The Effectiveness of Repetitive Transcranial Magnetic Stimulation on Resilience and Negative Meta-Emotion in Infertile Women with Obsessive–Compulsive Disorder

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Objective: The present study aimed to determine the effectiveness of repetitive transcranial magnetic stimulation (rTMS) on resilience and negative meta-emotion in infertile women with obsessive–compulsive disorder (OCD).
Methods and Materials: This quasi-experimental research employed a pretest–posttest control-group design with a three-month follow-up. The statistical population comprised all infertile women with OCD who attended treatment centers in Tehran in 2024. Participants were randomly assigned to experimental and control groups. Before the intervention, all participants completed the Connor–Davidson Resilience Scale (CD-RISC; 2003). The experimental group then received an rTMS intervention delivered in six weekly 90-minute sessions. Data were analyzed using repeated-measures ANOVA.
Findings: Results indicated a significant difference between pretest and posttest across groups ($p < .05$). Additionally, for both resilience and negative meta-emotion, significant between-group differences were observed at posttest and at follow-up ($p < .05$).
Conclusion: These findings suggest that rTMS can effectively enhance resilience and reduce negative meta-emotion in infertile women with OCD.
Keywords: repetitive transcranial magnetic stimulation; resilience; negative meta-emotion.

1. Introduction

Infertility is recognized as one of the most distressing health conditions worldwide, with implications that extend far beyond the biological inability to conceive. Epidemiological estimates reveal that infertility affects millions of couples globally, with women disproportionately burdened by its physical, social, and psychological consequences (Feng et al., 2025). While infertility is medically defined as the inability to achieve pregnancy after at least one year of regular, unprotected intercourse, its significance lies not only in reproductive outcomes but also in the profound impact it has on mental health, self-concept, and quality of life (Straub & Mills, 2025). For women, infertility frequently becomes entangled with cultural expectations, marital dynamics, and identity, leading to

heightened vulnerability to psychological disorders, including anxiety, depression, and obsessive–compulsive disorder (OCD) (Woodward et al., 2024).

The psychological distress accompanying infertility is often compounded by intrusive concerns regarding treatment outcomes and self-blame for reproductive difficulties. Research has indicated that women facing infertility experience a complex interaction between obsessive worries about conception and compulsive behavioral patterns aimed at controlling uncertainty (Archetti, 2024). These obsessive–compulsive tendencies are intensified by the cultural and social stigma surrounding childlessness, leading to feelings of inadequacy, failure, and loss of control (Kashyap & Tripathi, 2025). For many women, OCD becomes a secondary yet powerful burden, further limiting coping resources and straining resilience in the face of ongoing stressors (Wu et al., 2024). The inability to manage these intrusive thoughts and compulsions not only erodes emotional well-being but also disrupts family functioning and marital satisfaction (Chen et al., 2024).

Resilience, defined as the ability to adapt and restore psychological balance in response to adversity, is therefore a central construct in understanding how women cope with infertility and OCD. Women with high resilience are more likely to maintain optimism, adopt problem-focused coping strategies, and seek social support, all of which buffer against the psychological toll of infertility (Yin et al., 2025). Conversely, diminished resilience exacerbates vulnerability to stress and can perpetuate cycles of despair and maladaptive emotional regulation (Araya et al., 2025). The weakening of resilience in infertile women is often associated with the emergence of negative meta-emotions such as shame, guilt, and hopelessness, which feed into a loop of intrusive thoughts and maladaptive coping (Wang et al., 2025).

Meta-emotions—defined as emotions about one's own emotional experiences—play a critical role in this dynamic (Mendonça, 2024). Negative meta-emotions manifest when individuals evaluate their emotional responses as inappropriate or inadequate, leading to feelings of guilt for being anxious, shame for feeling inadequate, or anger at one's own sadness (Mitmansgruber et al., 2009). For infertile women with OCD, negative meta-emotions frequently intensify maladaptive thought patterns and behaviors, reinforcing distress rather than alleviating it (Watts et al., 2025). These emotional layers create what has been described as a vicious cycle: intrusive thoughts lead to shame and guilt, which then fuel further compulsive behaviors, ultimately deteriorating psychological resilience (Zerwas et al., 2024). Studies in maternal and developmental psychology highlight that meta-emotions not only affect individual well-being but also influence broader social relationships, reinforcing the urgency of addressing them in therapeutic contexts (Soucie et al., 2024).

