



Original Article

Effectiveness of strengthening metacognitive therapy with transcranial Direct Current Stimulation (tDCS) in major depressive disorder

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Abstract

Introduction: One out of four patients with psychiatric disorders does not respond adequately to standard treatment, and this will lead to personal and social burdens. The present study aimed to assess the effectiveness of strengthening metacognitive therapy with transcranial Direct Current Stimulation (tDCS) in major depressive disorder.

Materials and Methods: The statistical population of this clinical trial consisted of outpatients with major depressive disorder in Mashhad city-Iran. Forty-five patients were selected by purposeful sampling and randomly divided into three groups (active group (metacognitive therapy enriched with tDCS), sham group (metacognitive therapy unenriched with tDCS), and metacognitive group). The intervention was conducted in 10 training ninety-minute sessions. All patients responded to the Beck Depression Inventory (BDI-II) and the Hamilton Depression Scale (HAM-D) in pre-test, post-test, and follow-up stages. Data were analyzed using multivariate analysis of covariance and ANOVA for repeated measures.

Results: The results showed a significant difference between the depression scores in the three stages ($P < 0.01$). Furthermore, there was a significant difference between depression scores in the mentioned groups, and this difference is greater for metacognitive therapy enriched with tDCS.

Conclusion: Based on the findings, added transcranial Direct Current Stimulation (tDCS) to metacognitive therapy positively impacts treating depression in patients with major depressive disorder.

Keywords: Major depressive disorder, Metacognitive therapy, Transcranial Direct Current Stimulation

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Introduction

Depression is the most common mental disorder worldwide and is one of the main causes of disability (1). Depression is usually conceptualized with negative symptoms and

signs such as a negative mood, negative cognitions, and avoidance behaviors (2). Because the high prevalence of suicidal ideations and planning in patients with Major Depressive Disorder (MDD) (3,4).

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Several intervention strategies have been developed for treating anxiety disorders and depression based on cognitive theoretical models. Despite the effectiveness of most cognitive therapy methods for these disorders, there are still shortcomings, and as a result, alternative theoretical models, such as metacognitive therapy, have been formed (5). Metacognitive therapy is a treatment method that focuses on changing metacognitive beliefs, which stabilizes attention and reduces anxiety and rumination (6). This treatment is theoretically based on the self-regulation executive function model, which states that psychopathology arises due to a continuous thinking style called cognitive attention syndrome (7). In recent years, various Non-Invasive Brain Stimulation (NIBS) techniques have been used, which can lead to the modulation of cortex excitability and activity and, as a result, changes in cognitive and behavioral functions (8). Non-invasive brain stimulation techniques including transcranial Direct Current Stimulation (tDCS), can create and modulate neural plasticity in humans. Therefore, they have the potential to change pathological flexibility on the one hand and cultivate physiological flexibility on the other hand in neuropsychiatric disorders to reduce symptoms and increase rehabilitation (9). tDCS includes the use of a weak current on the scalp by facilitating and inhibiting the ongoing neuronal processes to modulate cortical excitability (10), which has the potential to change flexibility and restore disturbed cognitions (in psychiatric disorders) to their original state (11). In addition, this treatment is an effective tool for creating neural flexibility and modulating human cognition and behavior (12). Thorslund et al., in a study investigating the effect of metacognitive therapy on adolescents' depression and anxiety disorders, showed that metacognitive therapy is promising in efficiency and effectiveness for adolescents with anxiety and depression disorders (5). The results of Normann and Morina's meta-analysis showed that metacognitive therapy is an effective treatment for a wide range of psychological disorders, and the largest effect size is related to anxiety and depression (13).

Furthermore, research conducted in transcranial direct current stimulation (TDCS) showed that TDCS was a promising treatment, especially for the symptoms of anxiety and

depression (14). In a review study, the effects of TDCS on major depressive episodes showed improvement in depressive symptoms (15). Therefore, considering the importance of effectiveness research in generalizing the results to society and real treatment situations, although there have been various studies about depression and its treatment around the world, there has been no research comparing these treatments or the combination of these two treatments in improving the symptoms of patients with depression. Therefore, the current research aims to determine whether direct transcranial current stimulation can be used to strengthen (metacognitive) psychotherapy to reduce the symptoms of depression in people with major depression.

Materials and Methods

In this clinical trial, according to DSM-5 criteria, the statistical population consisted of outpatients aged 20 to 60 with a primary diagnosis of major depression for either a single or recurrent period (4 weeks). The patients were referred to one psychological clinic and one psychiatrist office in Mashhad- Iran.

