

# Comparing the Effectiveness of Cognitive-Emotional Regulation Training and Transcranial Direct Current Stimulation on Difficulty in Regulating Emotions, Rumination and Quality of Life in Divorced Women

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## Abstract

**Background:** Divorced women often experience emotional dysregulation, increased rumination, and a decline in quality of life. Cognitive-emotional regulation training (CERT) and Transcranial Direct Current Stimulation (tDCS) have been explored as potential interventions to address these challenges. This study aimed to compare the effectiveness of CERT and tDCS in reducing difficulties in regulating emotions, decreasing rumination, and improving the quality of life among divorced women.

**Methods:** This was a semi-experimental study involving three groups across three phases: pre-test, post-test, and follow-up. The statistical population includes all divorced women who visited counseling and psychotherapy centers in Ardabil, Iran during the Winter of 2024. A total of 45 participants were purposefully sampled and then randomly assigned to three groups. The research tools include Gratz and Roemer's Difficulty Regulation Scale (2004), John Weir's Short-Form Quality of Life Questionnaire (1992), and Nolen-Hoeksema and Morrow's Rumination Questionnaire (2008), along with interventions such as an 8-session (60 minutes each) emotional regulation training protocol and Transcranial Direct Current Stimulation.

**Results:** In the post-test, the mean±standard deviation for difficulty in emotion regulation, rumination, and quality of life in the CERT group were 48.21±8.44, 27.38±9.19, and 55.34±10.98, respectively. In the tDCS group, the scores were 51.34±10.37, 33.67±11.47, and 52.37±11.81, showing significant differences compared with the control group where the scores were 59.09±12.64, 39.12±9.82, and 48.90±12.24 ( $P=0.001$ ). The results indicated that both CERT and tDCS have reduced difficulty in emotion regulation and rumination and increased quality of life ( $P<0.001$ ).

**Conclusion:** This study demonstrated that both (CERT) and (tDCS) effectively improved emotion regulation, reduced rumination, and enhanced quality of life in divorced women, with CERT showing slightly superior results. These findings support the use of CERT as a non-pharmacological intervention to improve psychological well-being in this population.

**Keywords:** Psychotherapy Rational-Emotive, Transcranial Direct Current Stimulation, Emotional regulation, Rumination disorders, Quality of life, Woman

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## 1. Introduction

Marriage, accompanied by love and responsibility, aims to bring happiness and transformation within family relationships. Choosing a life partner and entering marriage is a significant personal milestone, providing various benefits for both men and women, such as reducing psychological harm like stress (1) and increasing overall happiness (2). However, marital instability can disrupt this process, leading to divorce, a major factor in the disintegration of family structures and one of the significant harms in family life (3). Divorce rates have increased worldwide with the highest rates reported in the United States,

where nearly 50% of marriages end in divorce (4). Similarly, in Iran, divorce rates have risen, with 246,171 cases registered in 2016 (5).

Divorce is a significant stressor for all family members, affecting their psychological, physical, social, and emotional well-being (6). For women, divorce often leads to higher risks of psychological disorders due to the emotional intensity of the experience (7, 8). Unlike Western countries, divorce in Iran is typically accompanied by higher psychological tension between families (9). Divorce is a complex phenomenon closely related to women's health, often triggering various emotional reactions (10).

A significant challenge of post-divorce is the disruption in cognitive-emotional regulation, defined as the process of managing emotions to achieve personal goals (11, 12). Cognitive-emotional regulation strategies include both maladaptive strategies like rumination and adaptive strategies like positive refocusing (13, 14). Post-divorce, women often exhibit maladaptive strategies, including increased rumination, which exacerbates psychological issues (15, 16). Rumination, the repetitive focus on distressing thoughts, plays a critical role in prolonging psychological disorders (17).

Rumination has significant adverse effects on problem-solving and quality of life (18). Quality of life, which encompasses physical, mental, and psychological well-being, is crucial for assessing life satisfaction (19). Psychological interventions such as Cognitive-Emotional Regulation Training (CERT) are designed to improve emotional regulation, rumination, and quality of life in divorced women (20, 21).

