

Original Article

The effectiveness of transcranial direct current stimulation (tDCS) on improving attention in women with chronic schizophrenia

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Abstract

Schizophrenia is one of the most common and severe psychiatric disorders that is characterized by abnormalities in perception, behavior, motivation, thinking and cognition. One of these cognitive defects is defect in attention. Therefore, the purpose of this study was to determine the effectiveness of transcranial direct current stimulation (tDCS) on improving attention in women with chronic schizophrenia in 2016, Ardabil, Iran. In this experimental study (pre-test and post-test with a control group), the population included all women with chronic schizophrenia in Ardabil-Iran, and 28 participants were randomly selected who were in rehabilitation centers of Ardebil and randomly divided into an experimental group (n=14) and a control group (n=14). The members of both groups were individually subjected to a pre-test using Toulouse Pieron attention Test, then using tDCS the intervention was individually performed by a trained researcher on the experimental group for 10 consecutive days in 20 minutes with anode, FP2, and the cathode. The post-test was administered on both experimental and control groups. To analyze the data, univariate covariance analysis was used. The results showed that tDCS increased the mean scores of attention ($p < .05$) in subjects with chronic schizophrenia. Considering that tDCS has a significant effect on improving the attention of people with chronic schizophrenia, it can be concluded that tDCS can improve the attention of people with chronic schizophrenia.

Keywords

Attention
Chronic schizophrenia
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Introduction

Schizophrenia is one of the most common and sever psychiatric disorders in which the underlying quiddity of such disorder is still unclear. Sometimes, it is called the syndrome as it is included by the fifth edition of the diagnostic and statistical manual of mental disorders (DSM-5). Although schizophrenia is defined as a single disease, it is probably a combination of disorders group

which have a heterogeneous etiology, and it includes patients whose clinical manifestations, therapeutic response and course of the disease are not the same (Sadock, Sadock & Ruiz, 2015). To summarize, schizophrenia is a disorder of thought restless mood. This kind of issue (disorder of thought) would be revealed by having quandary in memorizing, focusing, and forming the concepts. Furthermore, it can lead to misconception, huge difficulties in understanding reality, language and emotional expression (Rosenhan & Seligman, 2007).

According to DSM-5, the spectrum of schizophrenia and other psychotic disorders is specified by abnormalities in one or more of five areas: delusions, hallucinations, disturbed contemplation (speech), highly disturbed or abnormal movement including catatonic, and negative signs. The symptoms of such disease is divided into two categories: positive symptoms and negative symptoms. Positive symptoms are the signs of hyperactivity in behavior and it would include hallucinations, delusions, strange behaviors and disrupted thinking. Negative symptoms that are the sign of deficiency and behavioral deficits include superficial emotion, poor speech, lack of willpower, lack of motivation, lack of pleasure, attention deficits, and cognitive deficits. Some studies have indicated that men are more vulnerable to negative symptoms than women. Also, women may have better social functioning before the initiation of the disease than men (Sadock et al., 2015). Cognitive impairment is one of the defects that has existed since the first period of schizophrenia and mainly remains during the initial course of the disease. Attention is one of the cognitive functions that is impaired in people with schizophrenia. In general, attention is a complex and ambiguous structure and refers to a variety of components, including taking the initiative or focusing, maintaining attention or care, inhabiting response to irrelevant stimuli or selective attention and transferring attention (Rostamzade, Atadokht & Basharpour, 2017). All individuals need mechanisms to categorize the mass of information and stimuli that they receive, so they can ignore a series of stimuli then process a set to go through their so-called cognitive or selective filtering. This cognitive filtering is flexible, sensitive and durable. However, in people with schizophrenia, attention filtering is impaired and as a result individuals are unable to control their attention which cause difficulty in concentration (Rosenhan & Seligman, 2007). Various experimental studies have shown that patients with schizophrenia have difficulty in maintaining attention or care (Atadokht, Rostamzade & Basharpour, 2017). Hence, it is indispensable to notice the attention deficits in the treatments and interventions of people with schizophrenia.

