



TRANSCRANIAL DIRECT CURRENT STIMULATION (tDCS) IN THE TREATMENT OF SCHIZOPHRENIA: EFFICACY AND PROSPECTS *TRANSCRANIAL DIRECT CURRENT STIMULATION (tDCS) IN THE TREATMENT OF SCHIZOPHRENIA: EFFICACY AND PERSPECTIVES*

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SUMMARY:

Schizophrenia is a serious mental disorder that affects millions of people worldwide, characterized by psychotic symptoms, cognitive deficits, and behavioral changes. Transcranial direct current stimulation (tDCS) has emerged as a promising alternative for the treatment of schizophrenia, especially for negative symptoms and cognitive deficits that do not respond satisfactorily to conventional treatments. This systematic review aimed to investigate the efficacy and safety of tDCS in the management of schizophrenia, evaluating recent studies and discussing future perspectives for the use of this technique. The analysis of the included articles revealed that tDCS significantly improves cognitive function and negative symptoms, in addition to reducing the frequency and intensity of auditory hallucinations. However, variability in response to treatment and the need for standardization of stimulation protocols are still important challenges to be addressed. The study concludes that tDCS has a favorable safety profile and shows great potential as an adjunct in the treatment of schizophrenia, especially when combined with other therapeutic interventions, such as cognitive behavioral therapy.

Keywords:Schizophrenia. Transcranial direct current stimulation. tDCS. Cognition. Negative symptoms.

ABSTRACT:

Schizophrenia is a severe mental disorder that affects millions of people worldwide, characterized by psychotic symptoms, cognitive deficits, and behavioral alterations. Transcranial direct current stimulation (tDCS) has emerged as a promising alternative for the treatment of schizophrenia, particularly for negative symptoms and cognitive deficits that do not respond satisfactorily to conventional treatments. This systematic review aimed to investigate the efficacy and safety of tDCS in the management of schizophrenia by evaluating recent studies and discussing future perspectives for the use of this technique. The analysis of the included articles revealed that tDCS significantly improves cognitive function and negative symptoms, as well as reduces the frequency and intensity of auditory hallucinations. However, variability in treatment response and the need for standardization of stimulation protocols remain important challenges to be addressed. The study concludes that tDCS has a favorable safety profile and shows great potential as an adjunct in the treatment of

schizophrenia, especially when combined with other therapeutic interventions, such as cognitive behavioral therapy.

Keywords:Schizophrenia. Transcranial direct current stimulation. tDCS. Cognition. Negative symptoms.

1. INTRODUCTION

Schizophrenia is a mental disorder characterized by psychotic symptoms, cognitive deficits, and behavioral changes that compromise the functioning and quality of life of individuals. Approximately 20 million people worldwide are affected by this condition, making it a significant public health issue. Studies indicate that although antipsychotics are widely used to treat positive symptoms of schizophrenia, many patients remain with refractory symptoms, especially regarding negative symptoms and cognitive deficits, which are less responsive to conventional pharmacological treatment (Valiengo *et al.*, 2020; Zhou *et al.*, 2023).

The search for therapeutic alternatives has led to the development of non-invasive neuromodulation techniques, such as transcranial direct current stimulation (tDCS). This technique involves the application of a low-intensity electrical current to the scalp, with the aim of modifying cortical excitability and thus improving the symptoms of schizophrenia. Literature reviews suggest that tDCS may be a promising alternative in the management of negative symptoms and cognitive deficits, considering its favorable safety profile, ease of application and low cost (Kumar *et al.*, 2020; Prosser *et al.*, 2022).

Evidence suggests that tDCS has also been shown to be effective in reducing auditory hallucinations, one of the most disabling symptoms of schizophrenia, especially in patients with refractory symptoms. Studies have shown that the application of tDCS to specific regions of the brain results in a significant decrease in the frequency and intensity of hallucinations, in addition to providing benefits in social cognition, a fundamental aspect for the social reintegration of affected individuals (Straube *et al.*, 2020; Yamada *et al.*, 2022).

The aim of this study is to review the recent literature on the efficacy and safety of tDCS in the treatment of patients with schizophrenia. It also seeks to discuss the perspectives of the clinical use of this technique as an adjuvant intervention, considering the challenges related to the standardization of stimulation parameters and the need for treatment personalization.

