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Examining the Effectiveness of Repetitive Transcranial Magnetic Stimulation on Obsessive-Compulsive Symptoms in Adults with Attention Deficit Disorder

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A B S T R A C T

One of the disorders that has affected many individuals today is Attention Deficit Disorder. The present study aimed to examine the effectiveness of Repetitive Transcranial Magnetic Stimulation (rTMS) on obsessive-compulsive symptoms in adults diagnosed with Attention Deficit Disorder. This study utilized a quasi-experimental design with pretest-posttest and a control group. The statistical population included all adults diagnosed with Attention Deficit Disorder who visited psychological clinics in Yazd, Iran, in 2024. From this population, 30 individuals were selected through convenience sampling based on inclusion and exclusion criteria. Participants were then randomly assigned to the intervention group (n = 15) and the control group (n = 15). The research instrument was the Maudsley Obsessive-Compulsive Inventory (MOCI). Participants in the experimental group received 10 sessions of rTMS, each lasting 20 minutes. Data were analyzed using ANCOVA in SPSS version 23. The results indicated a significant reduction in obsessive-compulsive symptom scores in adults with Attention Deficit Disorder in the intervention group compared to the control group after receiving treatment ($F = 23.22$, $p < .05$). According to the effect size results, 71% of the variance between the intervention and control groups in obsessive-compulsive symptoms was attributable to rTMS treatment. Given the study's findings, rTMS may be an effective intervention for reducing obsessive-compulsive symptoms in adults with Attention Deficit Disorder.

Keywords: *Repetitive Transcranial Magnetic Stimulation, Obsessive-Compulsive Symptoms, Attention Deficit Disorder.*

1. Introduction

Attention Deficit Disorder (ADD) is a condition that has been extensively studied during childhood and adolescence. The

term “attention deficit” is a misleading label for a specific type of mental functioning and is better conceptualized as a cluster of symptoms—some positive, some negative (1). Attention refers to a group of complex mental operations, including focusing on a topic, sustaining it, maintaining vigilance over a relatively long period, encoding stimulus features, and shifting focus from one subject to another (2). Attention impairment stems from abnormalities in the brain’s chemical neurotransmitters. In other words, the brain operates slowly or inefficiently in regions responsible for filtering incoming stimuli and managing focus and attention (3). According to the diagnostic criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), individuals with ADD often fail to pay attention to details, struggle to sustain attention in tasks and activities, frequently do not follow through on instructions, and have difficulties organizing tasks that require mental effort (4).

One of the components often observed in individuals with Attention Deficit Disorder is the presence of obsessive-compulsive symptoms (5). Obsessive-Compulsive Disorder (OCD) affects approximately 1 in 40 people globally and is a major source of psychological distress (6). OCD is characterized by intrusive obsessions and compulsions that are distressing and time-consuming (7). Obsessions may include thoughts, images, or urges that are intrusive and unwanted, often accompanied by anxiety, distress, disgust, or a sense of something being wrong. Common obsessive themes include fear of harming others, fears of being immoral, or fears of contamination. Compulsions are repetitive behaviors or mental rituals, such as checking, cleaning, counting, or arranging, that are performed to prevent or reduce anxiety or avoid a feared (often imagined) event (8). Evidence-based treatments—including both pharmacological and psychotherapeutic interventions—have been developed over recent decades and can offer significant relief for most patients (9). However, diagnosis is often delayed, and access to specialized treatment remains limited. Delayed, suboptimal, or inappropriate treatment can exacerbate an individual's suffering (10).

One therapeutic approach increasingly used for psychiatric disorders is Repetitive Transcranial Magnetic Stimulation (rTMS).

Repetitive Transcranial Magnetic Stimulation is a non-invasive neurostimulation technique that utilizes a series of focused magnetic field pulses to modulate neuronal activity in brain areas associated with specific disorders. The magnetic field is generated by a handheld or cap-like coil placed on the scalp over the targeted brain region. Different types of coils have been designed, each producing unique magnetic field patterns. The original design was a circular coil, which could not reach deeper brain structures. Other coils have since been developed to deliver more focal and deeper stimulation. For instance, a double-cone coil conforms to the shape of the head and enables deeper, more targeted stimulation patterns (11).

Evidence suggests that this technique, particularly when applied to the dorsolateral prefrontal cortex (DLPFC), can have beneficial effects on cognitive functioning and emotional regulation. Since both ADD and obsessive-compulsive symptoms are linked to functional abnormalities in this region, the application of rTMS may help improve these symptoms. The antidepressant effects of rTMS may be associated with a range of neurobiological changes in brain regions interconnected with the stimulation site. Brain imaging studies show that the left DLPFC receives inputs from sensory-specific cortices and maintains dense reciprocal connections with subcortical areas involved in emotional regulation, such as the limbic system and striatum (12).

