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Original Article

Modified Unified Protocol and tDCS for Cognitive Flexibility, Emotion Regulation and Repetitive Negative Thoughts in Women with Suicidal Ideation: A Comparative Study

Mohammadreza Noroozi Homayoon[1], PhD Candidate; Ali Nasiri[2]*, MSc; Esmaeil Sadri Damirchi[1], PhD; Mohammad Narimani[2], PhD; Hadiseh Eyvazzadeh Gharajeh[2], MSc; Negin Habibi[3], MSc

[1]Department of Counseling, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran
[2]Department of Psychology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran
[3]Department of Psychology, Islamic Azad University, Hamedan Branch, Hamedan, Iran

Corresponding author:* Ali Nasiri, MSc; Department of Psychology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Postal code: Ardabil, Iran. **Tel: +98-9918037009; **Email:** ali.nasiri.sp@gmail.com

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Abstract

Background: Suicidal ideation, a serious mental health concern, threatens individuals' well-being and has significant social and psychological consequences. This study aimed to compare the effectiveness of the Modified Unified Protocol (UP) and Transcranial Direct Current Stimulation (tDCS) on cognitive flexibility, emotional regulation strategies, and repetitive negative thinking in women with suicidal ideation.

Methods: This study was quasi-experimental with pre-test and post-test design and a six-month follow-up. The participants included women with suicidal ideation, recruited from counseling centers affiliated with the State Welfare Organization in Ardabil, Iran between 2022 and 2024. Using criterion-based sampling and random assignment, 75 participants were divided into three groups (n=25 each): Modified Unified Protocol (UP), transcranial Direct Current Stimulation (tDCS), and control. The intervention lasted 12 weeks (UP: individual sessions on emotion regulation & cognitive flexibility; tDCS: 2 mA stimulation at F3/F4 areas). Data were collected at pre-test, post-test, and six-month follow-up using the Cognitive Flexibility Inventory (CFI), the Difficulties in Emotion Regulation Scale–Short Form (DERS-SF), and the Repetitive Thoughts Questionnaire (RTQ). For data analysis, ANCOVA was used to examine between-group differences, and repeated measures ANOVA was used to assess within-group changes over time. All tests were conducted using SPSS version 27, with statistical significance set at $P<0.05$.

Results: For cognitive flexibility, mean scores increased in the UP group (76.80±10.06 to 100.45±14.12) and tDCS group (79.40±11.07 to 91.35±10.49), with minimal change in the control group. Significant differences were found between UP and control groups (P=0.001) and between tDCS and control groups (P=0.008). In cognitive emotion regulation difficulties, scores decreased in the UP group (72.55±7.72 to 52.25±7.90) and tDCS group (72.45±8.48 to 61.70±9.29), while the control group remained unchanged. Post-test comparisons showed significant differences; UP vs. control (P=0.001), tDCS vs. control (P=0.001), and UP vs. tDCS (P=0.001). Repetitive negative thinking decreased in the UP group (39.20±5.85 to 20.85±5.14), moderately in the tDCS group (29.05±6.72), and showed no change in the control group. All between-group comparisons in post-test were significant (P=0.001).

Conclusions: Both the Modified Unified Protocol (UP) and tDCS were effective in enhancing cognitive flexibility, improving emotion regulation strategies, and reducing repetitive negative thinking in women with suicidal ideation. However, UP showed a more substantial and sustained impact over time, particularly in emotion regulation and repetitive negative thought reduction.

Keywords: Treatment Protocols, Transcranial Direct Current Stimulation, Cognitive Flexibility, Emotion Regulation, Negative Thinking, Suicidal Ideation

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1. Introduction

Suicidal ideation is one of the most serious indicators of psychological crisis and a major public health concern due to its potentially irreversible consequences for individuals, families, and society. According to the World Health Organization (WHO), more than 700,000 people die by suicide each year worldwide, making suicide one of the four leading causes of death globally (1). In Iran, statistical data indicate a rising trend in suicidal behaviors, particularly among adolescents and young adults. National studies reported that in some provinces, up to 20% of the population experiences suicidal thoughts (2, 3). This troubling upward trend highlights an urgent need to identify underlying causes and implement effective psychological interventions (4).

Cognitive flexibility is a key factor in understanding the mechanisms behind suicidal ideation. It is defined as the ability to modify one's cognitive processes in response to changing or challenging conditions (5). This capacity enables individuals to shift mental frameworks, reorganize thought patterns, and adapt effectively to new or stressful situations (5). People with low cognitive flexibility often display rigid thinking, polarized perspectives, and poor problem-solving skills when facing adversity or psychological distress. These difficulties can contribute to feelings of hopelessness and the emergence of suicidal thoughts (6). Empirical studies have shown that lower levels of cognitive flexibility are associated with more severe suicidal ideation, suggesting that strengthening this cognitive function may serve as a protective mechanism (7, 8).