Using the purposeful sampling method, 45 people were selected and randomly assigned to three experimental groups by the sample size calculation formula based on Delavar's contention that 15 individuals are sufficient for each group in semi-experimental investigations (16). The Beck Depression Questionnaire and the Hamilton Depression Scale were completed by the participants in all three groups before, during, and 30 days following the intervention. The inclusion criteria, included not having a history of using shock therapy (ECT), not having participated in a metacognitive psychotherapy program, scoring higher than 20 on the Beck depression inventory, having an imbalance between alpha and beta signals in the F3 and F4 areas, not having a history of acute suicide for attending treatment sessions, and having a positive immune screening to perform tDCS. Exclusion criteria included substance abuse or dependence in the previous six months (apart from nicotine use with current or past use), psychotic disorders (lifetime), including schizoaffective disorders or periods of depression with psychotic symptoms (lifetime), bipolar disorders (types I and II), neurological disorders such as stroke in the previous two years, epileptic attacks (lifelong), epilepsy, dementia, Parkinson's disease, Huntington's

disease, multiple sclerosis, as well as any additional neurological diseases. Based on the researcher's evaluation, there was no suicide risk at the time of the study.

Ethical considerations were taken into account when discussing the method and goals of the training sessions with the subjects and when they gave their informed consent to participate in the study. This consent was then written during the first assessment meeting. This instructional session included research work that was also disclosed to the participants. The subjects were also assured that the information collected from each person would be kept private. Additionally, it was mentioned that the subject might leave the program whenever he/she felt like not participating in the sessions.

Research instruments

A) The Beck Depression Inventory version 2 (BDI-II): Beck et al. presented this inventory in 1961; a revised version was published in 1971 (17). This 21-item self-report inventory was updated in 1996 to be more aligned with the DSM-VI criteria for depression aimed at assessing the severity of depression in adults and adolescents. The responses to this questionnaire are graded on a scale of 0 to 3. The cut-off points are set so that a score of 0 to 13 indicates that the person is not depressed, followed by scores of 14 to 19 for mild to moderate depression, 20 to 28 for moderate to severe depression, and 29 to 63 for severe depression. Higher scores denote depressed symptoms that are more severe.

The Hamilton Depression Rating Scale (HRSD) and the BDI-II have a positive collaboration of $r=0.71$, and its one-week retest reliability is 0.93 (18). The internal consistency meta-analysis revealed that this coefficient can range from 0.73 to 0.92, and the correlation between the two revised forms and the original is equal to 0.89 (19). A Cronbach's alpha of 0.91, a re-test coefficient of 0.81 following a one-week break, and a correlation coefficient with the Beck Anxiety Inventory of 0.61 were all reported by Fata, Birashk, Atef, and Dobson (18). Additionally, in research with a sample of 354 people who were diagnosed with major depression and were in recovery, an internal validity of 0.91 was obtained (20).

B) Hamilton Depression Scale (HAM-D): The HAM-D originally included 21 items, but Hamilton believed that the final four (daily changes, depersonalization, paranoid symptoms,

and obsessive-compulsive symptoms) should not be counted in the final score because they are either unusual or do not accurately represent the severity of depression. Therefore, for clinical research, a standard 17-item HAM-D version was used. A total score is obtained by summing each item with a range of 0 to 4 (absent, mild, moderate, or severe symptoms) or 0 to 2 (absent, few, or negligible, clearly present) for the 17-item version. Each patient's score ranges from 0 to 54 (21). Recently, research has fully investigated the psychometric characteristics of HAM-D (21) and the validity of HAM-D has been reported with a range from 0.65 to 0.90 for the overall depression severity scale, and this scale has a high correlation with therapist-oriented scales such as MADRS and IDS-C (22). In Iran, Gharaii et al. reported the reliability coefficient of this scale with the Hamilton Anxiety Rating Scale with the re-test method of 85% and 89% (23).

For the subjects of the experimental groups, the intervention was carried out in ten sessions of training that lasted 90 minutes each. The clinical psychologist had undergone formal training to record and analyze Quantitative Electroencephalography (QEEG) data to record brain signals from the patient's prefrontal cortex while at rest. The BDI-II and HAM-D was administered to and evaluated in the following examination step for those who displayed an imbalance between alpha and beta signals in the F3 and F4 regions.

