of the test to detect significant differences.

According to Table 5, the effectiveness of tDCS on executive functions was significant at the 0.001 level, with an effect size of 0.418. This indicates that tDCS explains 41.8% of the variance in changes in executive functions from pre-test to post-test. The power of the statistical test in this analysis is 0.987, confirming the high power of the test in discovering significant differences.

5. Discussion

Obsessive-compulsive disorder is a chronic and treatment-resistant neuropsychological disease that often develops during childhood and adolescence, leading to significant long-term problems in a person's life. This disorder involves uncontrollable thoughts that compel individuals to repeat specific actions, causing disruptions in daily functioning (32). Despite advances in patient management, approximately 30 - 60% of patients show only a partial response to current medications or experience no improvement (33). Increasing evidence suggests that the neurobiological substrates of OCD include abnormal activity and connectivity in the orbitofronto-striato-pallido-thalamus network, with heightened activity in the OFC, cingulate gyrus, and caudate (34). Consequently, this research aimed to evaluate the effectiveness of tDCS on executive functions, the severity of obsessive-compulsive symptoms, and rumination in individuals with obsessive-compulsive symptoms.

The results of our study comparing the two groups demonstrated that the mean post-test scores, compared to the pre-test scores, in the active tDCS group showed a greater reduction in obsessive-compulsive symptoms and rumination. Additionally, there was a greater improvement in executive functions in the active tDCS group compared to the sham treatment group, with a significant difference between the two groups. Fineberg

Table 3. Covariance Analysis Test on Yale-Brown Obsessive Compulsive Scale

Variable	Source of Change	SS	df	F	P-Value	Effect Size	Statistical Power
Y-BOCS	Group	179.627	1	18.89	0.001	0.412	0.987

Abbreviation: Y-BOCS, Yale-Brown Obsessive Compulsive Scale.

Table 4. Covariance Analysis Test on Mistake Rumination

Variable	Source of Change	SS	df	F	P-Value	Effect Size	Statistical Power
Mistake rumination	Group	444.07	1	64.96	0.001	0.706	1.000

et al. (32) reported that tDCS treatment improves cognitive control in individuals with OCD.

Asadollahzadeh Shamkhal et al. (35) indicated that tDCS induces changes in brain complexity in individuals with contamination-related OCD by influencing neuronal interactions and balancing neuronal activity. Bation et al. (18) showed that, despite significant acute effects, tDCS was not effective in achieving long-term symptom reduction in patients with treatment-resistant OCD. In another study (36), tDCS, with the anode placed on the right cerebellum and the cathode placed on the left OFC, was found to be a safe, favorable, and appropriate approach to reducing OCD symptoms in treatment-resistant patients.

Brunelin et al. (20) conducted a systematic study investigating the effects of tDCS on OCD reviewing 12 studies involving a total of 77 patients (20). The findings indicated that, despite methodological limitations and heterogeneity in stimulation parameters, tDCS appears to be a promising tool for reducing obsessive-compulsive symptoms, as well as co-occurring depression and anxiety, in patients with treatment-resistant OCD.

Transcranial direct current stimulation enables simultaneous stimulation of various regions and modulation of different brain areas involved in cortico-subcortical loops (37). It has been suggested that tDCS may effectively reduce symptoms in patients with treatment-resistant OCD (38), although the optimal target sites and stimulation parameters remain a topic of debate.

One possible explanation for its effectiveness is that tDCS helps regulate brain activity, leading to a reduction in obsessive-compulsive symptoms. Previous studies have shown that tDCS can improve symptoms by influencing the interactions and dynamics of brain neurons. It is concluded here that tDCS, by modulating brain neuron activity and bringing it closer to a normal state, causes changes in the complexity of brain activity in individuals with obsessive-compulsive symptoms.

In explaining these findings, it can be posited that individuals with OCD experience disturbances in executive functions. By stimulating the frontal lobe, tDCS improves executive functions in these individuals, thereby enhancing their cognitive performance. Furthermore, tDCS's ability to modulate neuroplasticity, specifically by increasing cortical excitability in the left dorsolateral prefrontal cortex (DLPFC) and decreasing it in the right DLPFC, contributes to the improvement of obsessive-compulsive symptoms.