Cognitive emotion regulation is another important factor influencing suicidal ideation. It refers to the cognitive strategies individuals use to interpret, manage, and regulate their emotional experiences (9). People who predominantly rely on maladaptive strategies—such as rumination, self-blame, or catastrophizing—are at greater risk for suicidal thoughts and behaviors (10). In contrast, adaptive strategies such as cognitive reappraisal, acceptance, and positive refocusing have been shown to reduce the intensity of negative emotions and improve coping, thereby serving as protective factors against suicidal ideation (11).

Repetitive negative thinking plays a critical role in the progression of suicidal behaviors. This pattern often arises from an individual's difficulty in managing negative emotions and resolving complex psychological challenges (12). Such recurring thoughts represent uncontrollable cognitive patterns frequently characterized by self-blame, hopelessness, anxiety about the future, or preoccupation with past failures (13). This cognitive style creates a cycle of rumination and heightened emotional distress, increasing vulnerability to psychological instability and suicide risk (14). Empirical evidence indicates that chronic negative thinking is associated with reduced cognitive flexibility and impaired emotion regulation, especially during psychological crises, thereby facilitating both the onset and persistence of suicidal ideation (15). These thoughts distort one's perceptions of self, others, and the future, intensifying feelings of powerlessness and inadequacy, and consequently raising suicide risk (16).

Given the strong association between suicidal ideation and the three fundamental constructs—cognitive flexibility, cognitive emotion regulation, and repetitive negative thinking—interventions specifically designed to target these domains may serve as critical tools for suicide prevention. One promising and innovative approach is the Modified Unified Protocol (MUP), developed by Barlow and Long, which has recently drawn significant interest in psychotherapy (17). The Unified Protocol is a well-established, evidence-based treatment that targets common psychological mechanisms underlying various mental health disorders, including emotional avoidance, distress intolerance, and ineffective emotion regulation (18). It has demonstrated efficacy in treating a range of psychological issues, such as anxiety, depression, and suicidal tendencies (19). Core components of this protocol include training in emotional awareness, cognitive restructuring, exposure-based interventions and promoting cognitive flexibility (20). These elements collectively enhance psychological resilience and the ability to manage emotional stress adaptively (21). Empirical studies consistently showed that this transdiagnostic intervention leads to significant improvements in cognitive flexibility and emotion regulation strategies, as well as reductions in repetitive negative thinking (22-25).

Alongside psychotherapeutic interventions, transcranial direct current stimulation (tDCS) has emerged as a noninvasive adjunctive technique for enhancing cognitive and emotional functioning (2). By delivering lowintensity electrical currents to targeted brain regions—particularly the prefrontal cortex—tDCS can stimulate neural activity, improve executive functioning, and reduce suicidal ideation (26). Several studies supported the effectiveness of tDCS in enhancing cognitive flexibility, improving emotion regulation strategies, and decreasing repetitive negative thought patterns, along with other related cognitiveemotional processes (9, 13, 27-29). Given the sharp increase in suicidal ideation among women and its extensive psychological, social, and economic consequences, it is essential to focus on the cognitive and emotional factors that contribute to this phenomenon. Evidence repeatedly shows that deficits in cognitive flexibility, maladaptive emotion regulation and persistent negative thinking are central to the persistence of suicidal ideation (30). Consequently, innovative treatments such as the Unified Protocol and tDCS have gained attention because of their direct impact on these core psychological processes.

Importantly, tDCS has shown promise as a safe, noninvasive, and costeffective neuromodulation technique, particularly for enhancing executive functions and emotion regulation through stimulation of the dorsolateral prefrontal cortex. Despite the growing promise of these two interventions, comparative studies evaluating their efficacy remain scarce, particularly in non-Western cultural settings such as Iran. Cultural factors significantly influence the expression of psychological symptoms and individuals' responsiveness to treatment. Therefore, the present study aimed to bridge this gap by assessing the comparative effectiveness of the Modified Unified Protocol and tDCS in modifying cognitive emotional factors among Iranian women experiencing suicidal ideation.

2. Methods

2.1. Design

This study was quasi-experimental with pre-test and post-test design and a six-month follow-up. The study was conducted between 2022 and 2024 at counseling centers affiliated with the State Welfare Organization in Ardabil, Iran.