Ample research has been done on ameliorating attention in dissimilar groups of healthy people or people with mental disorders that impair cognitive function. Narimani and Soleimani (2013) examined the effectiveness of cognitive rehabilitation on executive functions (working memory and attention) and academic progression for students with learning disabilities in math. Results of their study showed that cognitive rehabilitation is appropriate to improve cognitive functions which also effect academic achievement. In a study that was carried out by Bahmany, Zandi Ghashghaee and Khosravi (2014), the effect of three types of music on attention retention performance in schizophrenic patients were compared. Analysis of covariance indicated that music therapy is

effective in maintaining attention in which pop music has been most effective than other types.

Khalaf Beigi, Fahimi Malahat, Ashayeri and Hatf (2013) showed that music therapy is effective in raising the attention scores of people with schizophrenia. Music also aggrandizes executive performance scores.

In general, the most customary approach toward the treatment of schizophrenia is medication which can be combined with various types of psychotherapy to enhance the effectiveness of the treatment. However, antipsychotic drugs have the best outcome for positive symptoms of schizophrenia (hallucinations, delusions and thought disorders) and have less effect on the negative symptoms (isolationism, lack of willpower, indifference, cognitive deficits, etc.). Thus, considering medication as the only therapy cannot provide satisfactory results to improve attention as a cognitive deficit and there is an emerging demand for non-pharmacological treatments. One of the non-pharmacological therapies, that is considered as a complementary method, is transcranial direct current stimulation (tDCS) (Atadokht et al., 2017). tDCS is a non-invasive and harmless method in which a weak direct electric current (0.5 to 2 mA) is applied to the scalp to create long-term changes in the polarity of the cerebral cortex following the depolarization and hyperpolarization of neurons and the influence on neurotransmitters. The mechanism of tDCS impact is the stimulation (anode) or inhibition (cathode) of action potential in neurons. In fact, tDCS coerces the neuron into being active or inactive. tDCS is based on predetermined treatment protocols and Brodmann's brain map and regions. To reach the desirable outcome, two electrodes, one positive pole (anode: activity stimulation) and a negative pole (cathode: activity inhibitor) are placed on the head through a sponge pad soaked by conductive solution (Rostamzade et al., 2017).

In the tDCS method, the magnitude of the electric current, its duration and direction, the position of each electrode and the size of sponge pads and the number of sessions ought to be specified (Nitsche, Boggio, Fregni & Pascual-Leone, 2009). Boggio et al. (2009) asserted that one of the most prominent specifications of direct electrical stimulation of the brain is the ability to make cortical changes even after the end of stimulation. They also stated that five sessions of direct anode electrical stimulation of the brain with current magnitude of 1 mA for 20 minutes results in beneficial effects in improving psychotic disorders.

In a research using tDCS, Akbari, Talebi and Fathi-Ashtiani (2015) evaluated the effectiveness of tDCS in reducing depressive symptoms in people with depression disorder. The results showed that this treatment can reduce depressive symptoms in individuals with major depression.

Soltaninejad, Nejati and Ekhtiari (2015) examined the effect of tDCS on improvement of the inhibition of individuals with attention deficit and hyperactivity

disorder. They observed that anodic stimulation (rIFG) on these people would improve inhibitory control in the inhibition of previously targeted stimuli.

Asbaghi (2016) studied the influence of tDCS on autistic people. Anodic stimulation was applied for five days on 20 individuals for 20 minutes with a current of 1mA on the left side of the forehead lobe (F₃). The results indicated that the treatment was effective in all three tests of autism (CART, ATEC and CGAS) and the score reduced dramatically in all of them.

In a meta-analysis done by Dedoncher, Brunoni, Baeken and Vanderhasselt (2014), the effect of tDCS on the posterior lateral cortex of the forehead of healthy individuals was investigated. The results showed that healthy participants responded to cognitive tasks faster, but not more correctly after a tDCS session.