The BDI-II must be completed with a score of 20, and the F3 and F4 regions must show an imbalance between the alpha and beta impulses. Patients who experienced severe suicidal thoughts were not allowed to participate in the trial because participants had to be able to attend two therapy sessions per week. Through systematic clinical interviews (DSM-5 SCID), accompanying axes I and II disorders were found. Selected patients who did not utilize medications started therapy sessions. The first group, known as the active group, was subjected to 90 minutes of tDCS during metacognitive psychotherapy sessions, while the second group, known as the sham group, received the same care with the exception that the electric current stopped after 30 seconds and electrical stimulation was no longer tolerated. The "metacognitive group" was the third group and received only metacognitive psychotherapy. tDCS was employed during the metacognition sessions of the first group, the active group.

Since no transcranial electrical stimulation devices were available, each group was split into three groups of five individuals so that stimulation could be administered concurrently with psychotherapy sessions. After introducing and reviewing the exercises from the previous session (roughly 20 minutes after the session started) and the start of the main part of the metacognition session, namely training and analysis, this method was started for all patients placed in subgroups simultaneously. According to a prior investigation by Padberg et al. (24), electrical stimulation was carried out. The montage is set up, in brief, using the international 10-20 system, with the cathode on F4 (the right dorsal PFC) and the anode on F3 (the left dorsal PFC).

Additionally, a transcranial electrical stimulation device under the Active Dosell brand was used in the current investigation. To evaluate and verify the findings, Beck's and Hamilton's depression tests were completed after the re-sessions. Additionally, as a follow-up to the evaluations above, a re-evaluation was conducted to assess durability 30 days after the final session.

The content of training sessions

A: Psychotherapy (Metacognitive therapy)

The metacognitive therapy group was conducted based on the practical guide to metacognitive treatment of anxiety and depression for ten sessions of 90 minutes among the experimental group subjects. The summary of the meetings is as follows: The first session includes the completion of questionnaires, introduction of group members and development of group rules, elaboration of case formulation, introduction of models and preparation, identification and naming of rumination courses, practice of attention training techniques, and homework presentation. The second session consisted of reviewing assignments, introducing and practicing detached mindfulness, introducing postponing rumination as an experiment to change uncontrollability beliefs and presenting homework. The third session involves examining assignments, identifying stimulants, applying detached mindfulness, practicing attention training techniques, and presenting homework. The fourth session includes reviewing homework, checking the application of postponing rumination, challenging positive beliefs about rumination, practicing attention training techniques, and

presenting homework. The fifth session includes checking and reviewing homework, extensive use of detached mindfulness practice, continuing the challenge with positive beliefs about rumination, checking the level of activities and providing recommendations to improve them, practicing attention training techniques, and presenting homework. The sixth session consisted of reviewing homework, challenging negative beliefs about rumination, practicing attention-training techniques, and presenting homework. The seventh session involves reviewing homework, working on developing new programs, completing the program summary sheet, practicing attention training techniques, and presenting homework. The eighth session contains reviewing homework, preventing relapse by completing the overall treatment plan, working on the remaining metacognitive beliefs, discussing how to use the new program, and finally completing the questionnaires. The ninth session consisted of reviewing homework, working on developing a new program, preventing relapse, and practicing attention training techniques. The tenth session involves checking homework, planning reinforcement sessions, and practicing attention-training techniques (25). A month after the last session of metacognitive therapy, to implement the follow-up phase, the subjects of the experimental groups completed the questionnaires.

B. Transcranial Direct Current Stimulation (tDCS)

This brain stimulation approach is non-invasive and involves passing a weak current of electricity between two electrodes, which can deliver up to 2 milliamps of current to the brain (26). The anode and cathode electrodes of the tDCS device are wired to a power source that produces direct current (DC). Current flowing through the brain alters how it enters from the anode, passes through the tissue, and leaves from the cathode (27). The length of stimulation in this technique is up to 20 minutes at the maximum (27), and the anode pole increases cortical excitability while the cathode pole decreases it (28). With a current intensity of 2 mA, tDCS was used in the current study as anodal stimulation on the left DLPFC (F3) and cathodal stimulation on the right DLPFC (F4). The patients were required to attend two 15-minute therapy sessions each week for ten weeks, two sessions per week, starting at the beginning of the metacognition sessions.

According to a prior investigation by Padberg et al. (24), electrical stimulation will occur.

The summary of metacognitive therapy sessions with transcranial direct current stimulation was prepared by combining the metacognitive approach content sessions and transcranial direct current stimulation.