2.2. Selection and Description of Participants

The study population consisted of women with suicidal ideation who sought counseling services at centers affiliated with the State Welfare Organization in Ardabil, Iran, between 2022 and 2024. Participants were selected using a criterion-based sampling method. Eligibility was determined through structured clinical interviews and psychological screening. Inclusion criteria were: being female, aged 30–45 years, having at least a high school diploma, scoring between 20 and 30 on the Beck Scale for Suicide Ideation (BSSI) indicating moderate suicidal ideation, willingness to participate, and referral to counseling services. Exclusion criteria included a history of psychotic disorders, epilepsy, traumatic brain injury, or dementia; the presence of metal implants in the head or body; use of psychiatric medication within one month prior to the study; and unwillingness to attend intervention sessions. Participants were excluded during the study if they missed more than two sessions, withdrew voluntarily, or showed a significant increase in suicidal ideation (BSSI score above 30 confirmed by clinical interview). In such cases, participants were referred to appropriate psychiatric or crisis intervention services. The participants were fully informed about the purpose of the study, procedures, confidentiality measures, and their right to withdraw at any time. Written informed consent was obtained from all participants.

2.3. Sample Size Determination

The sample size was determined based on recommendations of pilot and previous quasi-experimental research involving clinical populations, suggesting a minimum of 15–20 participants per group to ensure feasibility and detect medium to large effect sizes (31). Accordingly, an initial total sample of 75 participants (25 per group) was selected to ensure balanced group allocation and to account for potential attrition during the intervention and follow-up periods. In addition, an a priori power analysis was conducted using G*Power software for a repeated measures ANOVA design with three groups and three measurement occasions. Assuming a minimum sample of 45 participants (15 per group), an effect size of f=0.35, an alpha level of 0.05, and a statistical power of approximately 0.70 were estimated. To enhance statistical robustness and compensate for possible dropouts, the final sample size was increased to 75 participants (Figure 1).

2.4. Data Collection and Measurements

Data were collected at three phases including pre-test, post-test, and six-month follow-up. Participants completed a set of self-report questionnaires assessing the primary study variables. The measurement instruments included standardized scales for evaluating cognitive flexibility, emotion regulation, and repetitive negative thoughts. Each instrument was administered in all three phases under similar conditions to ensure consistency of measurement. The details of each measurement tool, including structure, scoring procedures, validity, and reliability, are as follows:

2.4.1. Cognitive Flexibility Inventory (CFI)

To assess the cognitive flexibility of yogis, the study employed the Cognitive Flexibility Inventory developed by Dennis and Vander Wal (32). This instrument uses a 7-point Likert scale, enabling participants to indicate the extent of their agreement or disagreement with various statements, ranging from "strongly disagree" to "strongly agree".