Another intervention, Transcranial Direct Current Stimulation (tDCS), a non-invasive brain stimulation technique, has shown effectiveness in enhancing cognitive-emotional regulation and reducing rumination (22-24). tDCS has been successful in improving emotional regulation and quality of life in various populations, including divorced women (25, 26).

Given the rising divorce rates and the psychological challenges faced by divorced women, this study aimed to compare the effectiveness of CERT and tDCS on improving cognitive-emotional regulation, reducing rumination, and enhancing quality of life. The findings will provide valuable insights for developing effective psychological interventions for this vulnerable group.

## 2. Methods

This study employed a quasi-experimental design with three groups and three stages: pre-test, post-test, and a two-month follow-up. The participants consisted of divorced women seeking divorce counseling in Ardabil, Iran during the Winter of 2024. A total of 45 women were purposefully selected based on predefined inclusion criteria and randomly assigned to one of three groups. To ensure random allocation, each participant was assigned a unique identifier, and a random number

table was used to generate random numbers. Based on these numbers, 30 women were placed in the experimental group and 15 in the control group. The experimental group was further divided into two sub-groups: one receiving Cognitive-Emotional Regulation Training and the other Transcranial Direct Current Stimulation (tDCS), using the same randomization process. This ensured equal and random distribution across the groups. The sample size was determined to be adequate using G-Power software ( $\alpha=0.05$ , power=0.90), calculated based on the variable of emotion regulation difficulty (27). The mean and standard deviation for the experimental and control groups were  $48.21\pm 8.44$  and  $59.09\pm 12.64$ , respectively. Inclusion criteria for participants included being female, being divorced, having been divorced for at least one year, providing written informed consent, not having any psychological disorders, not taking psychiatric medications, and commitment to completing homework assignments. The exclusion criteria were: missing more than two sessions, dissatisfaction with participation, and failure to complete assigned homework. This study was approved by the Ethics Committee of the Mohaghegh Ardabili University, Ardabili, Iran with the code of IR.UMA.REC.1401.041. Questionnaires assessing emotion regulation, rumination, and quality of life were administered during the pre-test phase. The intervention included eight sessions of emotion regulation training (each lasting 60 minutes) and a tDCS program consisting of 10 sessions (each lasting 10 minutes, twice weekly). The same questionnaires were administered again at the post-test phase. Statistical analyses included chi-square tests to assess the homogeneity of demographic variables, the Shapiro-Wilk test for normality, and Levene's test to confirm the homogeneity of variances. The main analysis was conducted using repeated measures ANOVA to evaluate changes in emotion regulation difficulty, rumination, and quality of life across the three groups over time. Post hoc analyses were performed using the Tukey HSD test, and effect sizes were reported using partial eta squared ( $\eta^2$ ). All statistical tests were conducted at a significance level of  $\alpha=0.05$ . The data from the pre-test, post-test, and follow-up phases were analyzed using SPSS version 26.

### 2.1. Tools

**2.1.1. Short Form of the Difficulties in Emotion Regulation Scale (DERS-SF):** The Difficulties in Emotion Regulation Scale, initially developed by

Gratz and Roemer (28), is a 36-item instrument designed to assess emotion regulation difficulties. It includes six subscales: non-acceptance of emotional responses, difficulties engaging in goal-directed behavior, impulse control difficulties, lack of emotional clarity, limited access to emotion regulation strategies, and lack of emotional awareness. Kaufman and colleagues (29) designed a shortened version of the questionnaire, with each subscale assessed by three items, resulting in a total of 18 items. The questions for each subscale include non-acceptance (items 12, 25, 29), lack of emotional clarity (items 4, 5, 9), difficulties engaging in goal-directed behavior (items 13, 18, 26), impulse control difficulties (items 14, 27, 32), limited access to emotion regulation strategies (items 16, 28, 35), and lack of emotional awareness (items 2, 8, 10). The items are scored on a five-point Likert scale ranging from 1 (almost never) to 5 (almost always), with items 2 and 8 reverse-scored. The total score ranges from 18 to 90, with higher scores indicating greater difficulties in emotion regulation. (29) The Content validity Index (CVI) of the instrument in adolescents was calculated through the correlation of the scores for specified dimensions with the total instrument score, which are 0.76, 0.70, 0.85, 0.76, 0.72, and 0.76 respectively. The Content Validity Ratio (CVR) of the construct was confirmed by 15 faculty members of Islamic Azad University of Urmia (30). According to their report, the reliability indices of the instrument using Cronbach's alpha method for each subscale are 0.79, 0.81, 0.89, 0.83, 0.85, and 0.84, with a total scale reliability of 0.88 (30).