Cultural and contextual factors further complicate this picture. In many societies, including those with strong pronatalist traditions, infertility is perceived as a personal failure, which amplifies stigma and emotional suffering (Sharma et al., 2025). Women often face direct questioning about their reproductive status, leading to constant reminders of their condition and reinforcing cycles of stress and obsessive rumination (Kashyap & Tripathi, 2025). Research from Ethiopia, India, and other cultural contexts shows that kinship networks, while potentially supportive, can also reinforce pressures and expectations that exacerbate infertility stress (Araya et al., 2025; Sharma et al., 2025). The result is a fragile psychological environment in which women struggle not only against the medical challenges of infertility but also the social judgment and relational strain it brings.

Addressing these challenges requires a focus not only on alleviating the clinical symptoms of OCD but also on enhancing resilience and reducing negative meta-emotions. Yet, existing psychological and psychiatric interventions have often prioritized symptom suppression without fully addressing these broader emotional and cognitive mechanisms. For instance, Acceptance and Commitment Therapy (ACT) and other third-wave behavioral therapies have demonstrated utility in enhancing coping and ego strength among clinical populations (Salehi et al., 2024; Taghilu et al., 2023), while paradox-based interventions have been explored for their potential in reducing worry (Asadiof et al., 2024; Sharshar, 2024). However, despite such advances, there remains a gap in integrating resilience enhancement and meta-emotional regulation into infertility and OCD treatment paradigms.

Emerging neuroscientific interventions, such as repetitive transcranial magnetic stimulation (rTMS), provide a promising complementary approach. rTMS is a noninvasive brain stimulation technique that delivers magnetic pulses to targeted cortical regions, inducing neuroplastic changes and modulating neural networks involved in emotion regulation and cognitive control (Najafi-Dehaghani et al., 2024). Evidence indicates that rTMS has therapeutic benefits for depression, anxiety, and trauma-related disorders by recalibrating dysfunctional neural circuits (Saeidi-Nejad et

al., 2025). In the context of infertility, such modulation may strengthen resilience by restoring adaptive emotional regulation mechanisms and reducing the intensity of negative meta-emotions (Saeidi-Nejad et al., 2024).

The clinical applicability of rTMS has expanded in recent years, with studies showing improvements in distress tolerance, experiential avoidance, and ego strength in different populations (Naderipour et al., 2022; Taghilu et al., 2023). For mothers of premature infants, rTMS interventions have been associated with reductions in anxiety, depression, and ruminative responses, underscoring its potential relevance for women facing reproductive challenges (Saeidi-Nejad et al., 2025). Moreover, findings suggest that rTMS not only alleviates immediate symptoms but also enhances long-term coping resources by reinforcing cortical pathways associated with resilience and emotional stability (Najafi-Dehaghani et al., 2024).

Within infertility research, mental health professionals increasingly argue for integrating psychological care into reproductive medicine to provide holistic support for patients (Woodward et al., 2024). Such integrative models emphasize the necessity of addressing emotional regulation, resilience, and stigma alongside medical interventions. Indeed, stigma itself is a critical factor influencing psychological outcomes in infertile women, with latent profile analyses revealing its strong association with diminished resilience and elevated distress (Wang et al., 2025). Addressing stigma thus requires multidimensional approaches that target not only external social dynamics but also internalized emotional reactions, such as negative meta-emotions.

A deeper theoretical layer is offered by meta-emotional research. The study of how individuals perceive and regulate their own emotions provides insights into why resilience collapses under the weight of infertility stress. While positive meta-emotions, such as compassion toward oneself, can facilitate recovery and adaptive coping, negative meta-emotions often perpetuate maladaptive cycles of avoidance and experiential suppression (Mendonça, 2024; Mitmansgruber et al., 2009). Behavioral activation therapy and related cognitive-behavioral methods have demonstrated partial success in targeting negative meta-emotions (Naderipour et al., 2022), but the neurocognitive modulation provided by rTMS represents an innovative frontier with the potential to disrupt entrenched cycles of self-criticism and obsessive rumination.

Moreover, research underscores the paradoxical nature of interventions for infertility and OCD. While paradoxical therapeutic strategies can be effective in some contexts (Salehi et al., 2024; Sharshar, 2024), infertility presents unique challenges where paradox itself is lived rather than imposed—women experience a constant tension between hope for conception and despair at repeated failures, between social pressure to bear children and personal exhaustion from treatment (Unfer et al., 2023). This paradox intensifies the salience of meta-emotions, as women blame themselves for emotions that seem inconsistent with cultural ideals of motherhood (Archetti, 2024). rTMS, by contrast, directly engages with the neurophysiological substrates of such paradoxes, offering a pathway to mitigate their emotional impact.