In a study conducted by Asbaghi and colleagues, the effect of rTMS on working memory and mood symptoms in patients with bipolar disorder in Tehran was examined. The results indicated that rTMS was effective in improving both working memory performance and mood symptoms in these patients (13). In another study, Li and colleagues investigated the efficacy of rTMS on auditory hallucinations and inner speech in patients with schizophrenia. Their findings showed a reduction in both auditory hallucinations and inner speech following rTMS treatment (14). Beynel and colleagues studied the effectiveness of rTMS on working memory and found that repetitive transcranial magnetic stimulation improved working memory in both young and elderly adults (15). Brabenec and colleagues evaluated the effects of rTMS on auditory feedback and speech-language abilities in patients with Parkinson’s disease, concluding that

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rTMS enhanced auditory feedback, speech, and language functioning in this population (16).

Considering the significant prevalence of Attention Deficit Disorder in the country, its adverse effects on individual lives, and its strong association with obsessive-compulsive symptoms, it becomes essential to investigate the impact of Repetitive Transcranial Magnetic Stimulation on obsessive-compulsive symptoms in this segment of the population.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a quasi-experimental design with pretest-posttest and a control group. The statistical population included all adults diagnosed with depressive disorder who sought services from psychological and psychiatric clinics in Yazd in 2024. Given that in experimental research a minimum sample size of 15 participants per group is recommended (17), 30 eligible and willing individuals were selected through convenience sampling based on inclusion and exclusion criteria. These individuals were then randomly assigned to an intervention group (n = 15) and a control group (n = 15).

Inclusion criteria consisted of having a diagnosis of depressive disorder confirmed by a psychiatrist, being aged 20 or older, signing an informed consent form to participate in the study, and not receiving any concurrent psychotherapy or pharmacotherapy. Exclusion criteria included missing one treatment session, failing to complete the questionnaire, and unwillingness to continue participation during the study. In the first session, each participant completed a consent form to take part in the research.

After evaluating the participants' conditions and conducting the pretest in both groups, the intervention group received 10 sessions of 20-minute Repetitive Transcranial Magnetic Stimulation (rTMS) over five weeks (twice per week) using an rTMS device. The treatment involved 1 Hz frequency stimulation at 80% motor threshold and 1400 pulses, targeting the right dorsolateral prefrontal cortex. In the control group, the coil was angled in such a way that the magnetic waves did not reach the brain. Following the intervention, posttests were administered to both groups, and analysis of covariance (ANCOVA) was used to assess the difference in pretest and posttest scores.

2.2. Measure

Maudsley Obsessive-Compulsive Inventory (MOCI): This 30-item questionnaire was developed by Hodgson and Rachman in 1977. It measures four subscales: checking, cleaning, slowness, and doubting. The questions are answered in a true/false format. The total obsessive-compulsive score obtained from this instrument ranges from 1 to 30 (18). According to the report by Norman and colleagues, the Cronbach's alpha coefficient for the entire test was .87, test-retest reliability was .70, and the retest reliability coefficient was reported as .89 (Norman et al., 1996). In a study by Alilou, the Cronbach's alpha for the full test was .75, concurrent validity between the Vancouver Obsession Questionnaire and the MOCI was .81, and test-retest reliability was reported as .84 (19).

2.3. Intervention

The intervention consisted of ten sessions of Repetitive Transcranial Magnetic Stimulation (rTMS) administered over a five-week period, with two sessions per week. Each session lasted 20 minutes and was conducted using an rTMS device targeting the right dorsolateral prefrontal cortex (DLPFC). The stimulation parameters included a frequency of 1 Hz, an intensity of 80% of the motor threshold, and a total of 1400 pulses per session. In the control group, the coil was angled in a way that prevented the magnetic pulses from effectively penetrating the scalp and reaching the brain, thereby serving as a sham condition. This setup was used to assess the specific effects of rTMS on obsessive-compulsive symptoms in adults with attention deficit disorder.