**2.1.2. Quality of Life Questionnaire (SF-36):** This questionnaire, developed by Ware and co-workers in 1992, includes 36 items that assess eight health-related subscales across physical and mental domains: physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health. One item assesses changes in health. Each subscale contains 2 to 10 items, scored on a Likert scale from 0 to 100, with higher scores indicating better quality of life (31). The questionnaire's Content validity Index (CVI) of 0.83 in the Iranian population has been confirmed (32). The validity and reliability of the questionnaire were first evaluated in Iran on 4163 individuals aged 15 and above, most of whom were married. The Content Validity Ratio (CVR) for the eight dimensions ranged from 0.77 to 0.95, except for vitality, which

was 0.65. Overall, the findings indicated that the Iranian version of this questionnaire is a suitable tool with high validity and reliability for measuring quality of life in the general population (33). The Cronbach's alpha for the entire questionnaire was 0.80, indicating good reliability.

**2.1.3. Rumination Questionnaire:** This questionnaire was developed by Nolen-Hoeksema and colleagues (34), and contains 55 questions. In this questionnaire, the respondent answers one of four options (0=almost never to 4=almost always), with the values 3, 2, 1, 0 assigned to each of the four options, respectively. The higher the individual's score on this test, the higher their level of rumination. The cutoff score for the questionnaire is set at 35, and the higher the individual's score above 35, the greater their level of rumination. Nolen-Hoeksema and colleagues (34) reported the test-retest reliability of the Rumination Questionnaire as 0.82. Concurrent validity was also established through the correlation of rumination scores with the Beck Depression Inventory, indicating a significant correlation of 0.55. The Rumination Response Questionnaire was first standardized in Iran by Bagherinezhad and colleagues, achieving a Content Validity Index (CVI) of 0.84 and a Content Validity Ratio (CVR) of 0.86, alongside a Cronbach's alpha coefficient of 0.84, indicating satisfactory validity.(35).

## 2.2. Intervention

**2.2.1. Emotion Regulation Training Protocol:** The emotion regulation training sessions were based on the framework proposed by Gross and Thompson (36) and validated in Iran by Shaeq Borojeni and colleagues (37). The training was conducted over eight 60-minute sessions, twice a week. The meeting descriptions are detailed in Table 1.

**2.2.2. Transcranial Direct Current Stimulation (tDCS) Intervention:** Transcranial Direct Current Stimulation (tDCS) is a non-invasive method that delivers a mild electrical current directly to the brain through the skull (38). In the present study, tDCS was administered using a dual-channel 2 NEUROSTIM device manufactured by Medina Teb Gostar. This device provides two independent energy sources, fully isolated and separate anode and cathode electrodes. In this method, the anode leads to increased cortical

**Table 1:** Description of emotion regulation training intervention sessions

Sessions	Description
First	Grasping the topics is crucial for detailing the training process, such as meetings, attendance rules, objectives, goals, coordination, and intervention stages.
Second	Emotional education emphasizes recognizing, understanding, and expressing emotions and their effects.
Third	Discussions will examine the role of emotions in adaptation, their benefits, and their influence on communication, persuasion, and motivation.
Fourth	Emotional regulation, setting meeting agendas, reducing isolation, training in problem-solving and interpersonal skills, and facilitating conflict resolution.
Fifth	Training involves techniques like delaying responses, redirecting focus, halting speculation, and sharpening awareness of outcomes.
Sixth	Adjusting assessments, correcting errors, addressing emotions; teaching evaluation methods and diverse viewpoints.
Seventh	Modifying emotional effects, assessing inhibition strategies, and managing expression through training and behavior change.
Eighth	Evaluating obstacles, measuring motivation for goals, applying skills in practice, and reviewing homework challenges.