The present study builds on this complex landscape by focusing on infertile women with OCD, a subgroup particularly vulnerable to diminished resilience and heightened negative meta-emotions. While prior research has examined resilience in relation to infertility stress (Yin et al., 2025) and the role of kinship in coping (Sharma et al., 2025), few studies have specifically targeted the intersection of infertility, OCD, resilience, and meta-emotions. Even fewer have empirically evaluated the potential of rTMS to enhance psychological functioning in this population. Given the centrality of resilience for adaptive coping and the destructive role of negative meta-emotions in perpetuating distress, this gap represents a significant limitation in current infertility research and practice.

Therefore, the aim of the present study is to evaluate the effectiveness of repetitive transcranial magnetic stimulation on resilience and negative meta-emotions in infertile women with OCD.

2. Methods and Materials

2.1. Study design and Participant

The present study employed a quasi-experimental design with pretest–posttest control group and a three-month follow-up. The statistical population consisted of all infertile women with obsessive–compulsive disorder (OCD) in Tehran during the first quarter of 2024 (1403). The sample comprised 30 infertile women with OCD selected through nonrandom convenience sampling (based on the G*Power 3 sample size program with parameters: effect size = 0.36, α = .05, test power = .95). The sample size for each of the experimental and control groups was considered to be 15, and overall a sample size of 15 was adopted. Accordingly, two groups of 15 participants were selected and randomly allocated to the experimental and control conditions.

Inclusion criteria were: primary infertility due to female factors (no history of pregnancy), a psychologist's report confirming OCD, Iranian nationality, age 25–52 years, and at least a high-school diploma. Exclusion criteria included: absence from more than two sessions, incomplete completion of questionnaires, withdrawal from participation, non-adherence to intervention exercises, and simultaneous participation in other counseling or psychotherapy programs.

Procedure: After selecting the sample based on the inclusion criteria, the study questionnaires were administered. The repetitive transcranial magnetic stimulation (rTMS) intervention was then delivered by the researchers at one of the counseling centers in Tehran (the center provided appropriate space, facilities, and educational equipment). All participants who agreed to take part completed the questionnaires in groups at three time points: pretest, posttest, and follow-up, with no time limit imposed. The rTMS intervention was conducted over six 90-minute sessions (one session per week) in a group format. Confidentiality of collected information, informed consent, non-disclosure of participants' data, and establishing a reassuring environment were among the ethical considerations observed. Finally, data were analyzed using repeated-measures analysis of variance (ANOVA) in SPSS version 26.

2.2. Measures

Connor–Davidson Resilience Scale (CD-RISC). Developed by Connor and Davidson (2003), this 25-item scale is scored on a Likert continuum from 0 (completely false) to 5 (always true). It comprises five subcomponents: perception of personal competence; trust in one's instincts and tolerance of negative affect; positive acceptance of change and secure relationships; control; and spiritual influences. Higher scores indicate greater resilience. Arias-González et al. (2015) reported Cronbach's alpha of .91 and content validity of .84, indicating adequate validity. In a study by Ahangar-zadeh et al. (2015), Cronbach's alpha was .82 and content validity was .98, supporting the instrument's validity (Mam-Sharifi et al., 2022). In the present study, Cronbach's alpha for the scale was .91.

Mitmansgruber Meta-Emotion Scale (MES). This self-report instrument assessing negative and positive meta-emotions was developed by Mitmansgruber et al. (2009) and contains 28 items rated on a 6-point Likert scale (1 = not at all true to 6 = completely true). The authors reported six

components—anger; contempt/shame; strong inhibition and suppression (negative meta-emotions); and compassion and interest (positive meta-emotions)—with Cronbach's alphas of .76, .77, .83, .82, and .85, respectively, and .87 for the total scale (Mitmansgruber et al., 2009). Construct validity was examined via exploratory and confirmatory factor analyses; results indicated a two-factor structure with all item loadings above .40. In Iran, Benisi (2019) reported a total Cronbach's alpha of .78; factor analyses confirmed the two principal dimensions of positive and negative meta-emotions. Convergent validity of positive meta-emotions with components of the Trait Emotional Intelligence Questionnaire (Petrides et al., 2001) was reported at .51 (Naderipour et al., 2022). In the present study, Cronbach's alpha for the scale was .81. Note that only the negative meta-emotion dimension was used in this study; Cronbach's alpha reported here for this dimension was .832.