Results

The demographic characteristics of the participants are presented in Table 1.

The descriptive indices related to the depression scores in the three stages of pre-test, post-test, and follow-up are presented in Table 2. The table results indicate that in the post-test and follow-up stages, the difference in depression scores in the experimental group is noticeable, which indicates that the interventions affected the improvement of depression symptoms. In addition, the follow-up scores did not change significantly, which indicates that the treatment was durable.

Table 1. Demographic characteristics of the participants

	Enriched psychotherapy with tDCS		Unenriched psychotherapy with tDCS		Metacognitive therapy	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Age (Year)						
20-30	3	25.0	1	8.3	4	8.3
31-40	7	58.3	4	33.4	8	66.7
41-50	5	16.7	10	58.3	3	25.0
Education						
Diploma	1	6.7	2	13.3	2	13.3
Associate Degree	4	26.7	3	20.0	3	20.0
Bachelor's degree	9	60.0	7	46.7	6	40.0
Master's degree	1	6.7	3	20.0	4	26.7
Gender						
Woman	12	80.0	9	60.0	9	60.0
Man	3	20.0	6	40.0	6	40.0

Table 2. The depression scores in the psychotherapy group enriched with tDCS, metacognitive therapy, and unenriched psychotherapy with tDCS in the three stages

Group		Enriched psychotherapy with tDCS		Unenriched psychotherapy with tDCS		Metacognitive therapy	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Depression (Beck)	Pre-test	28.80	2.57	27.73	1.83	26.40	3.56
	Post-test	17.27	3.15	19.78	3.14	19.20	3.47
	Follow-up	14.27	4.11	17.27	4.42	18	3.36
Depression (Hamilton)	Pre-test	16.93	2.34	16.60	1.06	16.47	1.25
	Post-test	10.20	1.42	12.93	2.60	12.53	2.36
	Follow-up	6.60	1.55	11	3.80	11.73	2.40

The analysis of variance with repeated measurements was employed to determine whether the changes achieved in the post-test and follow-up were statistically significant. The application of this test necessitates adherence to a few fundamental presumptions. These assumptions include the homogeneity of variances and the normality of the distribution of scores, both of which were looked into first.

The assumption of the normality of the data distribution was made using the Kolmogorov-Smirnov test. The target variable in this test has a significance level larger than $P > 0.05$, indicating a normal distribution. The assumption of equal variances within the participants was examined using Mauchly's test

of Sphericity. The premise of equality of variances within individuals was upheld when Mauchly's test of Sphericity results revealed that this test was insignificant for depression. The homogeneity of variance presumption was examined using Levene's test. The experimental groups' homogeneity of variance test results does not indicate any significance for the variable of depression. The variances of the test groups are, therefore, identical. This statistical test can be applied, provided the prerequisites for applying variance analysis with repeated measurements have been satisfied. Table 3 presents the results of the analysis of variance with repeated measurements on the depression scores.

Table 3. The results of the analysis of variance with repeated measurements on the depression scores

	Variable	Sum of squares	Degrees of freedom	Mean of squares	F	P	Impact rate	Test power
Depression (Beck)	Level	3115.60	2	1557.80	309.37	0.001	0.88	1
	Level*Group	160.76	4	40.19	7.98	0.001	0.28	1
	Group	54.711	2	27.35	1.14	0.33	0.05	0.23
	Error	1006.88	42	23.97				
Depression (Hamilton)	Level	1121.11	2	560.55	177.01	0.001	0.80	1
	Level*Group	139.55	4	34.88	11.01	0.001	0.34	1
	Group	158.80	2	79.40	9.11	0.001	0.30	0.96
	Error	365.86	42	8.71				

In the experimental groups of psychotherapy enriched with tDCS, metacognitive therapy, and unenriched psychotherapy with tDCS, there is a statistically significant difference in the mean of pre-test, post-test, and follow-up depression (depression (Beck), depression (Hamilton)). In other words, there is a significant difference in pre-test, post-test, and follow-up scores (Depression (Beck) $F=37.309, P<0.01$, and Depression (Hamilton) $F=01.177, P<0.01$). Additionally, the mean score of the experimental group in the post-test and follow-up stages is significantly higher than the control group (depression (Beck) $F=7.98, P<0.01$, and depression (Hamilton) $F=11.01, P<0.01$), according to the significance of the interaction between the stages with the experimental group in depression. Between subjects in the experimental group and the control group, there is not a significant difference in the scores of BDI-II. (depression (Beck) $F=1.14, P>0.05$). Additionally, depression (Beck) and depression (Hamilton)