One of the limitations of the present research is the sample size. Although comparable to other studies in this field, it can be considered relatively small, particularly given the heterogeneity in OCD. Further studies should focus on factors that can enhance the clinical efficacy of tDCS. First, inducing activity during the stimulation of targeted neural networks is crucial for achieving neurobiological and clinical effects, as tDCS primarily acts by enhancing neural plasticity (39) and learning (40). Using a greater number of sessions over a longer period may be necessary to achieve clinically significant outcomes. The optimal placement of electrodes in OCD remains a challenging issue. Neuroimaging studies can only infer correlation, not causation, which limits the understanding of specific stimulation targets.

Another limitation is the lack of access to a sufficient sample size to examine and compare stimulation protocols with multiple current intensities. Due to time constraints, it was not possible to include a follow-up phase. Additionally, the generalizability of the results is limited. Therefore, caution should be exercised when

Table 5. Covariance Analysis Test on Executive Functions Questionnaire

Variable	Source of Change	SS	df	F	P-Value	Effect Size	Statistical Power
Executive Functions Questionnaire	Group	1444.79	1	19.38	0.001	0.418	0.989

applying these findings to non-experimental conditions and other clinical groups.

Future research should be conducted with larger sample sizes and include follow-up procedures. The effectiveness of stimulation protocols using multiple current intensities and different electrode sizes should also be investigated. Furthermore, the protocol used in this study should be tested on other clinical groups and common psychiatric disorders. This study did not account for the effect of medications, which should be considered in future research. Follow-up periods should also be included to assess the long-term stability of tDCS effects.

5.1. Conclusions

Transcranial direct current stimulation appears to have a significant effect on obsessive-compulsive symptoms, rumination, and executive functions in people with obsessive-compulsive symptoms. Using a greater number of tDCS sessions over a longer duration may be necessary to achieve clinically meaningful results. Moreover, determining the optimal electrode placement in OCD remains an important and complex issue that requires further investigation.

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Footnotes

Authors' Contribution: S. N., E. M., A. M., A. F., and M. J. contributed to the conception of the work, conducting the study, revising the draft and agreed for all aspects of the work.

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Conflict of Interests Statement: The authors declare that they have no conflict of interests.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after its publication.

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References

1. American Psychiatric Association. *Obsessive-Compulsive Disorder (OCD)*. American Psychiatric Association; 2020. Available from: https://www.appi.org/getattachment/3c3b89a8-6d86-4230-b352-e2b5104fcd68/APA-Publishing_Obsessive_Compulsive_Disorder_First_Learning-DSM-5-Case-Example.pdf.
2. Torres AR, Fontenelle LF, Shavitt RG, Hoexter MQ, Pittenger C, Miguel EC. Epidemiology, comorbidity, and burden of OCD. *Obsessive Compul Dis: Phenomenol, Pathophysiol, Treat*. 2017;**12**.
3. Asghar MA, Rehman AA, Shafiq Y, Siddiq A, Zehravi M, Khan K, et al. Relationship of Obsessive-Compulsive Disorders with Religion and Psychosocial attitude among Local Medical College Students of Karachi: An epidemiological study. *J Pak Med Assoc*. 2020;**70**(9):1563-7. [PubMed ID: 33040109]. https://doi.org/10.5455/JPMA.34245.
4. Raynal P, Melioli T, Chabrol H. Personality disorder traits in young adults with subclinical obsessive-compulsive symptoms: Not just traits related to obsessive- compulsive personality. *Bull Menninger Clin*. 2019;**83**(4):433-52. [PubMed ID: 31380698]. https://doi.org/10.1521/bumc_2019_83_05.
5. Huang L, Lei W, Xu F, Liu H, Yu L. Emotional responses and coping strategies in nurses and nursing students during Covid-19 outbreak: A comparative study. *PLoS One*. 2020;**15**(8). e0237303. [PubMed ID: 32764825]. [PubMed Central ID: PMC7413410]. https://doi.org/10.1371/journal.pone.0237303.
6. Ebrahem M, Diab Abd-Elwahab S, A. Shokr E, A. Radwan H. Effectiveness of Mindfulness Skills on Self-Efficacy and Suicidal Ideation among First-Year Nursing Students with Obsessive-Compulsive Symptoms during COVID-19 Pandemic. *Int Egypt J Nurs Sci Res*. 2022;**3**(1):221-39. https://doi.org/10.21608/ejnsr.2022.247075.
7. Rao NP, Reddy YC, Kumar KJ, Kandavel T, Chandrashekar CR. Are neuropsychological deficits trait markers in OCD? *Prog Neuropsychopharmacol Biol Psychiatry*. 2008;**32**(6):1574-9. [PubMed ID: 18582524]. https://doi.org/10.1016/j.pnpbp.2008.05.026.
8. Kocak OM, Erhan N, Ozguven HD, Nalcaci EG, Ergenc I. Evaluation of cognitive slowing in OCD by means of creating incongruence

