

Effectiveness of Transcranial Direct Current Stimulation on Depression Severity and Automatic Thoughts Reduction in Depressed Women

Saideh Masafi^{1,*}, Mohammad Ebrahim Maddahi², Adis Kraskian Mujembari³, Shapour Badiee Aval⁴, and Masoumeh Radfar³

¹ Department of Psychology, Iranians University an e-Institute of Higher Education, Tehran, Iran, E-mail: saideh.masafi@net2university.com

² Department of Psychology, Shahed University, Tehran, Iran

³ Department of Psychology, Karaj Branch, Islamic Azad university, Karaj, Iran

⁴ Department of Complementary and Chinese Medicine, School of Persian and Complementary Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

* **Corresponding author:** Saideh Masafi, Department of Psychology, Iranians University an e-Institute of Higher Education, Tehran, Iran, E-mail: saideh.masafi@net2university.com

Received 2018 March 04; Accepted 2018 October 13.

Abstract

Background: 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 (tDCS).

Objectives: The study aimed to determine the effectiveness of transcranial direct electrical stimulations on reducing the severity of depression and negative automatic thoughts.

Methods: A quasi-experimental study was conducted on 24 depressed women between 2015 and 2016 who were randomized via clinical interview in Tehran, district 2. The patients' age range was from 20 to 55 years old. The process was done through the convenience sampling which was randomly assigned into test (n = 12) and control (n = 12) groups.

The applied assessment tool in the clinical interview was Beck Depression Inventory (BDI- Form 21) and Automatic Thoughts Questionnaire (ATQ) respectively. All the patients underwent 15-20 minutes anodal stimulation of T3 region, and Kathodal stimulation of FD1 with a current of 2-mA intensity along with a Transcranial Direct Current Stimulation (tDCS). The Data were analyzed using the independent t-test analysis.

Results: The results showed that there was 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 frequency of automatic thoughts (P<0.05).

Conclusion: According to the results, it seems that Transcranial Direct Current Stimulation could 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: Automatic thoughts, Depression, Transcranial direct current stimulation

1. Background

Depression is currently the newest disease of the century, which is ranked as the first or the second common disease 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. 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 (3). Depressed people tend to pay more attention to the negative event and understand them as general and universal events due to the faulty information processing (4,5). There are differences between the two hemispheres of the brain in terms of positive and negative emotional processing (6). The damage to the left hemisphere in the wake of a stroke, trauma, or epilepsy is often associated with depression, whereas the right hemisphere damage is associated with the elevated mood. Therefore, one of the depression disorder treatments that has recently been spread is Transcranial Direct Current Stimulation (7). The Transcranial Direct Current Stimulation is a non-

invasive method, in which a weak direct current (1 to 4 mA) gets into the scalp and long-term changes in cortical polarity in polarization and hyperpolarization of neurons and acting on nervous receivers are created by its utilization (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. Considering the disorder, the following cases should be determined to perform this method: Electric current intensity, duration and direction, location of each of the electrodes, size of the foam pads, and number of sessions (9). Boggio et al. have shown that dorsolateral prefrontal cortex activation is associated with the positive emotional state using direct electrical current. Recent studies have been conducted to change the prefrontal cortex and creating balance in prefrontal cortex activity of the left and right hemispheres (10). Arul-Anandam and Loo (11) have reported a significant decreasing in depressive symptoms following the frontal areas anodal stimulation of the left hemisphere. Rigonatti et al. have compared the effect of Transcranial Direct

Current Stimulation and fluoxetine. They concluded that both the Transcranial Direct Current Stimulation and fluoxetine have similar effects (12). In another study, Hadley et al. applied 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 was decreased as much as 67%, which had statistically a significant value compared to the sham group (active stimulation) (13). Kalu et al. also suggested that Transcranial Direct Current Stimulation may have strong and significant clinical effects in the treatment of depression. In other words, 48% of those who received 30 Transcranial Direct Current Stimulation therapy sessions have responded to treatment (14).

There are other studies regarding the effectiveness of tDCS in depression, but researchers in this study have a fewer investigations on the negative automatic thoughts in depressed patients.

2. Objectives

The present study aimed to evaluate the effectiveness of direct electrical stimulations on reducing the severity of depression and negative automatic thoughts as well as investigating whether tDCS is effective in improving symptoms of depression.