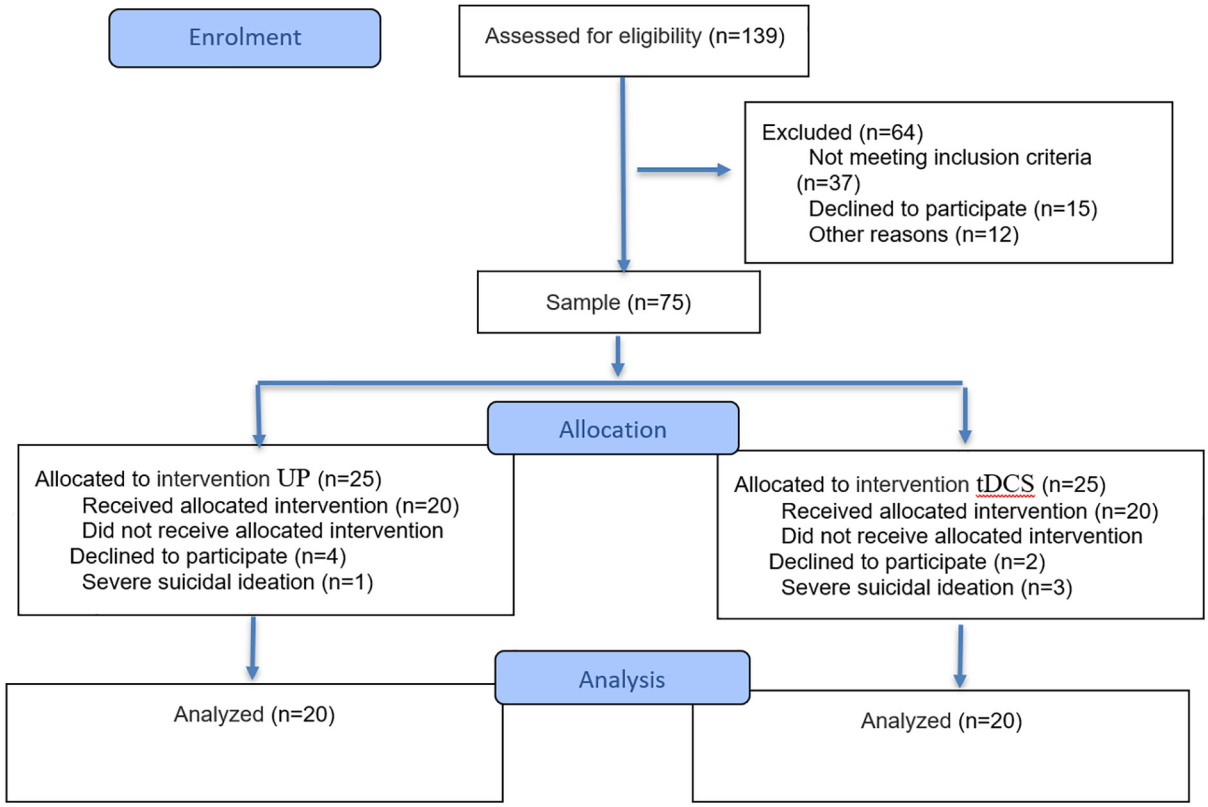

Figure 1: The figure shows the CONSORT flow diagram of the study.

The scoring method includes both direct and reverse-coded items, and overall cognitive flexibility is determined through the calculation of a total score. Higher scores reflect greater cognitive flexibility, often linked to better coping mechanisms in the face of stress. In contrast, lower scores are indicative of cognitive rigidity, typically associated with reduced adaptability during challenging situations. The validity of the CFI has been previously supported through comparisons with measures such as the Beck Depression Inventory and the Cognitive Flexibility Scale (33). In the Iranian context, Soltani and colleauges (33) examined the psychometric properties of the scale and confirmed its reliability and validity. Findings in the Iranian population implied that the content validity ratio (CVR=0.70) and content validity index (CVI=0.83) were in an acceptable range (33). The present study reported the internal consistency of the scale with a Cronbach's alpha of 0.73.

2.4.2. Short Form of the Difficulties in Emotion Regulation Scale (DERS-SF)

Originally developed by Gratz and Roemer (34), the Difficulties in Emotion Regulation Scale is a comprehensive 36-item measure aimed at identifying challenges individuals may face in regulating their emotions. It encompasses six key domains including non-acceptance of emotional experiences, trouble pursuing goals when distressed, difficulty controlling impulses, poor emotional clarity, limited availability of effective emotion regulation strategies, and low emotional awareness. A more concise version of the instrument, developed by Kaufman and co-workers (35), includes 18 items, with each subscale represented by three questions. Specifically, the items are as follows: non-acceptance (items 12, 25, 29), emotional clarity (items 4, 5, 9), goal-directed behavior (items 13, 18, 26), impulse control (items 14, 27, 32), strategy access (items 16, 28, 35), and emotional awareness (items 2, 8, 10). The participants responded on a 5-point Likert scale ranging from 1 ("almost never") to 5 ("almost always"), with items 2 and 8 reverse-coded. The total possible score spans from 18 to 90, where higher scores reflect more pronounced difficulties in emotion regulation (34). The content validity index (CVI) of the scale for adolescent populations was evaluated by correlating subscale scores with the overall scale score, yielding values of 0.76, 0.70, 0.85, 0.76, 0.72, and 0.76, respectively. Content validity ratio (CVR) was further confirmed through expert evaluation by 15 faculty members

from Islamic Azad University of Urmia, Iran (36). Reliability assessments using Cronbach's alpha indicated internal consistency coefficients for each subscale as 0.79, 0.81, 0.89, 0.83, 0.85, and 0.84, with the overall scale demonstrating a strong reliability score of 0.88 (30).

2.4.3. Repetitive Negative Thoughts Questionnaire (RTQ)

The Repetitive Negative Thoughts Questionnaire (RTQ) is a 10-item tool designed to assess repetitive negative thinking (37). Responses are recorded on a five-point Likert scale, ranging from never (1) to always (5). The total score, which can range from 10 to 50, reflects the severity of repetitive negative thoughts, with higher scores indicating more frequent occurrences. In their research, McEvoy and colleagues (37) examined the predictive validity of RTQ by correlating it with the Beck Depression Inventory and the Beck Anxiety Inventory, reporting correlation coefficients of 0.42 and 0.38, respectively. Akbari (38) supported the unidimensional structure of RTQ through exploratory factor analysis, finding a Cronbach's alpha of 0.91 and confirming strong divergent and convergent validity. For the Persian version of the questionnaire, its validity was confirmed with a Content Validity Index (CVI) of 0.87 and a Content Validity Ratio (CVR) of 0.84 (38). In this study, RTQ demonstrated excellent internal consistency, with a Cronbach's alpha of 0.93 for the total scale.