show that there is a significant interaction between the stages of the experimental group in depression, illustrating that the mean of the experimental group is significantly higher than the control group in the post-test and follow-up stages (depression (Beck) $F=7.98, P<0.01$, and depression (Hamilton) $F=11.01, P<0.01$). There is not a significant difference between the patients in the experimental group and the control group in terms of their depression (Beck) score (depression (Beck) $F=1.14, P>0.05$). Between the experimental group subjects with depression (Hamilton) and the control group, there is a statistically significant difference (depression (Hamilton) $F=11.9, P<0.01$). These findings demonstrate the efficacy of metacognitive therapy, psychotherapy enriched with tDCS, and unenriched psychotherapy with tDCS on depression scores based on BDI-II and HAM-D. The Bonferroni test was performed for a more thorough analysis and to identify the groups that differ. The findings are shown in Table 4.

Table 4. Bonferroni post hoc test results of the adjusted mean of depression in the groups

Variable	Group	Group	Means difference	P
Depression (Beck)	Enriched psychotherapy with tDCS	Metacognitive therapy	-1.51	0.420
		Unenriched psychotherapy with tDCS	-1.09	0.890
	Unenriched psychotherapy with tDCS	Enriched psychotherapy with tDCS	1.51	0.450
		Metacognitive therapy	0.42	1.000
	Metacognitive therapy	Enriched psychotherapy with tDCS	1.08	0.890
		Unenriched psychotherapy with tDCS	-0.42	1.000
	Enriched psychotherapy with tDCS	Metacognitive therapy	-2.26	0.002
		Unenriched psychotherapy with tDCS	-2.33*	0.002
Depression (Hamilton)	Unenriched psychotherapy with tDCS	Enriched psychotherapy with tDCS	2.26*	0.002
		Metacognitive therapy	-0.06	1.000
	Metacognitive therapy	Enriched psychotherapy with tDCS	2.33	0.002
		Unenriched psychotherapy with tDCS	0.06	1.000

According to findings, the significant level of Beck depression score, metacognitive therapy alone, and psychotherapy enriched and unenriched with tDCS are greater than 0.05 in the control group. There is no significant difference between the groups stated in depression. The significant level in depression scores of BDI-II and HAM-D for metacognitive therapy, psychotherapy enriched with tDCS, and psychotherapy unenriched with tDCS is less than 0.05. So, there was a significant difference in depression score based on HAM-D between the groups above. The difference was greater for the psychotherapy group enriched with tDCS. Thus, compared to unenriched psychotherapy with tDCS and metacognitive therapy, psychotherapy training enriched with tDCS had a greater impact on depression. It demonstrates the impact of tDCS added to psychotherapy training on depression based on Hamilton Depression Scale.

Discussion

It is crucial to examine treatments that, either alone or in conjunction with other forms of treatment, can effectively address psychological concerns (29). In this context, the current study was carried out to assess the efficacy of metacognitive therapy, unenriched psychotherapy with tDCS (sham), and psychotherapy training enriched with tDCS in major depressive disorder. The findings demonstrate that metacognitive therapy enriched with tDCS is more effective than unenriched psychotherapy with tDCS and psychotherapy alone in treating depression. The findings of this study are consistent with other studies by Thorslund et al. (5), Gruchala et al. (30), and Sijercic et al. (31), which have demonstrated the efficacy of metacognitive therapy in treating depression. The results of this study in the follow-up phase also demonstrated the lasting effect of therapeutic intervention after training. According to Nordahl's research, depression has decreased due to metacognitive therapy (32). The results of this study also line up with a study by Dargahiyan on the effectiveness of metacognitive therapy on depressive symptoms on women with depressive disorders. The results demonstrated that metacognitive therapy significantly decreased depression in post-test, which persisted throughout the follow-up phase (33). It can be said that the metacognitive approach is based on the idea

that people are caught in the trap of emotional discomfort because their metacognitions lead to a pattern that causes the continuation of negative emotions and strengthens negative beliefs in these people. This premise can be used to explain the effect of metacognitive therapy on improving the symptoms of depression. According to the metacognitive paradigm, failure to assess the accomplishment of personal goals is a factor in depression. Ruminative thoughts are regarded by the metacognitive method as a means of self-control and coping. Although the persistence of these thoughts can be voluntarily controlled, they are frequently associated with the perception that these strategies are effective. Rumination and self-centeredness cause people to lose their flexibility in effective and efficient processing and to become less focused on adaptive modes of coping, such as problem-solving (34). Therefore, the therapy of depression will not advance effectively until ruminations are explicitly addressed and the metacognitive beliefs associated with them, particularly negative and positive metacognitive beliefs, are modified (35). Additionally, it challenges and emendates their negative and positive metacognitive beliefs on worry and rumination. As a result, this treatment reduces the risk of starting or ending periods of depression and anxiety by focusing on the processes of worry, rumination, and monitoring (36).