A review of research shows that people with schizophrenia have attention deficit disorders. Previous studies have also confirmed the effectiveness of various interventions on improving attention in schizophrenia. Due to the fact that the effectiveness of tDCS on improving the attention of people with chronic schizophrenia has not been studied and research on the effectiveness of tDCS on improving the symptoms of schizophrenia has not been conclusive, this study aims to investigate the effectiveness of tDCS on ameliorating attention in people with chronic schizophrenia..

Method

Participants

This study is experimental having pre-test and post-test with a control group. Transcranial Direct current stimulation is considered as an independent variable and attention as a dependent variable. The population of the study was all people with chronic schizophrenia who were admitted to medical and rehabilitation centers in Ardabil (five centers with approximate number of 250 patients) in 2016. As research sample, Toubia Rehabilitation Center was selected by cluster random sampling. Among the patients with chronic schizophrenia in this center, 28 persons were selected according to the simple random sampling and randomly assigned to the experimental group (n=14) and control group (n=14). The criteria for inclusion of patients in this study were diagnosis of schizophrenia by a psychiatrist, clinical interview based on DSM-5 diagnostic criteria, and the consent of patients and their families to participate in the study. Moreover, the criteria to exclude patients from the study included non-cooperation of the patient, discharge during the intervention, and absence of even one session during the intervention and disability to understand the contents of the pre-test.

Instrument

In order to conduct the research, the following instruments were used:

Toulouse-Pieron sequential quadratic test

This test is one of the continuous performance tests that consists of a number of images of continuous squares. These squares have several patterns repeated alternately on the page. The participant must select and mark squares that are similar to the pattern squares at the top of the page within a specified time. This test has been abundantly used in mentally retarded populations and has been standardized to apply for people of Iran and various demographics (Adibsereshki, Moradi, Yadegari & Kanani, 2016). To perform the test, the participants were initially instructed on how to mark the right squares, then the test sheet was given to the participants for 5 minutes. In order to measure the scores of the participants, each correct choice was scored by one positive score whereas 0.5 negative score was considered for wrong or forgotten choices. By the summation of scores, the score of each participant was calculated. The reliability of the test using Cronbach's alpha test was 0.75 and it was estimated to be 0.81 by halving the test and the validity was obtained by performing Wechsler memory test which was estimated to be 0.81 (Pasha, Bakhtiarpour & Akhavan, 2010).

Transcranial Direct Current Stimulation Device (tDCS)

This device is small and portable and has a 9-volt battery that generates direct current which is conducted by wires to 2 electrodes. These electrodes are placed into a sponge pad soaked by saline solution to enhance electrical conductivity. The aforementioned electrodes, which include a positive pole and a negative pole are placed on the scalp. Individuals who have a heart battery or heart beat regulation and people who have scars or scratch in their scalp should not be stimulated by this device. To use the device, the electrodes must be placed in the right place of the scalp and the appropriate treatment protocol must be implemented in order to achieve the desired outcomes. About the people with epilepsy or susceptible to epilepsy, caution should be exercised in using this device. Regarding data collection method, 28 women were selected as the sample from a rehabilitation center who were randomly assigned into a control group and an experimental group. Before starting the procedure, all the participants signed the consent form. Then, the Toulouse-Pieron continued squares test was performed as a pre-test on both groups individually by a trained researcher in the rehabilitation center. The experimental group was individually treated with tDCS for 10 consecutive days in a 20-minute session every day. The prerequisite to work with the tDCS device was to participate in training workshops and receive a qualification certificate. The tDCS device used in the study was a completely standard Activa Dose II. The control group did not receive any psychological intervention. At the end of the intervention

sessions, post-test was taken by all members of both groups and the data collected from the pre-test and post-test were eventually analyzed by ANCOVA in SPSS software and the following results were obtained