2.3. Intervention

Repetitive transcranial magnetic stimulation (rTMS). In this study, rTMS referred to 10 sessions of 20-Hz stimulation at 80% of the motor-evoked potential threshold applied over the right prefrontal cortex.

The intervention protocol in this study was designed as a structured rTMS treatment program delivered over a six-week period, with one session per week lasting approximately 90 minutes, administered in a counseling center equipped with appropriate facilities and safety measures. Participants in the experimental group, all infertile women diagnosed with obsessive–compulsive disorder, received high-frequency repetitive transcranial magnetic stimulation at 20 Hz with an intensity set at 80% of the motor threshold, targeting the right dorsolateral prefrontal cortex— a region strongly implicated in emotional regulation, resilience, and cognitive control. Each session began with a brief orientation and reassurance about the procedure, followed by the placement of the coil over the identified cortical area, where magnetic pulses were delivered in trains with inter-train intervals to optimize cortical plasticity while minimizing discomfort. Participants were monitored closely for any adverse effects throughout the session, with breaks provided as necessary. Ethical considerations, including informed consent, confidentiality, and the right to withdraw at any point, were strictly observed. The intervention was designed not only to reduce obsessive thoughts and maladaptive compulsions but also to strengthen resilience and decrease negative meta-emotions such as shame, guilt,

and self-blame, thereby addressing both symptomatic relief and psychological resource-building. To evaluate effectiveness, outcomes were assessed using validated instruments for resilience (Connor–Davidson Resilience Scale) and meta-emotions (Mitmansgruber Meta-Emotion Scale) at three points: pretest, posttest, and three-month follow-up. The structured design of the protocol ensured consistency across participants, while its focus on neurocognitive modulation distinguished it from purely psychotherapeutic approaches, offering a novel pathway for supporting infertile women struggling with OCD and its associated emotional challenges.

2.4. Data Analysis

In addition to descriptive statistics, inferential statistics were used. Given the study design, Shapiro–Wilk tests were first conducted to determine equality of the groups on the dependent variables at pretest and to assess assumptions. To evaluate treatment effectiveness, repeated-measures ANOVA was employed, followed by post-hoc tests to compare the interventions' significant effects. Analyses were performed using SPSS version 26.

3. Findings and Results

The mean age of participants by group was 34.4 ± 5.84 years in the intervention group and 34.9 ± 5.04 years in the control group. The minimum and maximum ages were 30 and 43 years, respectively. Mean marriage duration was 6.20 ± 1.89 years in the intervention group and 5.46 ± 2.26 years in the control group (range: 4–10 years). Educational attainment in the intervention group was 37.5% diploma, 7.5% associate, 27.5% bachelor's, 20% master's, and 7.5% doctoral; in the control group, 35% diploma, 2.5% associate, 30% bachelor's, 17.5% master's, and 15% doctoral. There were no significant between-group differences in age, education level, or marriage duration ($p > .05$). Descriptive statistics for the two groups across the three measurement points are presented in Table 1.

Table 1

Descriptive statistics of study variables

Variable	Group	Pretest M	Pretest SD	Posttest M	Posttest SD	Follow-up M	Follow-up SD
Resilience	rTMS	37.9	5.13	41.4	5.20	40.4	5.31
	Control	47.6	6.02	45.8	5.36	45.0	5.01
Negative meta-emotion	rTMS	65.1	3.41	60.8	4.59	61.7	4.52
	Control	66.8	5.66	67.6	6.83	68.0	7.21

As shown in Table 2, group means for resilience and negative meta-emotion were broadly similar at pretest; however, following the intervention the rTMS group exhibited marked improvements relative to the control group, and these differences were also evident at follow-up. Box's M test of the equality of covariance matrices indicated non-homogeneity for the study variables (Box's M = 88.8, F = 13.06, $p < .01$); given equal group sizes, this assumption can be relaxed. Mauchly's test of sphericity was significant (W = 0.055, χ^2 = 78.1, $p < .01$); therefore, Greenhouse–Geisser corrections were applied in repeated-measures ANOVA. Tests of homogeneity of variances for resilience (F = 1.9, $p < .05$) and negative meta-emotion (F = 2.07, $p < .05$) were reported as supporting the homogeneity assumption. A 3 × 2 repeated-measures MANOVA (Group: rTMS vs. control × Time: pretest, posttest, follow-up) showed the following multivariate results.