The outcomes of this study also align with those of Boggio et al. (37), Masafi et al. (38), De Raedt et al. (39), and Sarhadi et al. (40). This research has demonstrated that direct current stimulation therapy is a useful strategy for treating depression. The findings of a study by Vanderhasselt et al. demonstrated that rumination is connected to increased neural activity in the right DLPFC cortex and decreased neural activity in the left DLPFC. Therefore, it is anticipated that by stimulating this area, psychological symptoms, including rumination, anxiety, and depression, can be decreased (41). Also, a study by Meron et al. showed that the tDCS technique significantly reduces the symptoms of depression (42).

The results of this study are also consistent with Akbarzadeh et al.'s study, which compared the efficacy of tDCS and mindfulness-based cognitive therapy in reducing pain intensity and enhancing the quality of life in fibromyalgia patients. This study indicated the efficiency of

mindfulness-based cognitive therapy with tDCS on fibromyalgia patients, which can assist therapists in treating these patients more effectively and at less expense (43).

It is possible to say that the DLPFC is a significant area of dysfunction in depression, which is caused by a decrease in left function and an increase in right function, to explain the efficacy of transcranial direct current stimulation (tDCS) in treating depression. The primary target for anodal tDCS is stimulation of the left DLPFC (underactive) (F3 in the 10-20 EEG system). According to the theory of prefrontal asymmetry, the right prefrontal DLPFC is overactive in MDD. Therefore, applying the inhibitory effects of cathodal stimulation in this area can help improve depression symptoms (12). In treating psychological symptoms, creating waves with high frequencies in the left dorsolateral prefrontal cortex and low frequencies in the right dorsolateral prefrontal cortex leads to reducing those symptoms (anxiety and depression). Based on the findings of functional neurography, this area of the brain, which is located on the lateral side of the middle frontal gyrus, plays an important role in regulating mood and psychological disorders (anxiety and depression) due to its availability and connection with the limbic system (44). As a result, by using this treatment method, it is possible to identify cortical areas of the brain and changes related to behavioral action.

Furthermore, stimulation causes changes in self-control behaviors over thoughts and behavior, and as a result, people show less rumination and find more control over their thoughts (45). The background investigation showed no studies contrasting and integrating these two therapeutic modalities. As a result, the analysis of the results is fairly limited. It can be said that metacognitive therapy tries to decrease rumination and alter the patient's attitude towards it during sessions through attention training, detached mindfulness techniques, and the challenge of positive and negative metacognitive beliefs.

This helps to explain why psychotherapy enhanced with direct transcranial current stimulation is more effective than the other two treatments. According to the framework of metacognitive perspectives, alterations in ruminations and associated beliefs cause changes in depressive mood (46). It has been shown that tDCS can improve the use of

reappraisal strategies (47) and cognitive control techniques (48) required for emotion regulation. In addition, recent empirical findings suggest that tDCS effects are "activity-dependent", meaning that tDCS-induced antidepressant effects can be enhanced by concurrent cognitive activity (49). Combining these two methods may open up opportunities for combining psychotherapy and tDCS in future studies and clinical work, offering a new option for treating the rising number of women and men who suffer from serious depression.

Caution should be exercised when extrapolating these results to individuals with other psychological disorders due to the study's limitations, including using self-assessment tools, the 1-month follow-up period's short duration, and the sample of patients with major depression.

As a result, it is suggested that in future studies, TDCS should be compared to other psychological methods, as well as the use of these methods in combination and that additional psychological variables should be researched. A follow-up period of several months to a year should be used to examine the long-term effects of this research in other populations, such as those with personality disorders and addiction.

Conclusion

The results showed that added transcranial Direct Current Stimulation (tDCS) to metacognitive therapy positively impacts treating depression in patients with major depressive disorder. Therefore, psychotherapy training enriched with tDCS can be an effective and stable tool to reduce depression and improve brain frequencies in depressed patients.

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