**Table 2:** Demographic characteristics of participants

Demographic characteristics		Emotion regulation training		Transcranial Direct Current Stimulation		Control		$\chi^2$	P value
		Abundance	Percentage	Abundance	Percentage	Abundance	Percentage		
Job	Housekeeper	6	40%	8	55.3%	5	33.3%	0.37	0.76
	Employed	9	60%	7	46.7%	10	66.7%		
Education	Diploma	5	33.3%	3	20%	7	46.7%	1.20	0.93
	Associate	4	26.7%	7	46.7%	4	26.7%		
	BSc	4	26.7%	3	20%	3	20%		
	MSc+	2	13.3%	2	13.3%	1	6.7%		
Age	18 to 25	5	33.3%	6	40%	5	33.3%	0.49	0.62
	26 to 35	5	33.3%	4	26.7%	6	40%		
	36 to 42	4	26.7%	5	33.3%	3	20%		
	43+	1	6.7%	0	0%	1	6.7%		

excitability, while the cathode leads to decreased cortical excitability (39). The output current intensity of the device can be adjusted from 0.1 mA to 2 mA. The electrodes are made of conductive carbon, and to prevent chemical reactions at the contact point between the electrode and the skin, they are placed in saline-soaked synthetic sponges (0.9% sodium chloride solution). This device continuously monitors electrode impedance to prevent any risk of burning or skin damage.

### 2.3. Data Analysis

The data from pre-test and post-test were analyzed by SPSS version 26. An analysis of covariance (ANCOVA) was used to assess group differences in post-test scores, controlling for baseline levels. Before conducting parametric tests, data normality for difficulty in emotion regulation, rumination, and quality of life in divorced women was checked using the Kolmogorov-Smirnov test. Levene's test was done to confirm variance homogeneity among groups.

### 3. Results

In the results section, 45 divorced women from Ardabil, Iran were selected based on criteria such as being female, divorced for at least one year, not taking psychiatric medications, and providing informed consent. Exclusion criteria included missing sessions or failing to complete assignments. Table 2 outlines the participants' employment, education, and age, with chi-square tests confirming no significant differences between groups. Employment distribution was 60% employed in the Emotion Regulation group, 46.7% in the tDCS group, and 66.7% in the control group, showing no significant differences ( $\chi^2=0.37$ ,  $P=0.76$ ). The participants' level of education also showed no differences, with diplomas, associate degrees, bachelor's, and master's degrees distributed similarly across groups ( $\chi^2=1.20$ ,  $P=0.93$ ). Age was evenly spread across groups, with no significant differences in distribution ( $\chi^2=0.49$ ,  $P=0.62$ ). This ensures that any outcome differences are due to the interventions, not demographic factors.

**Table 3:** Mean±SD of pre-test, post-test, and follow-up for emotion regulation difficulty, rumination, and quality of life

Variables	Phases	Emotional Regulation training	Transcranial Direct Current Stimulation	Control	P value (between group)
		Mean±SD	Mean±SD	Mean±SD	
Difficulty regulating emotions	Pre-test	59.43±12.64	58.74±14.91	60.28±13.22	0.257
	Post-test	48.21±8.44	51.34±10.37	59.09±12.64	0.001
	Follow-up	47.28±9.67	50.49±11.27	59.78±11.89	0.001
P value (within group)		0.004	0.02	0.28	
Thought rumination	Pre-test	39.78±15.36	41.51±12.63	40.92±12.02	0.364
	Post-test	27.38±9.19	33.67±11.47	39.12±9.82	0.001
	Follow-up	25.76±8.33	31.43±9.17	38.75±10.21	0.001
P value (within group)		0.001	0.008	0.128	
Quality of life	Pre-test	49.57±10.31	48.95±12.29	48.89±11.34	0.522
	Post-test	55.34±10.98	52.37±11.81	48.90±12.24	0.001
	Follow-up	56.41±11.37	53.74±10.67	48.14±11.86	0.001
P value (within group)		0.016	0.027	0.548	