3. Methods

A quasi-experimental study was conducted on 24 depressed women, who were randomized via clinical interview in Tehran between 2015 and 2016 year, in district 2 of Tehran. The range of patients' age was selected between 20 to 55 years old. The process was through convenience sampling which was randomly assigned into 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 included 15- 20 minutes anodal stimulation of T3 region with a Transcranial Direct Current Stimulation (tDCS), and Kathodal stimulation of FD1 with a current of 2-mA. After the initial assessment and diagnosis of depression, the researcher introduced the depressive symptoms, treatment methods, purpose, duration of meetings, and research project to the visitors based on a clinical interview and informed them the collected data will be used for the treatment process with the obligation of confidentiality. Then, their questions and uncertainties are answered in the process. The data were analyzed using the independent t-test analysis. 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 based on the clinical results that do not consider any theory for the etiology of depression. The questions are related to the 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 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 is 0.73 by the Psychiatric Rating Scale for Hamilton Depression, 0.76 for Zung Depression Self-Rating Scale, and 0.74 for MMPI Depression Scale. The Cronbach's alpha of this questionnaire was 0.91 in Iran, and the retest reliability within a week was 0.96 (3,15).

Automatic Thoughts Questionnaire (ATQ)

The auto-test questionnaire evaluated 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. 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 into depressed or undepressed based on the Beck Depression Inventory scores and MMPI. The Automatic Thoughts Questionnaire Mean score was 79.64 in the depressed sample with a standard deviation of 22.29 and the Mean score was 48.57 in the other sample 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 was 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). The divergent convergence factor in Iran is 67% and 74%. The test-retest reliability values were 76% and 88%, respectively for the frequency of automatic thoughts and beliefs (16).

Transcranial Direct Current Stimulation

The initial projection of tDCS is related to more than a hundred years ago. Although results were important for the clinical use of tDCS, but medication showed itself as the more effective method in treating due to the lack of research in this area again. This argument continued to the present until increasing

interest in the studies about the basic functions of the brain (7,17). Boggio et al. suggested that stimulation will have beneficial effects on the treatment of psychotic disorders after 5 sessions Transcranial Direct Current Stimulation with 1- mA excitation anode in 20-minute (10).

4. Results

The average age of tDCS according to data obtained from the demographic questionnaire 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 summarizes the mean and standard deviation of the participants' scores for depression

variable.

Table 2 summarizes the mean and standard deviation of the participants' scores for the frequency of negative automatic thoughts.

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

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

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

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

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	

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	82.50	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-	

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	

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			

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 Control	2.87	22	0.009

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 Control	9.40	22	0.001

5. Discussion

The present research aimed to determine the effectiveness of Transcranial Direct Current Stimulation on improving the 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, the Transcranial Direct Current Stimulation reduces depression in patients with the depressive disorder. The results of this study are consistent with Nitsche et al. (9) results. 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 this research. The researchers concluded that dorsolateral prefrontal Anodal stimulation for 20 minutes 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 for the treatment of depression were 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 and 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 (2015) evaluated the effectiveness of Transcranial Direct Current Stimulation in reducing the craving for methamphetamine and improving the mood in people who were dependent on methamphetamine. In this study, the 2- mA current was imposed for 20 minutes 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 the mood in people who were dependent on methamphetamine. Alipour research showed that the applied tDCS aimed at reducing craving, may cause improving the mood, too. This research suggested that Transcranial Direct Current Stimulation is a different and very promising way, which is completely non-invasive. The related design features included stimulating place, electrode size, duration of stimulation, polarity of the anode and cathode, which have different effects (18). Ashrafpour (2013) conducted a study entitled comparing the efficacy of Transcranial Current Stimulation with and without neurofeedback on major depression and psychological well-being. The research results indicated that Transcranial Current Stimulation reduces the symptoms of major depression in patients with major depressive disorder with neurofeedback significantly. However, this intervention had no effect on the psychological well-being of depressed women (19). To explain this result, 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 efficiency of tDCS in reducing repeat automatic thoughts require 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 could further confirm the effectiveness of this method in improving the negative automatic thoughts with iteration in a similar situation.

tDCS is a tool that increases the ability of the brain to process the 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 centers 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, the 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.

Study Limitations

The main limitation of the current study was the lack of participants' awareness of the positive impact of direct electrical stimulation of the brain as a safe method without side effects, which led to the reluctance of some of them in the present study. Time limitations prevented the follow-up meetings to assess and evaluate the effectiveness of this therapy in long-term.