between lexicon and prosody. *Psychiatry Res*. 2010;**179**(8):306-11. [PubMed ID: 20488555]. https://doi.org/10.1016/j.psychres.2009.04.016.

9. Shin MS, Choi H, Kim H, Hwang JW, Kim BN, Cho SC. A study of neuropsychological deficit in children with obsessive-compulsive disorder. *Eur Psychiatry*. 2008;**23**(2):512-20. [PubMed ID: 18514491]. https://doi.org/10.1016/j.eurpsy.2008.03.010.
10. Chamberlain SR, Blackwell AD, Fineberg NA, Robbins TW, Sahakian BJ. The neuropsychology of obsessive compulsive disorder: the importance of failures in cognitive and behavioural inhibition as candidate endophenotypic markers. *Neurosci Biobehav Rev*. 2005;**29**(4):399-419. [PubMed ID: 15820546]. https://doi.org/10.1016/j.neubiorev.2004.11.006.
11. Bannon S, Gonsalvez CJ, Croft RJ. Processing impairments in OCD: it is more than inhibition!. *Behav Res Ther*. 2008;**46**(3):689-700. [PubMed ID: 18456243]. https://doi.org/10.1016/j.brat.2008.02.006.
12. Tandt HLN, Van Parys H, Leyman L, Purdon C, Lemmens GMD. How are OCD patients and their families coping with the COVID-19 pandemic? A qualitative study. *Curr Psychol*. 2022;**41**(1):505-15. [PubMed ID: 33867778]. [PubMed Central ID: PMC8040748]. https://doi.org/10.1007/s12144-021-01724-5.
13. Vieru D. Towards a Multi-Dimensional Model of Digital Competence in Smalland Medium-Sized Enterprises. In: Khosrow-Pour M, editor. *Encyclopedia of Information Science and Technology, Third Edition*. Hershey, PA: IGI Global; 2015. p. 6715-25. https://doi.org/10.4018/978-1-4666-5888-2.ch660.
14. Maye CE, Wojcik KD, Candelari AE, Goodman WK, Storch EA. Obsessive compulsive disorder during the COVID-19 pandemic: A brief review of course, psychological assessment and treatment considerations. *J Obsessive Compuls Relat Disord*. 2022;**33**:100722. [PubMed ID: 35194549]. [PubMed Central ID: PMC8855616]. https://doi.org/10.1016/j.jocrd.2022.100722.
15. Eddy KT, Dutra L, Bradley R, Westen D. A multidimensional meta-analysis of psychotherapy and pharmacotherapy for obsessive-compulsive disorder. *Clin Psychol Rev*. 2004;**24**(8):1011-30. [PubMed ID: 15533282]. https://doi.org/10.1016/j.cpr.2004.08.004.
16. Keeley ML, Storch EA, Merlo LJ, Geffken GR. Clinical predictors of response to cognitive-behavioral therapy for obsessive-compulsive disorder. *Clin Psychol Rev*. 2008;**28**(1):118-30. [PubMed ID: 17531365]. https://doi.org/10.1016/j.cpr.2007.04.003.
17. Drummond LM. The treatment of severe, chronic, resistant obsessive-compulsive disorder. An evaluation of an in-patient programme using behavioural psychotherapy in combination with other treatments. *Br J Psychiatry*. 1993;**163**:223-9. [PubMed ID: 8075915]. https://doi.org/10.1192/bjp.163.2.223.
18. Bation R, Mondino M, Le Camus F, Saoud M, Brunelin J. Transcranial direct current stimulation in patients with obsessive compulsive disorder: A randomized controlled trial. *Eur Psychiatry*. 2019;**62**:38-44. [PubMed ID: 31525581]. https://doi.org/10.1016/j.eurpsy.2019.08.011.
19. Harika-Germaneau G, Heit D, Drapier D, Sauvaget A, Bation R, Chatard A, et al. Treating refractory obsessive compulsive disorder with cathodal transcranial direct current stimulation over the supplementary motor area: a large multisite randomized sham-controlled double-blind study. *Front Psychiatry*. 2024;**15**:1338594. [PubMed ID: 38827437]. [PubMed Central ID: PMC11140596]. https://doi.org/10.3389/fpsyt.2024.1338594.
20. Brunelin J, Mondino M, Bation R, Palm U, Saoud M, Poulet E. Transcranial Direct Current Stimulation for Obsessive-Compulsive Disorder: A Systematic Review. *Brain Sci*. 2018;**8**(2). [PubMed ID: 29495298]. [PubMed Central ID: PMC5836056]. https://doi.org/10.3390/brainsci8020037.
