



## The Effectiveness of Transcranial Direct Current Stimulation (tDCS) on Reducing Depression Severity and Automatic Thoughts in Depressed Women

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### ABSTRACT

**Introduction:** Depression is a common disorder that is often associated with other mental and physical disorders. One of the innovative approaches applied in depressed patients is transcranial direct current stimulation. **Objective:** The aim of this study is to determine the effectiveness of transcranial direct electrical stimulations on reducing the severity of depression and negative automatic thoughts. **Method:** This study is a quasi-experimental study. The population of it all depressed women formed in Tehran in 2015-16. A total of 24 subjects were selected by convenience sampling and randomly assigned into two test ( $n=12$ ) and control ( $n=12$ ) groups. The assessment tool used in the clinical interview was Beck Depression Inventory (BDI- Form 21) and automatic thoughts questionnaire (ATQ) respectively. The treatment sessions with a transcranial direct current stimulation (tDCS) included 15-20 min anodal stimulation of T3 region, and Kathodal stimulation of FD1 with a current of 2 mA. Data were analyzed using analysis of covariance and a dependent t-test. **Results:** Analysis of the data using analysis of covariance showed that there is a significant difference between tDCS and control groups in the rates of depression ( $p<0.05$ ). There was also a significant difference between tDCS and control groups in terms of belief and the frequency of automatic thoughts ( $p<0.05$ ). **Conclusion:** According to the results, it seems that transcranial direct current stimulation can reduce the severity of depression. Therefore, psychologists and psychotherapists can use it as a method of intervention used to improve symptoms in patients with depression.

**Keywords:** Depression, automatic thoughts, transcranial direct current stimulation, depressed women

### INTRODUCTION

Depression is currently the newest disease of the century, which allocated the first or the second ranking of common diseases up to 2020 according to Harvard University [1]. The World Health Organization ranked the depression in the fourth place of the serious public health problems around the world. In addition, depression is one of the most important psychiatric neurological disorders whose possibility of developing in the lifetime is approximately 17% and almost 10% of people around the world are in need of serious treatment. The prevalence of depression in children is estimated as much as 0.4% to 2.5%, and 4% to 8% in teenagers in America. Prevalence duration in the lifetime of teenagers is 15 to 18 years old as much as 14%. Depression is the most common disease in 15-45 years old women [2].

Depression is treatable by various ways, such as medication, psychotherapy, and shock therapy (ECT). However, the symptoms of half of depressed patients remain and almost 20% response to the minimum treatment and others do not show any reaction to the treatment. Antidepressants are as the first-line treatment of mood disorders, especially

depression. Electric shock therapy is considered only for patients who do not respond to drugs, or medical treatment would not be tolerated by them. Despite the effective application of electric shocks in the treatment of mood disorders such as depression, psychiatrist mind was gradually shifted in other ways that can cause depression therapeutic effect without a comprehensive seizure and focal inciting of cortical areas [3]. Depressed people due to the faulty information processing, tend to pay more attention to the negative event and understand them as general and universal events. In fact, faulty information processing is one of the features of major depression. Inefficient mental structures, and consequently, the dysfunctional attitude of major depressed people prevent them to assess the life events efficiently. Despite confirming the effectiveness of cognitive-behavioural treatment, almost a third of people who benefit from this treatment, are at risk of recurrence. One of the strategies to improve the effectiveness of cognitive-behavioural treatment in reducing the residual symptoms of depression and promoting its power to prevent recurrence is targeting other recurrence predictive factors [4,5]. The prefrontal cortex plays a role in neural networks involved in processing mood and excitement and there are differences between the two hemispheres of the brain in terms of positive and negative emotional processing. The right hemisphere is mostly involved in negative emotions and the left hemisphere is mostly involved in positive emotional processing [6]. *In vitro* studies have shown that the dorsolateral prefrontal cortex of the left hemisphere is more active in the presence of positive emotional stimuli. The damage to the left in the wake of a stroke, trauma, or epilepsy often associated with depression, whereas the right hemisphere damage associated with elevated mood. Therefore, one of the depression disorder treatments has recently spread is transcranial direct current stimulation [7]. Transcranial direct current stimulation is a non-invasive method, in which a weak direct current (1 to 4 mA) enters on the scalp and long-term changes in cortical polarity in polarization and hyperpolarization of neurons and acting on nervous receivers are created by using it. In other words, in this type of electrical stimulation, some points in the head are targeted using weak electric currents [8]. The working principle is that two electrodes, one positive and the other negative are placed on the head, which have been soaked via a foam pad. The electrical current reaches the cerebral cortex level after passing different areas (scalp, skull, etc.) through these electrodes. The arrived current electrically charges neurons in this area and creates positive and negative poles, which leads to changes in the activity of that area. Considering the disorder, the following cases should be determined to perform this method: Electric current intensity, duration and direction, the location of each of the electrodes, the size of the foam pads, the number of sessions [9]. Recently a new approach has been introduced, in which a number of smaller electrodes to target specific cortical structures are used instead of using two screens. This approach is called tDCS with high quality (HD-tDCS). In a preliminary study, it was found that HD-tDCS has more and longer changes in the motor cortex excitability than the conventional method. Transcranial direct current stimulation is used to stimulate different brain areas in neurological and psychiatric patients. Boggio, et al. [10] stated that one of the most important characteristics of transcranial direct current stimulation is its ability to create cortical stimulation even after the end of stimulation. They suggested that this stimulation will have beneficial effects on the treatment of psychotic disorders after 5 sessions transcranial direct current stimulation (tDCS) with 1mA excitation anode in 20 min.