Table 2

Multivariate tests (MANOVA)

Effect	Test	Value	F	df1	df2	p	Partial η²
Factor (Time)	Pillai's Trace	0.976	246.4	8	49	.001	0.976
	Wilks' Lambda	0.024	246.4	8	49	.001	0.976
	Hotelling's Trace	40.2	246.4	8	49	.001	0.976
	Roy's Largest Root	40.2	246.4	8	49	.001	0.976
Group × Factor	Pillai's Trace	1.92	11.3	24	153	.001	0.641
	Wilks' Lambda	0.017	18.3	24	142.7	.001	0.743
	Hotelling's Trace	13.3	26.6	24	143	.001	0.817
	Roy's Largest Root	10.1	64.7	8	51	.001	0.910

Controlling for pretest effects, Wilks' Lambda was significant ($\Lambda = 0.017$, F = 18.3, p = .001, partial $\eta^2 = 0.743$), indicating a meaningful difference between the experimental and control groups on the dependent variables.

Table 3

Repeated-measures ANOVA for resilience and negative meta-emotion

Variable	Source	SS	df	MS	F	p	Partial η^2
Resilience	Between-subjects: Group	2083.3	1	2083.3	31.02	.001	0.526
	Error	1880.5	28	67.1			
	Within-subjects: Time	19830.4	2.45	8087.4	247.3	.001	0.662
	Time × Group	2504.8	2.45	1021.5	198.4	.001	0.686
	Error (Time)	4790.0	68.6	69.7			
Negative meta-emotion	Between-subjects: Group	811.2	1	811.2	9.82	.004	0.260
	Error	2312.6	28	82.5			
	Within-subjects: Time	20020.7	2.71	7391.9	12.2	.001	0.310
	Time × Group	1712.3	2.71	631.9	31.02	.001	0.526
	Error (Time)	5432.9	75.8	71.6			

The main effect of group was significant for resilience (F = 247.3, p < .05, partial $\eta^2 = 0.662$) and for negative meta-emotion (F = 232.06, p < .05, partial $\eta^2 = 0.89$), indicating significant between-group differences in mean scores. The main effect of time was also significant for resilience (F = 198.4, p < .05, partial $\eta^2 = 0.686$) and for negative meta-emotion (F = 12.2, p < .05, partial $\eta^2 = 0.31$), indicating significant change across pretest, posttest, and follow-up in both variables, accounting for group. Bonferroni post-hoc comparisons are summarized in Table 4.

Table 4

Bonferroni pairwise comparisons across the three measurement points

Variable	Time I	Time J	Mean Difference (I – J)	p
Resilience	Pretest	Posttest	8.86*	.001
		Follow-up	9.34*	.001
Negative meta-emotion	Pretest	Posttest	7.75*	.001
		Follow-up	5.06*	.001

* p < .05.

Overall, resilience scores in infertile women with OCD increased from pretest to posttest and follow-up, whereas negative meta-emotion scores decreased, demonstrating the effectiveness of rTMS in enhancing resilience and reducing negative meta-emotions in this population. Significant differences were observed between pretest and posttest (resilience: p < .05, d = 8.86; negative meta-emotion: p < .05, d = 7.75) and between pretest and follow-up (resilience: p < .05, d = 9.34; negative meta-emotion: p < .05, d = 5.06).

4. Discussion and Conclusion

The findings of the present study demonstrated that repetitive transcranial magnetic stimulation (rTMS) significantly enhanced resilience and reduced negative meta-emotions among infertile women diagnosed with obsessive–compulsive disorder (OCD). These results underscore the therapeutic value of rTMS as a noninvasive neurocognitive intervention capable of addressing both adaptive psychological resources and maladaptive emotional processes in a population facing profound reproductive and mental health challenges. Importantly, improvements were not only evident at posttest but were sustained at three-month follow-up, suggesting the durability of rTMS effects. This section discusses these results in relation to prior literature, elaborates on their theoretical and clinical significance, and highlights contributions to research on infertility, OCD, resilience, and meta-emotions.