Procedure

First, the patients diagnosed with generalized anxiety disorder by a psychologist or psychiatrist in clinics and counseling centers were referred to the researcher. A clinical interview was conducted to ensure the accuracy of the diagnosis of generalized anxiety disorder in patients and compliance of the diagnostic criteria of this disorder with DSM-5 diagnostic criteria with the consent of the patients. After ensuring compliance with the inclusion criteria and rejection of DSM-5 about the disorder, the researcher presented the questionnaires individually to patients in a quiet meeting in the same places referred to the treatment. After explanation on how to complete the questionnaires, the participants were asked to clear their ambiguities by asking question(s) if the items were ambiguous. There was no time limitation for completion of the questionnaires. The same procedure was used for the control group. In order to control the possible effect of the tests' order, a set of tests was presented to each subject randomly in a different order. The collected data were analyzed by multivariate analysis of variance.

Results

The average age of patients was 39.35 in the experimental group (with a standard deviation of 8.49) and it was 39.85 in the control group (with a standard deviation of 6.28) and the average duration of hospitalization for the experimental group was 3.28 years in the center while it was 5.28 years in the control group. The frequency distribution of patients in terms of education, marital status and economic status is also given for both control and experimental groups in Table 1. The descriptive results of Table 2 show that the average scores of the experimental and control groups in terms of attention in the pre-test are slightly different, while in the post-test, the average number of correct answers and total answers related to the experimental group increased as compared with the control group and the average number of incorrect and forgotten answers decreased in comparison with the control group.

Table 3 indicates that there is a statistically significant difference between the average scores of the experimental and control groups in attention and the component of forgotten responses ($p < .05$). Eta squared or effect size estimation shows that group membership of participants (receiving or not receiving tDCS intervention) explained 0.17% of the variance of scores in the forgotten responses and 0.18% of the variance of the scores in the total responses. In other words, tDCS has significantly increased attention.

Table 1. Frequency distribution of demographic characteristics (n = 28)

| Variables | Subgroups | Examination Group | | Control group | |
|-----------------|-------------------|-------------------|------------|---------------|------------|
| | | N | Percentage | N | Percentage |
| Education | Illiterate | 1 | 7.14 | 2 | 14.2 |
| | Less than diploma | 8 | 57.14 | 7 | 50 |
| | Diploma | 3 | 21.42 | 5 | 35.71 |
| | More than diploma | 2 | 14.2 | 0 | 0 |
| Marital Status | Single | 7 | 50 | 9 | 64.28 |
| | Married | 2 | 14.2 | 0 | 0 |
| | Widow | 1 | 7.14 | 0 | 0 |
| | Divorced | 4 | 28.57 | 5 | 35.71 |
| Economic Status | Weak | 3 | 21.42 | 5 | 35.71 |
| | Medium | 8 | 57.14 | 2 | 14.2 |
| | Well | 3 | 21.42 | 7 | 50 |

* To determine the economic status, education and marriage of the participants in the study, the help file and direct report of the center psychologist have been used.

Table 2. Mean and standard deviation of pre-test and post-test of attention components in experimental and control groups

| Components | Experimental group (n=14) | | | | Control group (n=14) | | | |
|------------------|---------------------------|-------|-----------|-------|----------------------|-------|-----------|-------|
| | Pre-test | | Post-test | | Pre-test | | Post-test | |
| | M | SD | M | SD | M | SD | M | SD |
| Correct Answer | 63.64 | 37.26 | 77 | 45.32 | 69.14 | 38.01 | 74.21 | 39.06 |
| Wrong Answer | 2.89 | 5.34 | 1.67 | 3.23 | 6.92 | 18.9 | 6.6 | 19.85 |
| Forgotten Answer | 9 | 11.62 | 6.35 | 9.94 | -9.1 | 14.13 | -11.32 | 15.37 |
| Total Answer | 49.6 | 42.37 | 68.96 | 48.45 | 53.1 | 46.47 | 56.28 | 47.34 |