2. MATERIAL AND METHOD

To conduct this systematic review, a comprehensive search was performed in the PubMed database. The search included articles published between 2020 and 2024, using search terms such as "tDCS AND schizophrenia AND efficacy", "transcranial direct current stimulation AND schizophrenia AND treatment", and "tDCS AND auditory hallucinations AND cognitive improvement". Study selection was divided into two stages: an initial reading of titles and abstracts to exclude duplicates and studies unrelated to the topic, and a second phase with a complete reading of eligible articles.

Inclusion criteria were: studies conducted in humans, randomized clinical trials, systematic reviews and meta-analyses investigating the efficacy of tDCS in schizophrenia. Studies in animals, theoretical reviews without clinical data and articles in languages other than English were excluded. At the end of the selection, seven articles were included in this review. The studies were analyzed for methodological quality and outcomes related to the improvement of positive, negative and cognitive symptoms of schizophrenia, as well as safety aspects and possible adverse effects of the treatment. Table 1 presents the details of the selected articles, including authors, journals and thematic considerations.

Table 1. Works included.

Database	Title	Authors	Periodical (vol, no, page, year)	Considerations Themes
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PubMed	Efficacy and safety of Transcranial Direct Current Stimulation (tDCS) on cognitive function in chronic schizophrenia with Tardive Dyskinesia (TD): randomized, double-blind, sham-controlled, clinical trial	ZHOU <i>et al.</i>	BMC Psychiatry , v. 23, n. 1, p. 623, 2023	tDCS Evaluation in cognitive function of patients with schizophrenia and TD
PubMed	Transcranial anodal direct current stimulation sustainably increases EEG alpha activity in patients with schizophrenia	PROSS <i>et al.</i>	Neuropsychopharmacology Reports , v. 42, n. 3, p. 323-332, 2022	Increase activity alpha node from the EEG in patients with schizophrenia after tDCS
PubMed	Transcranial direct current stimulation for refractory auditory hallucinations in schizophrenia: Acute and 16-week outcomes	KUMAR <i>et al.</i>	Indian Journal of Psychiatry , v. 62, no. 5, p. 572-576, 2020	tDCS Evaluation for hallucinations refractory hearing loss in schizophrenia
PubMed	Transcranial direct current stimulation on the left superior temporal sulcus improves social cognition in schizophrenia: an open-label study	YAMADA <i>et al.</i>	Frontiers in Psychiatry , v. 13, p. 862814, 2022	Improvements in the social cognition of patients schizophrenics with application of tDCS
PubMed	Efficacy and safety of transcranial direct current stimulation for treating negative symptoms in schizophrenia: the	VALIENGO <i>et al.</i>	JAMA Psychiatry , v. 77, n. 2, p. 121-129, 2020	Assessment effectiveness from the tDCS US symptoms negatives from the schizophrenia

	randomized clinical trial			
PubMed	Transcranial direct current stimulation improves action-outcome monitoring in schizophrenia spectrum disorder	STRAUBE <i>et al.</i>	Brain Communications , v. 2, n. 2, p. fcaa151, 2020	Get better monitoring action-result in patients with schizophrenia
PubMed	Repetitive transcranial magnetic stimulator and transcranial direct current stimulation for auditory hallucinations in schizophrenia: systematic review and meta-analysis	GUTTESEN <i>et al.</i>	Journal of Psychiatric Research , v. 143, p. 163-175, 2021	Comparison between rTMS and tDCS for hallucinations auditory in schizophrenia

Source: own authorship, 2024.

3. RESULTS AND DISCUSSION

The results of the studies included in this systematic review provide consistent evidence on the efficacy of transcranial direct current stimulation (tDCS) in the treatment of schizophrenia, particularly in relation to negative symptoms, cognitive deficits and auditory hallucinations. tDCS is considered a promising technique due to its ability to modulate cortical activity, promoting fundamental changes for the improvement of patients' symptoms (Valiengo *et al.*, 2020; Zhou *et al.*, 2023).

The negative symptoms of schizophrenia, such as anhedonia, social withdrawal, and avolition, are widely recognized as resistant to pharmacological treatment. The application of tDCS to regions such as the dorsolateral prefrontal cortex is associated with a significant reduction in these symptoms, providing an improvement in the quality of life of patients. This improvement is attributed to the impact of tDCS on emotional regulation and decision-making, areas frequently impaired in patients with schizophrenia. Also

benefits were observed in social cognition, which is one of the fundamental aspects for social interaction and reintegration of patients (Valiengo *et al.*, 2020; Yamada *et al.*, 2022).