It is recommended to conduct this study with men and compare the influence of gender on the effectiveness of this treatment. It is also recommended to perform a similar study to evaluate the effectiveness of direct electrical stimulation in long-terms and the obtained data can be assessed in the follow up meetings.

Strength of the study

Increasing the negative thoughts, especially those that are related to the humans' self and future and are one of the signs of depression, which will be decreased by improvement in patients. No study has so far been conducted on the effectiveness of tDCS on the negative automatic thoughts in depression and this can be considered as a strong point of this study.

6. Conclusion

Nowadays, due to the increasing number of depressed patients and those resistant to different types of treatments, such emerging methods as complementary therapies have been expanded. The results of this study support and confirm the use of TDCS approach as a safe and effective method in health clinics accordingly.

Acknowledgments

This paper is derived from a PhD thesis in Health Psychology, which was approved on 1.19.2016 by the research deputy of the university. The authors give their thanks and appreciation to those who accompanied in the process of this research.

Conflicts of interest

Authors declare no conflict of interest, thus, submitting authors are responsible for coauthors declaring their interests.

References

1. Fink M. Convulsive therapy: a review of the first 55 years.

2. Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EL. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry*. 2005;**62**(6):593-602. doi: [10.1001/archpsyc.62.6.593](https://doi.org/10.1001/archpsyc.62.6.593). [PubMed: [15939837](https://pubmed.ncbi.nlm.nih.gov/15939837/)].
3. Sadeghi K, Khazaie H. The comparison of efficacy pharmacotherapy and group cognitive therapy in dimensions of temperament and character of patients with major depression disorder. *J Kermanshah Univ Med Sci*. 2013; **17**(4):230-6. [Persian]
4. Melyani M, Allahyari AA, Falah PA, Ashtiani AF, Tavoli A. Mindfulness based cognitive therapy versus cognitive behavioral therapy in cognitive reactivity and self-compassion in females with recurrent depression with residual symptoms. *J Psychol*. 2015;**18**(4):393-407.
5. Yousefi Z, Bahrami F, Mehrabi HA. Rumination: beginning and continuous of depression. *J Behave Sci*. 2008;**2**(1):67-73.
6. Fregni F, Baggio PS, Nitsche MA, Marcolin MA, Rigonatti SP, Pascual-Leone A. Treatment of major depression with transcranial direct current stimulation. *Bipolar Disord*. 2006; **8**(2):203-4. doi: [10.1111/j.1399-5618.2006.00291.x](https://doi.org/10.1111/j.1399-5618.2006.00291.x). [PubMed: [16542193](https://pubmed.ncbi.nlm.nih.gov/16542193/)].
7. Brunoni A, Ferrucci R, Bortolomasi M, Vergari M, Tadini L, Boggio P, et al. Transcranial direct current stimulation (tDCS) in unipolar vs. Bipolar depressive disorder. *Prog Neuropsychopharmacol Biol Psychiatry*. 2011;**35**(1):96-101. doi: [10.1016/j.pnpbp.2010.09.010](https://doi.org/10.1016/j.pnpbp.2010.09.010). [PubMed: [20854868](https://pubmed.ncbi.nlm.nih.gov/20854868/)].
8. Sadock BJ, Sadock VA, Kaplan HI. Kaplan and Sadock's concise textbook of child and adolescent psychiatry. Philadelphia: Lippincott Williams & Wilkins; 2009.
9. Nitsche MA, Baggio PS, Fregni F, Pascual-Leone A. Treatment of depression with Transcranial direct current stimulation (tDCS): a review. *Expert Neurol*. 2009;**216**(1):9-14. doi: [10.1016/j.expneurol.2009.03.038](https://doi.org/10.1016/j.expneurol.2009.03.038). [PubMed: [19348793](https://pubmed.ncbi.nlm.nih.gov/19348793/)].
10. Baggio PS, Bermpohl F, Vesgara AO, Muniz AL, Nahas FH, Leme PB, et al. Go-no-go task performance improvement after anodal transcranial DC stimulation of the left dorsolateral prefrontal cortex in major depression. *J Affect Disord*. 2007;**101**(1):91-8. doi: [10.1016/j.jad.2006.10.026](https://doi.org/10.1016/j.jad.2006.10.026). [PubMed: [17166593](https://pubmed.ncbi.nlm.nih.gov/17166593/)].
11. Arul-Anandam AP, Loo C. Transcranial direct current stimulation: a new tool for the treatment of depression? *J Affect Disord*. 2009;**117**(3):137-45. doi: [10.1016/j.jad.2009.01.016](https://doi.org/10.1016/j.jad.2009.01.016). [PubMed: [19201483](https://pubmed.ncbi.nlm.nih.gov/19201483/)].
12. Rigonatti SP, Baggio PS, Myczkowski ML, Otta E, Fiquier JT, Ribeiro RB, et al. Transcranial direct stimulation and fluoxetine for the treatment of depression. *Eur Psychiatry*. 2008; **23**(1):74-6. doi: [10.1016/j.eurpsy.2007.09.006](https://doi.org/10.1016/j.eurpsy.2007.09.006). [PubMed: [18023968](https://pubmed.ncbi.nlm.nih.gov/18023968/)].
13. Hadley D, Anderson BS, Borckardt JJ, Arana A, Li X, Nahas Z, et al. Safety, tolerability, and effectiveness of high doses of adjunctive daily left prefrontal repetitive transcranial magnetic stimulation for treatment-resistant depression in a clinical setting. *J ECT*. 2011;**27**(1):18-25. doi: [10.1097/YCT.0b013e3181ce1a8c](https://doi.org/10.1097/YCT.0b013e3181ce1a8c). [PubMed: [21343710](https://pubmed.ncbi.nlm.nih.gov/21343710/)].
14. Kalu U, Sexton C, Loo C, Ebmeier K. Transcranial direct current stimulation in the treatment of major depression: a meta-analysis. *Psychol Med*. 2012;**42**(9):1791-800. doi: [10.1017/S0033291711003059](https://doi.org/10.1017/S0033291711003059). [PubMed: [22236735](https://pubmed.ncbi.nlm.nih.gov/22236735/)].
15. Abdolmanafi A, Besharat MA. Mediator role of anger rumination in the relationship between anger and depression among patients with external locus of control. *J Behave Sci*. 2013;**7**(2):173-80. [Persian]
16. Kaviani H, Javaheri F, Hatami N. Mindfulness-based cognitive therapy (MBCT) reduces depression and anxiety induced by real stressful setting in non-clinical population. *Int J Psychol Psychol Ther*. 2011;**11**(2):285-96.
17. Janicak PG, Davis JM, Gibbons RD, Erickson S, Chang S, Gallagher P. Efficacy of ECT: a meta-analysis. *Am J Psychiatry*. 1985;**142**(3):297-302. doi: [10.1176/ajp.142.3.297](https://doi.org/10.1176/ajp.142.3.297). [PubMed: [3882006](https://pubmed.ncbi.nlm.nih.gov/3882006/)].
18. Alipour H. Efficacy of electrical stimulation of the brain from the skull (tDCS) to reduce craving and improve positive affect and