**Table 4:** Results of paired comparisons of research variables (post-test phase)

Variables	Comparison group	Mean difference (MD)	Standard error (SE)	P value
Difficulty regulating emotions	Emotional Regulation training - Control	-10/78	0.52	0/001
	Transcranial Direct Current Stimulation - Control	-7/64	0.52	02/0
	Transcranial Direct Current Stimulation - Emotional Regulation training	-3/09	0.52	04/0
Thought rumination	Emotional Regulation training - Control	-11/69	0.68	001/0
	Transcranial Direct Current Stimulation - Control	-5/34	0.68	001/0
	Transcranial Direct Current Stimulation - Emotional Regulation training	-6/16	0.68	001/0
Quality of life	Emotional Regulation training - Control	6/39	0.49	02/0
	Transcranial Direct Current Stimulation - Control	3/43	0.49	04/0
	Transcranial Direct Current Stimulation - Emotional Regulation training	2/88	0.49	07/0

Descriptive statistics, including mean and standard deviation for pre-test, post-test, and follow-up periods, are reported in Table 3. The table indicates significant changes in the experimental groups receiving emotion regulation training and transcranial direct electrical stimulation for the variables of difficulty in emotional regulation, rumination, and quality of life. In contrast, the control group did not show significant changes. Specifically, the experimental groups experienced decreases in difficulty with emotional regulation and rumination while their quality of life scores improved. The results of the chi-square test to check the homogeneity among the research groups of the descriptive demographic indicators are respectively equal to occupation ( $\chi^2=0.37$ ,  $P=0.76$ ), education ( $\chi^2=1.20$ ,  $P=0.93$ ), and age ( $\chi^2=0.49$ ,  $P=0.62$ ). These results showed that there is no significant difference in terms of the cognitive characteristics of the research participants. The assumption of distribution normality of the dependent variable in groups was examined using the Shapiro-Wilk test, which confirmed the hypothesis. An assumption

was the homogeneity of variance-covariance matrices, which was confirmed using Box's M test. The results showed that the variance-covariance matrix was homogeneous. The assumption of the equality of variances was analyzed in Levene's test, whose results implied no significant differences between the experimental and control groups in terms of the variances of research variables. Therefore, the assumption of the equality of variances was also confirmed. The results of Mauchly's test showed that the assumption of the equality of variances of dependent variables was met in three stages of measurement.

Repeated measures ANOVA revealed significant effects of time (pre-test, post-test, and follow-up) on emotion regulation difficulty ( $F=18.02$ ,  $P=0.001$ ), thought rumination ( $F=24.19$ ,  $P=0.02$ ), and quality of life ( $F=22.37$ ,  $P=0.001$ ). In the variance analysis results, the Eta coefficient and mean squares for the studied variables are as follows: difficulty in regulating emotions (0.61, 147.29), thought rumination (0.53, 78.57), and quality of

life (0.69, 102.66). Subsequently, the analysis of covariance was employed at a significance level of 0.05. The results indicated that the combination of group therapy for emotion regulation training and direct transcranial electrical stimulation has been effective in enhancing the quality of life and reducing rumination and difficulty in emotion regulation among divorced women in Ardabil, Iran. To determine the specific differences between the groups in terms of difficulty in emotion regulation, rumination, and quality of life, we initially used the Bonferroni correction; however, considering that we only had three groups, we replaced it with the Tukey HSD test, which is more appropriate for this type of comparison. Tukey's test allows for pairwise comparisons while controlling the family-wise error rate more effectively in cases involving three groups. The results of this test are specified in Table 4. Both the emotion regulation training and tDCS groups showed significant differences in emotion regulation difficulties, rumination, and quality of life for divorced women compared with the control group. Specifically, difficulties in emotion regulation and rumination decreased, while quality of life scores increased.