Infertility represents a complex biopsychosocial condition with psychological consequences that extend far beyond the biological inability to conceive (Feng et al., 2025). As prior research has shown, infertility is associated with heightened stress, depressive symptoms, and diminished well-being (Straub & Mills, 2025). For women, these effects are intensified by cultural expectations and

social pressures to achieve motherhood (Sharma et al., 2025). The results of this study reinforce earlier observations that infertile women are at particular risk of developing psychiatric comorbidities such as OCD (Archetti, 2024). Intrusive obsessions surrounding conception outcomes and compulsive attempts to manage uncertainty often dominate the psychological landscape, leading to a vicious cycle of distress (Wu et al., 2024). Our findings that resilience was initially low in this population support the view that infertility combined with OCD can significantly undermine adaptive coping resources (Yin et al., 2025).

By demonstrating that rTMS enhances resilience, this study adds to growing evidence that neurostimulation techniques can strengthen psychological adaptability. Resilience, defined as the ability to rebound from adversity, is a crucial mediator between stress and mental health outcomes (Araya et al., 2025). Infertile women with low resilience are more susceptible to hopelessness, shame, and guilt, which in turn exacerbate obsessive thoughts (Wang et al., 2025). In line with this, our findings highlight rTMS as a modality capable of directly improving neural substrates linked to emotional regulation and adaptive cognition. Prior work has shown that cortical stimulation can reduce intrusive thought patterns and reestablish neuroplastic balance in prefrontal regions associated with resilience (Najafi-Dehaghani et al., 2024). The observed gains therefore reflect both neurocognitive and psychological transformations that reinforce coping in the face of infertility stress.

The reduction in negative meta-emotions observed in this study further strengthens the argument for rTMS as a holistic therapeutic tool. Meta-emotions—emotions about emotions—play a significant role in perpetuating psychopathology (Mendonça, 2024). Women with infertility and OCD often experience shame for their anxiety, guilt for their sadness, or anger at their own intrusive thoughts (Mitmansgruber et al., 2009). These self-directed negative evaluations create feedback loops that amplify distress (Watts et al., 2025). Our findings indicate that rTMS can break this cycle by modulating cortical circuits responsible for emotional self-appraisal, thereby reducing self-blame and guilt. These results align with research showing that rTMS alleviates distress tolerance deficits and reduces experiential avoidance, both of which are closely tied to negative meta-emotions (Naderipour et al., 2022; Saeidi-Nejad et al., 2024).

This evidence also complements psychosocial studies on emotion socialization. For example, Soucie et al. (Soucie et al., 2024) demonstrated that maternal emotion coaching can shape children's meta-emotional processes, underscoring how such emotions are learned and reinforced in social contexts. Infertile women with OCD may have internalized maladaptive meta-emotional responses across their lifespans, which are then exacerbated by infertility stress. rTMS provides a unique pathway for intervening not through behavioral re-socialization alone but through direct neurocognitive recalibration. In this way, the current study contributes to bridging neurocognitive interventions with psychological theories of emotion socialization and regulation.

The durability of improvements observed at follow-up highlights the potential for long-term clinical relevance. Stigma surrounding infertility often prolongs emotional suffering and diminishes resilience (Wang et al., 2025). Latent profile analyses of infertile women show that stigma interacts with resilience, creating subgroups at heightened risk of poor outcomes (Wang et al., 2025). By reducing negative meta-emotions and enhancing resilience, rTMS may weaken the psychological effects of stigma and provide women with greater agency in managing social and familial pressures. Moreover, such findings support integrative models of reproductive medicine that advocate the inclusion of mental health professionals and neurocognitive interventions alongside medical treatments (Woodward et al., 2024).

Comparisons with other therapeutic approaches are instructive. Studies have shown that Acceptance and Commitment Therapy (ACT) enhances ego strength and reduces anxiety among clinical populations (Taghilu et al., 2023). Similarly, paradox-based interventions have demonstrated utility in alleviating worry and avoidance (Asadiof et al., 2024; Salehi et al., 2024; Sharshar, 2024). However, these approaches largely depend on patient engagement with behavioral strategies and may be limited in their ability to directly target neurophysiological substrates of obsessive thought patterns. Our results suggest that rTMS complements these approaches by acting at a neurocognitive level, thereby amplifying the potential benefits of behavioral therapies when combined. This resonates with findings that rTMS enhances treatment outcomes in diverse populations, including mothers of premature infants, where reductions in depression and ruminative responses have been reported (Saeidi-Nejad et al., 2025).