Transcranial direct current stimulation (tDCS) is a non-pharmacological promising intervention for treating major depressive disorder. Boggio, et al. has shown that dorsolateral prefrontal cortex activation is associated with the positive emotional state using direct electrical current (tDCS). Depression is often associated with changing the activity of the prefrontal cortex, especially in prefrontal areas. Recent studies aimed at changing the prefrontal cortex and creating balance in prefrontal cortex activity of the left and right hemispheres, showed the significant effects of transcranial direct current stimulation (tDCS) on reducing the symptoms of depression [11]. Arul-Anandam and Loo [11] have examined the effectiveness of transcranial direct current stimulation (tDCS) on depression disorder. They have reported a significant decrease in depressive symptoms following the anodal stimulation of frontal areas of the left hemisphere. Rigonatti, et al. have compared the effect of transcranial direct current stimulation (tDCS) and fluoxetine. They concluded that the transcranial direct current stimulation (tDCS) and fluoxetine both have similar effects [12]. In another study, Hadley, et al. used the transcranial magnetic stimulation (TMS) in the left prefrontal area. The results showed that the symptoms of depression, especially thoughts of suicide in less than a week decreased as much as 67%, which had statistically a significant value compared to the sham group (active stimulation) [13]. Kalu, et al. also suggests that Transcranial Direct Current Stimulation (tDCS) may have strong and significant clinical effects in the treatment of depression. In other words, 48% of those who received 30 sessions of transcranial direct current stimulation (tDCS) (every day of the week and over a period of 6 weeks) have responded to treatment [14].

There are other studies regarding the effectiveness of tDCS in depression, but researchers in this study have lower investigations on the negative automatic thoughts in depressed patients. Increasing the negative thoughts, especially related to humans' self and future is one of the signs of depression, which will decrease by improvement in patients. Thus, the present study aimed to the effectiveness of direct electrical stimulations on reducing the severity of depression and negative automatic thoughts and to investigate whether tDCS is effective in improving symptoms of depression.

### MATERIALS AND METHODS

This study is a quasi-experimental study. The population of it all depressed women formed in Tehran in 2015-16. A total of 24 subjects were selected by convenience sampling and randomly assigned into two test (n=12) and control (n=12) groups. The assessment tool used in the clinical interview was Beck depression inventory (BDI- Form 21) and automatic thoughts questionnaire (ATQ) respectively. The treatment sessions with a transcranial direct current stimulation (tDCS) included 15-20 min anodal stimulation of T3 region, and Kathodal stimulation of FD1 with a current of 2mA. After the initial assessment and diagnosis of depression based on a clinical interview, the researcher introduced depressive symptoms, treatment methods, purpose, duration of meetings, and research project to the visitors and informed them the collected data will be used for the treatment process research purposes with the obligation of confidentiality. Then, their questions and uncertainties are answered in the process. Data were analyzed using analysis of covariance and a dependent t-test. The research instruments included:

Demographic characteristics questionnaire: the questionnaire was set up basically to collect systematic demographic information, including age, marital status, and education.