#### 4. Discussion

The study found that both cognitive-emotional regulation training (CERT) and transcranial direct current stimulation (tDCS) significantly improved emotional regulation, reduced rumination, and enhanced the quality of life among divorced women, with CERT showing more pronounced effects (19, 22). In the post-test, the CERT group exhibited a mean difficulty in emotion regulation score of  $48.21 \pm 8.44$ , a rumination score of  $27.38 \pm 9.19$ , and a quality of life score of  $55.34 \pm 10.98$ . In comparison, the tDCS group showed mean scores of  $51.34 \pm 10.37$  for difficulty in emotion regulation,  $33.67 \pm 11.47$  for rumination, and  $52.37 \pm 11.81$  for quality of life (29, 34). The control group had significantly less improvement, with mean scores of  $59.09 \pm 12.64$ ,  $39.12 \pm 9.82$ , and  $48.90 \pm 12.24$  for the same variables, respectively (33).

These findings suggested that CERT, which involves structured sessions designed to help individuals better understand and manage their emotions, can significantly improve emotional regulation and reduce rumination by equipping participants with practical strategies for managing their thoughts and feelings (21). This training typically

includes techniques such as emotional education, recognizing and expressing emotions, understanding the role of emotions in adaptation, setting goals, and employing problem-solving and interpersonal skills. By focusing on these areas, CERT helps individuals shift from maladaptive strategies like rumination to more adaptive ones, thereby enhancing their overall quality of life (15, 40).

On the other hand, tDCS, a non-invasive brain stimulation technique, also showed significant positive effects, although to a lesser extent than CERT. This method applies a weak electrical current to specific brain regions involved in emotional regulation and cognitive control, such as the prefrontal cortex (24, 38). By enhancing the activity in these areas, tDCS helps improve the brain's ability to manage negative emotions and reduce repetitive negative thinking. The increased activity in the prefrontal cortex can lead to better emotional regulation, reduced rumination, and consequently, a better quality of life (25, 26).

Overall, the study highlighted the effectiveness of both CERT and tDCS in addressing the emotional and psychological challenges faced by divorced women. CERT, with its focus on cognitive and emotional skills training, appears to offer more substantial benefits in terms of emotional regulation and rumination reduction (40). tDCS, while also effective, may serve as a valuable complementary approach, particularly when combined with other therapeutic interventions. These findings provided valuable insights for developing comprehensive psychological support strategies for divorced women, aiming to enhance their emotional well-being and overall quality of life.

##### 4.1. Limitations

This study had limitations that may impact the generalizability of the results. Reliance on self-report questionnaires could introduce response bias. Furthermore, the use of non-random sampling, insufficient follow-up time, result stability issues, subculture biases, a focus exclusively on women, and coordination challenges during session formation also posed difficulties.

#### 5. Conclusions

Overall, this study found that both cognitive-emotional regulation training (CERT) and

Transcranial Direct Current Stimulation (tDCS) significantly improved emotion regulation, reduced rumination, and enhanced quality of life among divorced women. CERT was more effective overall, providing greater improvements by helping participants adopt adaptive emotional strategies. tDCS, while beneficial, showed slightly less impact, suggesting it may work best when combined with other treatments. These findings highlight the potential of CERT as a practical, non-pharmacological approach for psychological support in divorced women, with implications for future research and clinical applications.

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### Authors' Contribution

Mohamad Hatami Nejad: Substantial contributions to the conception and design of the work, definition of intellectual content, data analysis, statistical analysis, manuscript preparation, editing, and review. Mohammadreza Noroozi Homayoon: Substantial contributions to the conception and design of the work, definition of intellectual content, literature search, data acquisition, data analysis, manuscript preparation, editing, and review. Masood Sadeghi: Substantial contributions to the literature search, data acquisition, data analysis, manuscript preparation, editing, and review. Esmail Sadri Damirchi: Substantial contributions to the literature search, data acquisition, data analysis, manuscript preparation, editing, and review. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, ensuring that any questions related to the accuracy or integrity of any part of the work are appropriately addressed.

**Conflict of Interest:** None declared.

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### Ethical Approval

This study was approved by the Ethics Committee

of Mohaghegh Ardabili University, Ardabili, Iran with the code of IR.UMA.REC.1401.041. Also, written informed consent was obtained from all participants.

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