2.4. Data Analysis

Data analysis was conducted using SPSS version 23. Descriptive statistics were used to summarize demographic variables and mean scores. Inferential statistics involved the use of Analysis of Covariance (ANCOVA) to compare posttest scores between the intervention and control groups while controlling for pretest scores. Prior to conducting ANCOVA, key assumptions including normality (tested via the Kolmogorov–Smirnov test), homogeneity of variances

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(tested via Levene's test), and homogeneity of regression slopes were assessed and met. The ANCOVA results revealed a statistically significant reduction in obsessive-compulsive symptoms in the intervention group compared to the control group, with an effect size (η^2) of 0.71, indicating that 71% of the variance in posttest scores was attributable to the rTMS treatment.

3. Findings and Results

The descriptive results of the demographic variables—age, gender, marital status, employment, and education level—are presented in Table 1.

Table 1

Demographic Data

Variable / Group	Intervention	Control
Age	24–29: 3	24–29: 2
	30–35: 5	30–35: 7
	36–40: 5	36–40: 5
	41–45: 2	41–45: 1
Gender	Female: 10	Female: 11
	Male: 5	Male: 4
Marital Status	Single: 6	Single: 8
	Married: 8	Married: 5
	Divorced: 1	Divorced: 2
Employment	Unemployed: 8	Unemployed: 6
	Employee/Worker: 7	Employee/Worker: 6
	Self-employed: 0	Self-employed: 3
Education	Primary or less: 0	Primary or less: 0
	Middle school: 4	Middle school: 2
	Diploma/Associate: 6	Diploma/Associate: 5
	Bachelor's: 5	Bachelor's: 6
	Master's: 0	Master's: 2
	Doctorate or higher: 0	Doctorate or higher: 0

In this study, participants with a high school diploma had the highest frequency, while those with a doctoral degree or higher had the lowest. Most participants were in the age range of 30 to 35 years. The means and standard deviations of pretest and posttest scores for obsessive-compulsive symptoms in the intervention and control groups are presented in Table 2.

Table 2

Mean and Standard Deviation of Pretest and Posttest Scores for Obsessive-Compulsive Symptoms

Variable	Group	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Obsessive-Compulsive Symptoms	Intervention	24	13.61	12	11.11
	Control	22	11.22	20	12.25

It is observed that the posttest mean score of obsessive-compulsive symptoms in the intervention group showed a greater reduction. Inferential statistical analysis was conducted using analysis of covariance (ANCOVA). Prior to conducting ANCOVA, its assumptions were examined. The Kolmogorov–Smirnov test confirmed the normality of the score distribution ($p > .05$). Additionally, Levene's test confirmed the equality of variances between the two groups in both the pretest and posttest for obsessive-compulsive symptoms ($p > .05$). The assumption of homogeneity of regression slopes was also met ($p = .221$).

The results of ANCOVA, after adjusting for the pretest effect (Table 3), showed a statistically significant difference in the posttest mean scores of obsessive-compulsive symptoms between the intervention group, which received repetitive transcranial magnetic stimulation (rTMS), and the

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control group, in which the coil angle was altered to prevent magnetic waves from reaching the brain ($p < .05$). This indicates that the treatment significantly reduced obsessive-compulsive symptoms in adults with attention deficit disorder. Furthermore, the effect size analysis revealed that 71% of the difference in obsessive-compulsive symptom scores between the intervention and control groups was attributable to rTMS.

Table 3

ANCOVA Results

Dependent Variable	Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Obsessive-Compulsive Symptoms	Group	4263.05	1	4263.05	23.32	.02	.71
	Pretest	211.23	1	211.23	13.08	.11	
	Error	89.26	27	3.30			

4. Discussion and Conclusion

The present study aimed to investigate the effectiveness of repetitive transcranial magnetic stimulation (rTMS) on obsessive-compulsive symptoms in adults with attention deficit disorder. The results of the analysis of covariance indicated that rTMS had a statistically significant effect on reducing obsessive-compulsive symptoms in individuals with attention deficit disorder. This finding is consistent with the results of prior studies (20-22).

Attention-Deficit/Hyperactivity Disorder (ADHD) in adults can be associated with various challenges, including obsessive-compulsive symptoms. Recent research has shown that some individuals with ADHD experience intrusive and obsessive-like thoughts that may disrupt their daily functioning. These findings have drawn increased attention to novel treatments, such as rTMS, in this population.