#### Beck Depression Inventory

This questionnaire has been prepared on the basis of clinical findings and it does not consider any theory for the aetiology of depression. The questionnaire comprised a total of 21 questions related to the different signs and when running, the subject will be asked to grade the severity of these symptoms on a 4-point scale from 0 to 3. Questions are related to areas such as feelings of failure, guilt, irritability, sleep disturbances, and loss of appetite. The questionnaire score range is at least 0 to at most 63 i.e., partial depression to major depression. The results of the meta-analysis were carried out on the Beck depression inventory showed that the internal consistency coefficients are from 0.73 to 0.93 with an average of 0.86. Retest reliability coefficient based on the running interval and population is in the range of 0.48 to 0.86. The correlation coefficient of this questionnaire by the psychiatric rating scale is 0.73 for Hamilton depression, 0.76 for Zung depression self-rating scale, and 0.74 for MMPI depression scale. In Iran, the Cronbach's alpha of this questionnaire was 0.91, the retest reliability within a week was 0.96 [3,15].

#### Automatic Thoughts Questionnaire (ATQ)

The auto-test questionnaire evaluates the frequency of negative statements about "self". These negatively implicit comments play an important role in creating, durability and treatment of various psychological damage, including depression. Four aspects of these automatic thoughts include personal conflict and the desire to change (PMDC), negative self-concept and negative expectations (NSNE), low self-esteem (LSE), and disappointment. This questionnaire is valuable because it is created to assess the cognitive changes related to clinical interventions and to evaluate cognitive "self-disclosure" in depression. The questionnaire is normalized on a sample of 312 students. The average age of the sample was 20-22 years with a standard deviation of 4.32 years. This sample of participants was classified as depressed or undepressed based on the Beck depression inventory scores and MMPI. Automatic thoughts questionnaire mean score in the depressed sample was 79.64 with a standard deviation of 22.29 and the Mean score in the other sample 48.57 with a standard deviation of 10.89. The validity of the questionnaire has a very good internal consistency with the Cronbach's as much as 0.97. The validity of 30 questions selected from a hundred questions. To verify the validity, the questionnaire was conducted on 60 students of Isfahan University and Cronbach's alpha coefficient was 0.94 [16].

#### Transcranial Direct Current Stimulation (tDCS)

The initial projection of (tDCS) is related to more than a hundred years ago. Some basic experiments were performed using this technique on animal and human samples before the 19th century. Adlinie (1804) conducted a study on the application of (tDCS) to improve mood in depressed patients. In the 1960s, a man named Albert was able to show that this method affects the brain function by changing the excitability of the cerebral cortex. He also discovered that the

positive and negative stimulations have different effects on brain's growth excitability. Although these findings were important for the clinical use of (tDCS), but due to the lack of research in this area again, medication showed itself as the more effective method in treating. This argument continued to the present until increasing interest in studies about the basic functions of the brain and therapeutic applications of this method as a new method of brain stimulation and new brain imaging techniques such as TMS and fMRI that flourished again [7,17].

## RESULTS

According to data obtained from the demographic questionnaire, the average age of tDCS was 37.67. This value was 39.92 in the control group. The minimum and maximum age in tDCS was 22 and 52. These values were 25 and 53 in the control group. The frequency of married people was more than singles in both groups and Bachelor's degree was the most level of education.

**Table 1 The Mean and standard deviation of the participants' scores for depression variable separated by group**

Variable		Group			
		tDCS		Control	
		Pre-test	Post-test	Pre-test	Post-test
Depression	Mean	19.83	10.17	21.25	21.08
	SD	2.62	4.36	3.25	2.39
	Min	17	4	17	17
	Max	24	19	26	24
	Differential average scores	-9.66		-0.17	

The mean and standard deviation of the participants' scores for depression variable are given in Table 1.

**Table 2 The mean and standard deviation of the participants' scores for the variable of frequency of negative automatic thoughts separated by group**

Variable		Group			
		tDCS		Control	
		Pre-test	Post-test	Pre-test	Post-test
Frequency of automatic thoughts	Mean	87.92	50.08	82.5	79.58
	SD	9.66	10.06	8.24	8.05
	Min	76	35	74	70
	Max	103	72	104	102
	Differential average scores	-37.84		-2.92	

The mean and standard deviation of the participants' scores for the frequency of negative automatic thoughts are given in Table 2.

**Table 3 The mean and standard deviation of the participants' scores for the variable of belief in negative automatic thoughts separated by group**

Variable		Group			
		tDCS		Control	
		Pre-test	Post-test	Pre-test	Post-test
Belief of negative automatic	Mean	91.75	56.17	86.58	81.67
	SD	34.55	11.95	4.25	9.66
	Min	63	35	79	71
	Max	136	76	94	96
	differential average scores	-35.58		-4.91	

The mean and standard deviation of the participants' scores for the variable of belief in negative automatic thoughts are given in Table 3.