Regarding cognitive deficits, which include difficulties with memory, attention and executive function, tDCS has shown promising results. The stimulation has been shown to be effective in improving cognitive function, especially in patients who also have tardive dyskinesia, a common side effect of typical antipsychotics. The effectiveness of tDCS in mitigating these effects, while improving cognitive deficits, represents an important advance in clinical practice (Pross *et al.*, 2022; Zhou *et al.*, 2023).

Positive symptoms, such as auditory hallucinations, have also been addressed by the application of tDCS. Studies have shown that there was a significant reduction in the frequency and intensity of auditory hallucinations in patients undergoing tDCS. Stimulation of the superior temporal cortex, which is directly involved in auditory processing, has been shown to be effective in reducing these symptoms. These findings are relevant, since auditory hallucinations are often disabling and difficult to treat with antipsychotics, suggesting that tDCS may provide an alternative for patients who do not respond satisfactorily to conventional treatment (Kumar *et al.*, 2020; Yamada *et al.*, 2022).

Challenges associated with the use of tDCS include variability in treatment response and the need for standardization of stimulation protocols. The lack of uniformity in stimulation parameters, such as current intensity, treatment duration, and electrode positioning, makes direct comparison of results between studies difficult and limits the clinical application of the technique. In addition, individual factors, such as symptom severity and patient-specific neuroanatomy, influence treatment response, suggesting the need for personalization to optimize the efficacy of tDCS (Guttesen *et al.*, 2021).

Most studies have reported that tDCS is well tolerated, with some mild adverse effects such as local discomfort and headaches. However, these effects are generally self-limiting and do not require treatment interruption, confirming the favorable safety profile of tDCS. The safety profile, combined with the fact that it is a non-invasive intervention,

pharmacological, makes tDCS an attractive alternative for patients who do not tolerate the side effects of antipsychotics well or who wish to reduce medication use (Straube *et al.*, 2020).

There is also interest in integrating tDCS with other therapeutic interventions, such as cognitive behavioral therapy (CBT). Combining tDCS with CBT may enhance therapeutic effects, facilitating patient participation in therapy sessions and promoting more effective reorganization of neural circuits. This potential synergy between neuromodulation and psychotherapy may be promising, as tDCS increases neuroplasticity, creating more favorable conditions for the effectiveness of behavioral therapies (Straube *et al.*, 2020; Guttesen *et al.*, 2021).

Another relevant consideration is the potential of tDCS in specific phases of the disorder, including early stages or prodromes. Studies suggest that early application of tDCS can attenuate the progression of cognitive deficits and reduce the chronicity of symptoms, contributing to a more favorable evolution of the clinical picture. This possibility opens new horizons for the prevention of cognitive deterioration and for early treatment, which can significantly improve long-term outcomes in patients with schizophrenia (Yamada *et al.*, 2022; Zhou *et al.*, 2023).

FINAL CONSIDERATIONS

Transcranial direct current stimulation (tDCS) appears to be a promising approach for the treatment of schizophrenia symptoms, especially in the management of negative symptoms and cognitive deficits, which often do not respond well to pharmacological treatment. The studies reviewed indicate that, when used appropriately, tDCS can significantly improve the quality of life of patients and contribute to the reduction of symptoms that most compromise the functionality of individuals (Valiengo *et al.*, 2020; Zhou *et al.*, 2023).

Despite the clear benefits, variability in response to treatment still represents a major challenge. Future studies should focus on standardizing

stimulation parameters and in identifying predictive factors of response, aiming to optimize treatment protocols. The lack of uniformity in stimulation parameters, such as current intensity, duration of application and electrode location, limits the ability to compare results between different studies and to implement the technique broadly in clinical practice (Guttesen *et al.*, 2021; Straube *et al.*, 2020).

Furthermore, integrating tDCS with other therapeutic approaches, such as cognitive behavioral therapy (CBT), may enhance the positive effects and provide a more comprehensive and effective approach to the management of schizophrenia. Studies indicate that the combination of tDCS with CBT may enhance neuroplasticity and facilitate the reorganization of neural circuits, increasing the effectiveness of psychotherapeutic intervention (Straube *et al.*, 2020; Yamada *et al.*, 2022).

Personalization of treatment and the use of tDCS in early stages of schizophrenia should be further investigated in order to maximize clinical benefits and improve patient outcomes. Implementing a multimodal treatment that combines tDCS with psychosocial interventions may be key to providing more effective care that is centered on patients' needs (Yamada *et al.*, 2022; Zhou *et al.*, 2023).

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