2.5. Procedure

After baseline assessment, eligible participants were randomly assigned (block randomization by an independent researcher) to three groups (n=25 each): Modified Unified Protocol (UP), tDCS, or control. The 12-week intervention included weekly monitoring of suicidal ideation using the Beck Scale for Suicide Ideation (BSSI). Participants were monitored weekly for changes in suicidal ideation and clinical status. If, during the intervention period, a participant exhibited evidence of increased suicide risk (e.g., emergence of active suicidal intent or plan) or significant clinical deterioration based on clinical judgment, the participant was withdrawn from the study and referred to psychiatric services for appropriate evaluation and treatment. Post-test occurred immediately after the intervention, with a six-month follow-up. All assessments were standardized across groups.

2.5.1 Transcranial Direct Current Stimulation (tDCS) Intervention

Transcranial direct current stimulation (tDCS) is a non-invasive and safe neuromodulation technique used to alter cortical excitability without the need for surgical intervention. In the present study, tDCS was delivered using the NEUROSTIM-2 dual-channel stimulator (Medinateb Co., Tehran, Iran), an Iranian-manufactured medical device designed for clinical and research applications. The device provides two independent current sources, enabling the simultaneous use of two anodal and two cathodal electrodes. Current intensity can be adjusted between 0.1 and 2 mA. To minimize chemical interactions between the electrodes and the skin, carbon electrodes were enclosed in sponge pads soaked in 0.9% sodium chloride solution before placement on the scalp (39).

2.5.2 Modified Unified Protocol (UP) Intervention

The Modified Unified Protocol (UP) used in this study was adapted from the standard emotion-focused framework described by McKay and co-workers (40), to specifically target cognitive flexibility, emotion regulation, and repetitive negative thoughts in women with suicidal ideation. The following modifications were made to the original UP: (1) a dedicated session on cognitive flexibility (Session 4) was added, in which participants learned to identify automatic thoughts and generate alternative interpretations; (2) behavioral activation and opposite action strategies were explicitly integrated and practiced (Sessions 7–8) to directly reduce emotion-driven avoidance behaviors; and (3) the protocol placed greater emphasis on repetitive negative thoughts across multiple sessions (e.g., Sessions 4, 6, 11) compared to the original UP.

This 12-session protocol incorporated core elements of emotional regulation, mindfulness, cognitive restructuring, and behavioral activation, while tailoring the content to the specific needs of the study population. Each session progressively targets mechanisms related to the dependent variables, including enhancing emotional awareness, improving cognitive flexibility, reducing repetitive negative thinking, and fostering adaptive emotion regulation strategies. The intervention techniques employed include psychoeducation about emotions, present-moment awareness exercises, identification

and labeling of emotions, values clarification, emotion exposure, and cognitive reappraisal. To ensure the clinical relevance and validity of the modifications, the intervention protocol was reviewed by a panel of five faculty members from the Department of Clinical Psychology at University of Mohaghegh Ardabili, Ardabil, Iran. These experts affirmed that the modifications made to the original Unified Protocol were appropriate for the target population and aligned with established clinical practices. Their feedback ensured that the treatment protocol remained rooted in evidence-based practices while being suitably adapted for this specific study. The session content is outlined in the Table 1.

2.6. Data Analysis

Data from the pre-test, post-test, and six-month follow-up were analyzed using SPSS version 27. To assess between-group differences while controlling for baseline scores, analysis of covariance (ANCOVA) was used. Within-subject changes over time and interaction effects between time and group were examined using repeated measures ANOVA. Assumptions for parametric tests were assessed prior to analysis. The Shapiro-Wilk test was used to evaluate normality, and Levene's test assessed homogeneity of variances. For repeated measures ANOVA, Mauchly's test of sphericity was conducted, with Greenhouse-Geisser correction applied if the assumption was violated. Post-hoc comparisons were performed using the Tukey test to explore pairwise group differences. Statistical significance was set at $P<0.05$.