21. Hashemloo L, Safaralizadeh F, Bagheriyeh F, Motearefi H. [The prevalence obsessive-compulsive disorder in students in Khoy University in 2013]. *Iranian J Psychiat Nurs*. 2014;**2**(2):13-21. FA.
22. Drubach DA. Obsessive-compulsive disorder. *Continuum (Minneap Minn)*. 2015;**21**(3 Behavioral Neurology and Neuropsychiatry):783-8. [PubMed ID: 26039854]. https://doi.org/10.1212/01.CON.0000466666.12779.07.
23. Cohen L, Manion L, Morrison K. *Research Methods in Education*. London, UK: Routledge; 2013. https://doi.org/10.4324/9780203720967.
24. Gall MD, Borg WR, Gall JP. *Educational research: An introduction*. London, UK: Longman; 1996.
25. Shojaei A, Yousefi R, Chalabianioo G. [Reliability and Validitymeasurement of the Obsessive Beliefs Questionnaire: child and adolescent version]. *J Clin Psychol*. 2018;**9**(4):95-105. FA. https://doi.org/10.22075/jcp.2018.9192.
26. Wallace A, Hoskyn M. Validation of the executive function strategy awareness and use questionnaire (SAUQ) in a university student population. *J Am Coll Health*. 2022;**70**(6):1810-8. [PubMed ID: 33048636]. https://doi.org/10.1080/07448481.2020.1825224.
27. Goodman W, Rasmussen S, Price L, Mazure L, Heninger G, Charney D. Yale-Brown Obsessive Compulsive Scale (Y-BOCS) (1986, überarbeitete Fassung 1989). *Verhaltenstherapie*. 1991;**1**(3):226-33.
28. Rajezi Esfahani S, Motaghipour Y, Kamkari K, Zahiredin A, Janbozorgi M. [Reliability and Validity of the Persian Version of the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS)]. *Iranian J Psychiatry Clin Psychol*. 2012;**17**(4):297-303. FA.
29. Flett GL, Nepon T, Hewitt PL, Zaki-Azat J, Rose AL, Swiderski K. The Mistake Rumination Scale: Development, Validation, and Utility of a Measure of Cognitive Perfectionism. *J Psychoedu Assess*. 2019;**38**(1):84-98. https://doi.org/10.1177/0734282919879538.
30. Hajloo N, Pourabdol S, Beyki M, Gharibzadeh R. [Psychometric Properties of the Persian Version of the Mistake Rumination Scale]. *Qom Univ Med Sci J*. 2023;**17**(0):281-98. FA. https://doi.org/10.32598/qums.17.2524.4.
31. Podda MV, Cocco S, Mastrodonato A, Fusco S, Leone L, Barbati SA, et al. Anodal transcranial direct current stimulation boosts synaptic plasticity and memory in mice via epigenetic regulation of Bdnf expression. *Sci Rep*. 2016;**6**:22180. [PubMed ID: 26908001]. [PubMed Central ID: PMC4764914]. https://doi.org/10.1038/srep22180.
32. Fineberg NA, Apergis-Schoute AM, Vaghi MM, Banca P, Gillan CM, Voon V, et al. Mapping Compulsivity in the DSM-5 Obsessive Compulsive and Related Disorders: Cognitive Domains, Neural Circuitry, and Treatment. *Int J Neuropsychopharmacol*. 2018;**21**(1):42-58. [PubMed ID: 29036632]. [PubMed Central ID: PMC5795357]. https://doi.org/10.1093/ijnp/pyx088.
33. Pallanti S, Quercioli L. Treatment-refractory obsessive-compulsive disorder: methodological issues, operational definitions and therapeutic lines. *Prog Neuropsychopharmacol Biol Psychiatry*. 2006;**30**(3):400-12. [PubMed ID: 16503369]. https://doi.org/10.1016/j.pnpbp.2005.11.028.
34. Fettes P, Schulze L, Downar J. Cortico-Striatal-Thalamic Loop Circuits of the Orbitofrontal Cortex: Promising Therapeutic Targets in Psychiatric Illness. *Front Syst Neurosci*. 2017;**11**:25. [PubMed ID: 28496402]. [PubMed Central ID: PMC5406748]. https://doi.org/10.3389/fnsys.2017.00025.
35. Asadollahzadeh Shamkhal F, Moghimi A, Kobravi H, Salehi Fadardi J. [The Effect of Transcranial Direct Current Stimulation on Linear and