- negative affect on methamphetamine-dependent individual. [Master Thesis]. Mashhad: Faculty of Medical Sciences, Mashhad Ferdowsi University; 2015. [Persian]
19. Ashrafpour S. Compare the effect of magnetic stimulation of the brain from the skull with and without neurofeedback on depression and psychological well-being depressed women in Tehran. [Master Thesis]. Ahvaz: Faculty of Psychology, Shahid Chamran University of Ahvaz; 2014. [Persian]
 20. Marshal L, Mölle M, Siebner HR, Born J. Bifrontal transcranial direct current stimulation slows reaction time in a working memory task. *BMC Neurosci.* 2005;**6**(23). doi: [10.1186/1471-2202-6-23](https://doi.org/10.1186/1471-2202-6-23). [PubMed: [15819988](https://pubmed.ncbi.nlm.nih.gov/15819988/)].
 21. Mulquiney PG, Hoy EK, Daskalakis ZJ, Fitzgerald PB. Improving working memory: Exploring the effect of transcranial random noise stimulation and transcranial direct current stimulation on the dorsolateral prefrontal cortex. *Clin Neurophysiol.* 2011;**122**(12):2384-9. doi: [10.1016/j.clinph.2011.05.009](https://doi.org/10.1016/j.clinph.2011.05.009). [PubMed: [21665534](https://pubmed.ncbi.nlm.nih.gov/21665534/)].
 22. Mylius V, Jung K, Menzler A, Haag PH. Effects of transcranial direct current stimulation on pain perception and working memory. *Eur J Pain.* 2012;**16**:974-982. doi: [10.1002/j.1532-2149.2011.00105.x](https://doi.org/10.1002/j.1532-2149.2011.00105.x). [PubMed: [22337597](https://pubmed.ncbi.nlm.nih.gov/22337597/)].