3. Results

The participants were women with suicidal ideation who sought counseling services at centers affiliated with the State Welfare Organization in Ardabil, Iran. Table 2 presents demographic characteristics including employment, education, and age. Chi-square tests revealed no significant baseline differences among the three groups (Unified Protocol, tDCS, and control), confirming group equivalence prior to intervention. Employment rates were 40% in the Unified Protocol group, 45% in the tDCS group, and 57.1% in the control group ($\chi^2=1.284$, $P=0.526$). Education levels (diploma, bachelor, master and higher) were similarly distributed ($\chi^2=1.523$, $P=0.823$), and age distribution was also comparable ($\chi^2=0.393$, $P=0.983$), indicating demographic homogeneity.

Descriptive statistics (mean and standard deviation) for pre-test, post-test, and follow-up phases are shown in Table 3. Our results indicated that participants in the Unified Protocol and tDCS groups experienced substantial improvements in cognitive flexibility, cognitive emotion regulation,

Table 1: Summary of Modified Unified Protocol sessions

Session 1	Introduction to treatment and establishment of treatment goals; enhancement of motivation for change; overview of emotional disorders as sharing common underlying mechanisms; rationale for the modified unified treatment approach
Session 2	Psychoeducation on the nature and function of emotions; exploration of the adaptive and situational roles of emotions; examination of the impact of emotional avoidance on long-term distress
Session 3	Training in present-focused emotional awareness; introduction to mindfulness skills and emotional monitoring strategies; development of non-judgmental observation of emotional experiences
Session 4	Enhancement of cognitive flexibility through identification of automatic thoughts and generation of adaptive alternative interpretations of emotional experiences
Session 5	Identification of emotional avoidance patterns and safety behaviors; examination of maladaptive behaviors that maintain negative emotional cycles
Session 6	Development of awareness of emotional, behavioral, and physical sensations; introduction to interoceptive exposure exercises to reduce fear of bodily sensations and increase distress tolerance
Session 7	Introduction to emotion-driven behaviors (EDBs); identification of emotion-driven actions; training in replacing them with goal-directed behaviors
Session 8	Practice of opposite action strategies; implementation of behavioral activation techniques to promote engagement in valued activities despite emotional discomfort
Session 9	Preparation for emotion exposure exercises; identification of personal emotional triggers and target situations for in-session and between-session exposure practice
Session 10	Implementation of in-session emotional exposure exercises through structured exposure tasks aimed at reducing emotional reactivity and increasing distress tolerance
Session 11	Continuation of exposure practice; application of troubleshooting strategies; promotion of skill generalization, management of emotional setbacks, and strengthening of adaptive coping strategies
Session 12	Relapse prevention and future planning; review of treatment progress; consolidation of acquired skills; development of a long-term plan for managing emotional difficulties

Table 2: Demographic characteristics of participants

Demographic Characteristics		Intervention Groups				Control Group		χ^2	P value
		Unified Protocol		Transcranial Direct Current Stimulation					
		n	%	n	%	n	%		
Job	Housekeeper	12	60	11	55	9	42.9	1.284	0.526
	Employed	8	40	9	45	12	57.1		
Education	Diploma	8	40	9	45	6	28.6	1.523	0.823
	BSc	7	35	7	35	8	38.1		
	MSc+	5	25	4	20	7	33.3		
Age	30 to 35	9	45	8	40	10	47.6	0.393	0.983
	35 to 40	6	30	8	40	7	33.3		
	40 to 45	5	25	4	20	4	19.1		

Table 3: Mean±SD of pre-test and post-test for dependent variables

Variables	Phases	Modified Unified Protocol		Transcranial Direct Current Stimulation		Control Group		P value (between group)
		Mean	SD	Mean	SD	Mean	SD	
Cognitive Flexibility	Pre-test	76.80	10.056	79.40	11.071	79.24	11.184	0.751
	Post-test	100.45	14.118	91.35	10.490	80.29	11.389	0.001
	Follow-up	97.45	14.544	80.15	11.677	77.14	12.932	0.001
P value (within group)		0.001		0.001		0.246		
Emotion Regulation	Pre-test	72.55	7.715	72.45	8.482	73.95	7.553	0.779
	Post-test	52.25	7.900	61.70	9.291	74.81	8.060	0.001
	Follow-up	50.45	9.000	71.00	8.700	73.14	8.731	0.001
P value (within group)		0.001		0.001		0.501		
Repetitive Negative Thoughts	Pre-test	39.20	5.845	39.60	6.227	38.62	6.144	0.918
	Post-test	20.85	5.143	29.05	6.724	39.05	6.764	0.001
	Follow-up	19.40	6.072	35.65	5.176	38.48	7.083	0.001
P value (within group)		0.001		0.001		0.703		

SD: Standard Deviation

and reductions in repetitive negative thoughts, while the control group showed no significant changes.