Nonlinear EEG Signal Characteristics in Contamination Obsessive-Compulsive Disorder Patients]. *Neurosci J Shefaye Khatam*. 2023;**12**(1):22-33. FA. https://doi.org/10.61186/shefa.12.1.22.

36. Bation R, Poulet E, Haesebaert F, Saoud M, Brunelin J. Transcranial direct current stimulation in treatment-resistant obsessive-compulsive disorder: An open-label pilot study. *Prog Neuropsychopharmacol Biol Psychiatry*. 2016;**65**:153-7. [PubMed ID: 26439873]. https://doi.org/10.1016/j.pnpbp.2015.10.001.

37. Fonteneau C, Redoute J, Haesebaert F, Le Bars D, Costes N, Suaud-Chagny MF, et al. Frontal Transcranial Direct Current Stimulation Induces Dopamine Release in the Ventral Striatum in Human. *Cereb Cortex*. 2018;**28**(7):2636-46. [PubMed ID: 29688276]. [PubMed Central ID: PMC5998959]. https://doi.org/10.1093/cercor/bhy093.

38. D'Urso G, Mantovani A, Patti S, Toscano E, de Bartolomeis A. Transcranial Direct Current Stimulation in Obsessive-Compulsive Disorder, Posttraumatic Stress Disorder, and Anxiety Disorders. *J ECT*. 2018;**34**(3):172-81. [PubMed ID: 30095684]. https://doi.org/10.1097/YCT.0000000000000538.

39. Huang YZ, Lu MK, Antal A, Classen J, Nitsche M, Ziemann U, et al. Plasticity induced by non-invasive transcranial brain stimulation: A position paper. *Clin Neurophysiol*. 2017;**128**(11):2318-29. [PubMed ID: 29040922]. https://doi.org/10.1016/j.clinph.2017.09.007.

40. Simonsmeier BA, Grabner RH, Hein J, Krenz U, Schneider M. Electrical brain stimulation (tES) improves learning more than performance: A meta-analysis. *Neurosci Biobehav Rev*. 2018;**84**:171-81. [PubMed ID: 29128578]. https://doi.org/10.1016/j.neubiorev.2017.11.001.