Table 3. Results of univariate analysis of covariance, differences between experimental and control groups in attention

| Variables | Homogeneity of variance | | Pre-test effect | | effect of main group | | |
|------------------|-------------------------|-------|-----------------|--------|----------------------|-------|-------|
| | Levine test | | F | P | F | P | Eta |
| | F | P | | | | | |
| Correct Answer | 0.445 | 0.511 | 98.39 | 0.001< | 1.27 | 0.27 | 0.048 |
| Wrong Answer | 0.169 | 0.684 | 496.68 | 0.001< | 0.545 | 0.467 | 0.021 |
| Forgotten Answer | 1.45 | 0.239 | 112.78 | 0.001< | 5.242 | 0.031 | 0.173 |
| Total Answer | 0.004 | 0.951 | 157.72 | 0.001< | 5.604 | 0.026 | 0.183 |

Statistically significant difference $p < .05$

Discussion

The aim of this study was to evaluate the effectiveness of Transcranial Direct Current Stimulation on improving attention in women with chronic schizophrenia. The

results of the covariance analysis showed that tDCS led to substantial differences in the experimental group's scope of attention in the post-test stage in comparison with the control group. This means that tDCS has been effective on improving the attention of people with chronic schizophrenia. This result is in line with the findings of research by Brazil-Neto, Jeon, and Han (Smith et al., 2015). They all believe that tDCS may improve cognitive test scores in healthy individuals, especially in attention-vigilance. Also, it is in line with the results of studies by Vercammen et al., Palm et al., Skretlen et al., Hoy et al. and Tarror-Padinjarovitol et al. (Vercammen et al., 2011) on the possibility of the effectiveness of tDCS on increasing attention in people with schizophrenia. Sometimes, people with schizophrenia may not be able to focus on the environment-related aspects (inattention) or focus too much on the environment-related aspects (over-attention) (Ganji, 2006). In schizophrenic cases, attention filter which ignores a number of stimuli and processes some of them is impaired. As a result, the person is unable to control their attention and consequently their thoughts and speech and eventually it becomes difficult for them to concentrate (Rosenhan & Seligman, 2007). tDCS causes change by increasing the readiness of the nerve cell to create action potential. In fact, this method increases the flexibility of the nerve cells to create the potential for stimulant or inhibitory action.

Conclusion

In the present study, tDCS was based on the standard treatment protocol to increase attention through brain neurons stimulation to create the potential for excitatory action in the fp_2 region which is related to attention function and subsequently improves attention in people with chronic schizophrenia. Therefore, tDCS increased attention in these patients and as an easy, complementary and acceptable treatment, it can improve attention in people with chronic schizophrenia.

Despite its significant results, the present study was also associated with limitations and weaknesses which include: 1) selecting a sample of one sex (women), 2) selecting a sample from the city of Ardabil, 3) selecting a sample among people with chronic schizophrenia referred to rehabilitation centers, 4) lack of follow-up test due to time constraint which limits the generalizations of the finding, 5) lack of control over other treatments that were being performed at the same time such as medication and dosage for each patient, which can affect the results of the research, and 6) performing tests, intervention, evaluation and in all stages of the research were done by the researcher himself which can pave the way for the researcher to be biased. Due to these limitations, it is recommended that similar research and treatment be performed on men with schizophrenia. A similar study

should be conducted with large communities, consisting of people with chronic schizophrenia, in Ardabil province or at the national level. The same research and treatment can be done on all hospitalized and non-hospitalized people with chronic schizophrenia. In the future research, follow-up tests should be performed to ensure the stability of changes in the subjects. Also, control of concomitant therapies with tDCS should be monitored to ensure that the intervention is not effected by other treatments such as medication. Applying a two-way blind strategy or double deadlock to prevent researcher bias, and finally, similar research using tDCS on other symptoms and psychological defects of people with schizophrenia could be performed. It is recommended that tDCS be used in hospitals, rehabilitation centers and centers associated with schizophrenics. Moreover, owing to the multiplicity and variety of psychological problems of patients with schizophrenia, this intervention method should be used to improve other problems of people with schizophrenia.

Disclosure statement

The authors of this article declare that there was no conflict of interest.

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