Additionally, assumptions for parametric testing were confirmed: the Shapiro-Wilk test indicated normal distribution of dependent variables; Box's M test confirmed homogeneity of the variance-covariance matrix; Levene's test showed equality of variances; and Mauchly's test supported the assumption of sphericity across the three phases.

Repeated measures ANOVA demonstrated overall significant effects of time (pre-test, post-test, follow-up) on cognitive flexibility (F=142.917, P=0.001), cognitive emotion regulation (F=466.505, P=0.001), and repetitive negative thoughts (F=323.705, P=0.001). Overall, Eta squared and mean squares for the variables were as follows: cognitive flexibility (η^2=0.711, Mean Square (MS)=2157.034), cognitive emotion regulation (η^2=0.889, MS=1821.214), and repetitive negative thoughts (η^2=0.848, MS=1583.416). Analysis of covariance (ANCOVA) showed that both the Unified Protocol and tDCS interventions significantly enhanced cognitive flexibility and emotion regulation while reducing repetitive negative thoughts compared with the control group. The six-month follow-up assessment indicated a significant decline in the tDCS group, whereas the UP group maintained its therapeutic gains in all dependent variables.

To determine between-group differences, the Tukey Honestly Significant Difference (HSD) post-hoc test was used, as it is more suitable for comparisons among three groups than Bonferroni correction (Table 4). Significant differences were observed between both intervention groups and the control group across all three dependent variables apart from the Cognitive Flexibility variable. The participants receiving the Unified Protocol or tDCS demonstrated improved cognitive flexibility and emotion regulation, along with reduced repetitive negative thoughts, compared with those in the control group.

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

	Comparison Groups	Mean Difference (MD)	Standard Error (SE)	P value
Cognitive Flexibility	Modified Unified Protocol vs Control Group	21.16	3.868	0.001
	Transcranial Direct Current Stimulation vs Control Group	12.06	3.868	0.008
	Transcranial Direct Current Stimulation vs Modified Unified Protocol	-9.10	3.915	0.060
Emotion Regulation	Modified Unified Protocol vs Control Group	-21.56	2.526	0.001
	Transcranial Direct Current Stimulation vs Control Group	-12.11	2.526	0.001
	Transcranial Direct Current Stimulation vs Modified Unified Protocol	9.45	2.557	0.001
Repetitive Negative Thoughts	Modified Unified Protocol vs Control	-18.20	1.957	0.001
	Transcranial Direct Current Stimulation vs Control Group	-10.00	1.957	0.001
	Transcranial Direct Current Stimulation vs Modified Unified Protocol	8.20	1.981	0.001

4. Discussion

The aim of the present study was to compare the effectiveness of the Modified Unified Protocol and transcranial direct current stimulation (tDCS) on cognitive flexibility, cognitive emotion regulation, and repetitive negative thoughts in women with suicidal ideation. The results of the first hypothesis showed that the Modified Unified Protocol had a significant positive effect on cognitive flexibility, cognitive emotion regulation, and repetitive negative thoughts in women with suicidal ideation. These findings are consistent with prior studies (22-25). This effect can be theoretically and empirically substantiated by the transdiagnostic nature of the Modified Unified Protocol (UP), which functions as an emotion-focused intervention targeting shared underlying mechanisms in emotional disorders—particularly deficits in emotion regulation and cognitive inflexibility (22-24). The UP facilitates cognitive restructuring by enhancing emotional awareness, reducing experiential avoidance, and increasing cognitive control, all of which are core deficits in individuals with suicidal ideation. In the present study, the implementation of the UP resulted in significant improvements in cognitive flexibility, adaptive cognitive emotion regulation, and a reduction in repetitive negative thoughts among women with suicidal ideation. This finding demonstrated that UP is effective in decreasing maladaptive strategies such as rumination, catastrophizing, and emotional suppression, while strengthening adaptive processes including reappraisal, acceptance, and distress tolerance. The Unified Protocol includes structured modules such as emotional awareness training, identifying avoidance patterns, and exposure to emotional triggers. These modules help people use better thinking and regulation strategies (top-down processes). As a result, they can manage emotional distress more effectively without turning to self-harm or suicidal thoughts (17). Furthermore, UP enhances emotional resilience by promoting meta-cognitive insight and behavioral flexibility, which are often impaired in those with suicidal ideation. From a neurocognitive standpoint, these improvements may reflect greater activation of the prefrontal cortex and inhibition of maladaptive neural circuits, thereby reducing psychological vulnerability and improving adaptive functioning (22-25). These consistent findings across multiple studies confirm that UP effectively addresses both cognitive and emotional dysregulation in women at high risk for suicide (22-25).