**Table 4 Determining the effectiveness of transcranial direct current stimulation in reducing the severity of depression in women**

Variable	Group	T	df	Sig
Depression	tDCS	5.22	22	0.001
	Control			

The significant levels of depression variable in the Table 4 show that there is a significant difference between tDCS and control groups for this variable ( $p < 0.05$ ).

**Table 5 Determining the effectiveness of transcranial direct current stimulation device for the variable of belief in negative automatic thoughts**

Variable	Group	T	df	Sig
Belief of negative automatic	tDCS	2.87	22	0.009
	Control			

The significant levels of belief in negative automatic thoughts in the Table 5 show that there is a significant difference between tDCS and control groups for this variable ( $p < 0.05$ ).

**Table 6. Independent t-test to determine the effectiveness of transcranial direct current stimulation device in the frequency of automatic thoughts**

Variable	Group	T	df	Sig
Frequency of automatic thoughts	tDCS	9.4	22	0.001
	Control			

The significant levels of the frequency of automatic thoughts in the Table 6 show that there is a significant difference between tDCS and control groups for this variable ( $p < 0.05$ ).

## DISCUSSION

The present research aimed to determine the effectiveness of transcranial direct current stimulation (tDCS) on improving symptoms of depression in women with the depressive disorder. The results of data analysis showed a significant decrease in depression scores of the experimental group compared to the control group. According to post-test results, it seems that the transcranial direct current stimulation (tDCS) is effective in reducing depression in patients with the depressive disorder. The results of this study are consistent with results of Nitsche, et al. [9]. The researchers concluded that left Anodal Stimulation leads to experience more positive emotions in people with depression. In addition, the results of Arol-Anandom and Lou are corresponded with these results. They have reported a significant decrease in depression following left anodal stimulation in the frontal area in 70 patients with major depression. Boggio, et al. research has confirmed our research. The researchers concluded that dorsolateral prefrontal Anodal stimulation for 20 min in 10 days leads to a significant decrease in depressive symptoms and this effect continues up to 4 weeks after treatment. In addition, the study results were consistent with the study of Rigonatti, et al. Their results showed that the effects of transcranial direct current stimulation (tDCS) for the treatment of depression are similar to fluoxetine drug [9,12].

Another aim of the present study was to determine the effectiveness of transcranial direct current stimulation on the negative automatic thoughts. Results showed that there was a significant difference in the frequency of automatic thoughts and the belief in automatic thoughts between the experimental group and the control group. According to post-test results, it seems that the transcranial direct current stimulation is effective in reducing negative automatic thoughts and its frequency in patients with the depressive disorder. Alipour evaluated the effectiveness of transcranial direct current stimulation (tDCS) in reducing the craving for methamphetamine and improve mood in people who were dependent on methamphetamine. In this study, the 2mA current was imposed for 20 min in ten consecutive days in the form of anodal stimulation to 3F point. The results of this study showed that tDCS therapy can reduce the craving for methamphetamine and improve mood in people who dependent on methamphetamine. Alipour research shows that tDCS, which was applied aimed at reducing craving may improve mood, too. This research suggests that transcranial direct current stimulation different and very promising way, which is completely non-invasive. The related design features include stimulating place, electrode size, duration of stimulation, polarity of the anode and cathode, which have different effects [18]. Ashrafpour conducted a study entitled comparing the efficacy of transcranial current stimulation with and without neurofeedback on major depression and psychological well-being. The research findings indicated that transcranial current stimulation with neurofeedback significantly reduce the symptoms of major depression in patients with major depressive disorder. However, this intervention had no effect on the psychological well-being of depressed women [19]. To explain this finding, it can be stated that variability in the results due to the effect of tDCS may be due to differences in the location of electrodes or the differences in the test. For this reason, conclusions about the efficacy of tDCS in reducing repeat automatic thoughts need more study and

similar research in this field. Since previous studies have not examined the effect of tDCS on negative thoughts, the results of the present research with iteration in a similar situation can further confirm the effectiveness of this method in improving the negative automatic thoughts.

### CONCLUSION

Transcranial direct current stimulation is a tool that increases the ability of the brain to process incoming information [20]. This method increases the effectiveness of other therapies, but it does not make individuals needless [21,22]. According to the results of the present study, it is recommended to apply this treatment technique by psychiatrists, psychologists and psychotherapists in psychiatric clinics and psychology service centres as a method of intervention and prevention of relapse. The only limitation in this study was the sampling method and low sample volume. Since the studied subjects were depressed women, generalization of results for men would be reduced. However, tDCS can be expected as one of the most modern tools for therapeutic purposes and improving cognitive abilities soon because of its low cost and safety.

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