Theoretically, the brain can be safely and non-invasively stimulated using strong magnetic fields. rTMS has multiple applications, including cognitive enhancement in healthy individuals and cognitive rehabilitation in patients with psychiatric disorders such as stress, depression, and obsessive-compulsive disorder. In this method, electrodes are placed on the scalp, and electrical stimulation is applied to a targeted area corresponding to the prefrontal cortex, causing hyperpolarization of neuronal activity. These electrodes generate brief magnetic pulses that painlessly penetrate the scalp, skull, and meninges to reach neural tissue and transiently activate the neurons. When pulses are delivered rapidly and repetitively, the procedure is known as repetitive transcranial magnetic stimulation, which can lead to more lasting changes in brain activity. Furthermore, rTMS can exert either inhibitory or excitatory effects on specific brain regions depending on the nature of the disorder (23).

In OCD, hyperactivity in the right dorsolateral prefrontal cortex has been observed. When rTMS is applied to this area with an inhibitory protocol, it can reduce hyperactivity in the region and thereby alleviate obsessive symptoms (Dehghani-Arani et al., 2024). Additionally, since OCD is associated with reduced levels of neurotransmitters such as dopamine and serotonin, rTMS may help regulate neurotransmitter secretion patterns—particularly dopamine and serotonin—which in turn contributes to symptom reduction (20).

The findings of the current study demonstrated that ten 20-minute sessions of rTMS applied to the right dorsolateral prefrontal cortex resulted in a significant reduction of obsessive-compulsive symptoms in adults with attention deficit disorder. rTMS may therefore serve as a non-invasive adjunct treatment to improve obsessive symptoms in this population.

Studies examining the effectiveness of rTMS on obsessive-compulsive symptoms in individuals with ADHD suggest that this method may reduce the severity of obsessive thoughts. Although the exact mechanism underlying this effect is not yet fully understood, some research indicates that magnetic stimulation may lead to the reorganization of brain networks involved in cognitive processing and impulse control. Moreover, rTMS offers notable advantages over pharmacological treatments. Many medications prescribed for ADHD and OCD are associated with side effects that may reduce treatment adherence. In contrast, rTMS, as a non-invasive technique with minimal side effects, is considered a safer option. However, not all

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studies have reached consistent conclusions. Some research has shown that the effects of rTMS on obsessive symptoms may be limited or evident only in certain individuals. Factors such as symptom severity, duration of illness, and neurocognitive characteristics may influence the efficacy of rTMS.

Given the existing findings, it appears that rTMS can be used as an adjunctive treatment alongside other approaches such as cognitive behavioral therapy (CBT) and pharmacotherapy. Combining these methods may enhance treatment efficacy and reduce obsessive-compulsive symptoms in patients with ADHD. Ultimately, to confirm the definitive effectiveness of rTMS in treating obsessive-compulsive symptoms in adults with ADHD, further studies with more rigorous designs, larger sample sizes, and long-term follow-ups are needed. Nevertheless, current findings are promising and suggest that rTMS may be a viable therapeutic option for this population.

One of the limitations of current studies is the variability in rTMS parameters, such as frequency, intensity, and target region. Some studies have used high-frequency stimulation (e.g., 10 Hz) over the left prefrontal cortex, while others have employed low-frequency stimulation (1 Hz) in different regions. These discrepancies can lead to varying results and underscore the need for further research to standardize therapeutic protocols. In addition, the long-term effects of rTMS on obsessive-compulsive symptoms and ADHD remain unclear. Some studies indicate that initial improvements may be temporary, and maintenance sessions or repeated treatments may be necessary. This highlights the importance of examining long-term outcomes and developing more effective treatment protocols.

A limitation of the present study is its cross-sectional nature. Future research should incorporate longitudinal designs to evaluate the sustained impact of rTMS on obsessive-compulsive symptoms. It is recommended that follow-up assessments be included in subsequent studies. Taken together, these findings suggest that rTMS can be an effective intervention for reducing obsessive-compulsive symptoms in adults with attention deficit disorder.

Authors' Contributions

K. E. developed the initial research idea and oversaw participant selection and intervention implementation. S. M. coordinated data collection and managed rTMS session scheduling. P. A. was responsible for statistical analysis and drafting the methodology section. M. R. Y. supervised the clinical procedures and provided expert insight into neurological aspects of rTMS. S. R. contributed to literature review, final manuscript editing, and ensured ethical compliance. All authors participated in reviewing and approving the final version of the manuscript.

Declaration

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

Transparency Statement

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

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study placed a high emphasis on ethical considerations. Informed consent obtained from all participants, ensuring they are fully aware of the nature of the study and their role in it. Confidentiality strictly maintained, with data anonymized to protect individual privacy. The study adhered to the ethical guidelines for research with human subjects as outlined in the Declaration of Helsinki. Ethical considerations included obtaining informed consent, ensuring confidentiality and anonymity, and avoiding any harm to participants.

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