The results of the second hypothesis revealed that tDCS had a significant positive effect on cognitive flexibility, cognitive emotion regulation, and repetitive negative thoughts in women with suicidal ideation. This finding is consistent with previous studies (9, 13, 27-29). The observed effectiveness of transcranial direct current stimulation (tDCS) in improving cognitive flexibility, cognitive emotion regulation, and reducing repetitive negative thoughts in women with suicidal ideation can be attributed to its neurophysiological impact on the dorsolateral prefrontal cortex (DLPFC), a region critically involved in executive functioning, emotional regulation, and impulse control (26). The findings indicated that anodal stimulation of the left DLPFC significantly enhances synaptic plasticity, functional connectivity, and prefrontal regulation of subcortical structures implicated in affective dysregulation. By increasing cortical excitability in DLPFC, tDCS appears to facilitate top-down modulation of negative affect, suppress hyperactivation of limbic regions, and modulate activity within the default mode network (DMN)—a network strongly associated with self-referential negative rumination and intrusive

repetitive thinking commonly observed in individuals with suicidal ideation. This aligns with evidence suggesting that tDCS interventions produce measurable improvements in cognitive control, thereby promoting more flexible problem-solving, reducing automatic maladaptive thought patterns, and enhancing the capacity for cognitive reappraisal (9, 13, 27-29). Furthermore, repeated low-intensity stimulation has been shown to improve inter-hemispheric balance, increasing left prefrontal activation (associated with approach-oriented processing and positive affect) while concurrently dampening right-hemisphere regions associated with negative emotional bias and withdrawal-related affect. These neural modulations contribute to more effective emotion regulation strategies and a reduction in impulsive and catastrophic thinking, which are hallmark features of suicidal cognition (26). In summary, our findings support the theoretical and empirical position that tDCS, through its targeted stimulation of prefrontal executive regions, yields meaningful clinical improvements in emotion-cognition integration in women vulnerable to suicide.

4.1. Limitations

The present study had several limitations. First, the sample was limited to women with suicidal ideation in Ardabil, Iran, which restricts the generalizability of the findings to other regions and social groups. This is particularly important because cultural, social, and economic factors can influence women's mental health and their responsiveness to interventions such as the Unified Protocol and tDCS. Second, we faced implementation-related challenges; these included difficulties in recruiting participants due to the sensitive nature of suicidal ideation, logistical constraints in maintaining consistent attendance, and limited access to tDCS equipment and trained personnel in resource-constrained clinical settings. Such factors may have affected the consistency and fidelity of intervention delivery. Third, temporal and environmental factors—such as seasonal changes and external stressors like socioeconomic fluctuations—may have influenced participants' psychological states during the intervention period.

5. Conclusions

In conclusion, both the Modified Unified Protocol and tDCS are effective in improving cognitive flexibility and cognitive emotion regulation, as well as reducing repetitive negative thoughts in women with suicidal ideation. Therefore, integrating these interventions into clinical practice is a key suicide prevention step, but future research must include multiple cities, diverse contexts, long-term outcomes, varied age groups and cultures, plus strategies to improve retention and access to standardized protocols. These findings suggest that interventions targeting both cognitive and emotional fundamental constructs can be highly effective in reducing risk factors associated with suicidal ideation. Given the crucial role of these variables in the psychological processes leading to suicide, the integration of structured psychotherapy with non-invasive neurostimulation offers a promising approach for prevention and clinical intervention, particularly for high-risk groups, such as women. These results also emphasize the importance of evidence-based, targeted treatments in the mental health system. The anticipated findings could support the development of culturally informed, evidencebased therapeutic approaches and help reduce the societal burden of suicide among women.

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Authors' Contributions

Mohammadreza Noroozi Homayoon: Substantial contributions to the conception and design of the work; drafting the work and reviewing it critically for important intellectual content. Ali Nasiri: Substantial contributions to the design of the work; drafting the work and reviewing it critically for important intellectual content. Esmaeil Sadri Damirchi: Substantial contributions to the acquisition of data; drafting the work and reviewing it critically for important intellectual content. Mohamad Narimani: Substantial contributions to the conception and design of the work; analysis and interpretation of data; drafting the results and discussion sections; reviewing the work critically for important intellectual content. Hadiseh Eivazzadeh: Substantial contributions to the conception and design of the work; analysis and interpretation of data; statistical strategy; drafting the results and discussion sections; reviewing the work critically for important intellectual content.

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.

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Ethical Approval

The Ethics Committee of the University of Mohaghegh Ardabili, Urmia, Iran approved the present study with the code of IR.UMA.REC.1401.041. Also, written informed consent was obtained from all participants.

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