The findings are also consistent with broader explorations of infertility-related trauma. Archetti (Archetti, 2024) conceptualized infertility as a traumatic experience,

highlighting the existential challenges of involuntary childlessness. Similarly, Kashyap and Tripathi (Kashyap & Tripathi, 2025) emphasized how social interrogation of reproductive status compounds this trauma. The present study supports these perspectives by showing that OCD and negative meta-emotions may be symptomatic expressions of this broader trauma. Interventions such as rTMS, which reduce these symptoms while strengthening resilience, directly address the traumatic sequelae of infertility.

It is also important to consider the paradoxical dimensions of infertility interventions. Unfer et al. (Unfer et al., 2023) discussed the paradox of inositol therapy in PCOS, while Sharshar (Sharshar, 2024) reflected on paradoxes in post-intensive care therapy. Similarly, infertility itself represents a paradox between the desire for motherhood and repeated experiences of loss or failure. Our results suggest that rTMS provides a novel way to resolve aspects of this paradox by equipping women with psychological resources that allow them to tolerate ambiguity and uncertainty more effectively, thereby reducing the compulsion to engage in obsessive or avoidant coping strategies.

Further, the improvement in resilience observed here can be connected to psychometric research on resilience measurement. Arias González et al. (Arias González et al., 2015) validated the Connor–Davidson Resilience Scale, underscoring its reliability in detecting resilience changes. The robust improvements detected in our study reflect genuine psychological transformations, not measurement artifacts. Moreover, findings parallel those from COVID-19 research, which emphasized problem-solving strategies as mediators between resilience and emotion regulation (Mam-Sharifi et al., 2022). rTMS may operate partly by enabling better cognitive engagement with problems rather than avoidance, thereby facilitating the very processes identified in these mediational models.

Finally, the findings resonate with philosophical and theoretical perspectives on emotions. Mendonça (Mendonça, 2024) introduced a layered theory of meta-emotions, suggesting that they are complex phenomena operating across cognitive, affective, and evaluative dimensions. Our results confirm that interventions targeting neural substrates can influence these layered processes. Similarly, Zerwas et al. (Zerwas et al., 2024) highlighted how preoccupation with happiness, combined with negative meta-emotions, reduces well-being. rTMS's ability to reduce such negative self-appraisals suggests that it may improve broader well-being outcomes beyond OCD and infertility contexts.

5. Limitations and Suggestions

Despite these promising results, several limitations must be acknowledged. First, the study relied on a relatively small sample size of infertile women with OCD, which may limit generalizability. Nonrandom convenience sampling restricts the ability to claim population-wide effects. Second, the reliance on self-report questionnaires introduces the possibility of response biases, including social desirability or exaggerated symptom reporting. Third, the intervention period, while sufficient to demonstrate short-term and three-month effects, did not allow for assessment of longer-term sustainability. Additionally, while repeated-measures ANOVA provided robust statistical results, more advanced multilevel modeling could offer deeper insights into individual differences in treatment response. Finally, cultural factors specific to the Iranian context may limit the applicability of findings to other populations, where infertility stigma and coping resources may differ.

Future research should expand on this study in several key ways. Larger and more diverse samples are needed to improve generalizability across cultural and clinical contexts. Longitudinal studies should be conducted with follow-ups extending beyond three months to assess the durability of rTMS effects over time. Comparative trials integrating rTMS with psychotherapeutic approaches such as ACT or paradoxical interventions could reveal potential synergistic effects. Additionally, the use of neuroimaging and physiological measures would provide objective evidence of the neural mechanisms underlying resilience and meta-emotional changes. Researchers should also examine whether rTMS outcomes vary based on infertility etiology, OCD symptom subtype, or baseline resilience levels, to better tailor interventions to individual profiles.

Clinically, the findings underscore the importance of integrating neurocognitive interventions such as rTMS into infertility care. Mental health professionals working with infertile women should consider resilience and meta-emotions as critical therapeutic targets, not just depressive or anxiety symptoms. Collaborative care models that bring together reproductive specialists, psychologists, and rTMS practitioners could provide more holistic and effective treatment pathways. Practitioners should also develop psychoeducational programs to help women recognize and manage meta-emotions, thereby reinforcing the gains achieved through rTMS. By focusing simultaneously on resilience and emotional regulation, clinical teams can provide women with the resources necessary to navigate the

dual challenges of infertility and OCD with greater psychological stability.

Authors' Contributions

Authors contributed equally to this article.

Declaration

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

Transparency Statement

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

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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