Effect of transcranial direct current stimulation on smoking craving in tobacco smokers

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Deanship of Scientific Research

Introduction

Tobacco smoking is one of the leading causes of mortality and morbidity worldwide. It affects many systems in the body and causes serious and life-threatening conditions like lung cancer, stomach cancer, oral cancer, cardiovascular diseases and osteoporosis (1–6). According to the world health organization (WHO), tobacco smoking kills up to half of its users, with an estimation of 7 million death per year. Tobacco users who die prematurely deprive their families of income, raise the cost of healthcare and hinder economic development (7). It has been estimated that, globally, smoking causes over 500 billion US dollar in economic damage each year (8). In Saudi Arabia, about six million smokers are between the age of 17 and 40 (9). 51.1% of them attempted to quit smoking. 88% of whom tried to quit could not last a year or more (10).

Most tobacco smokers who attempted to quit smoking fail to achieve such goal. The high rate of relapse in smoking cessation is strongly induced by craving for nicotine (11). Despite this crucial importance, many methods have been introduced in the past years to help people quit smoking, but unfortunately, favorable outcomes of accepted treatments have not been significant in the long run. These include new drugs to treat nicotine dependence, new ways of using existing medicines and increasing use of technology to support behavioral changes (12). Trans-cranial direct current stimulation is a safe noninvasive brain stimulation technique that functions by electrical cortical excitability (13). It has been used in many medical experimental trials for treating some diseases (14,15) and control addiction (16–18). While few studies have applied transcranial direct current stimulation (tDCS) to smoking addiction, existing work suggests that it is a promising technique for smoking cessation by increasing the dorsolateral prefrontal cortex (DLPFC) activity and integrity. (19). So, we hypothesized that tDCS over the DLPFC might be a promising therapeutic approach to treat nicotine dependence.

The goal of this study was to test whether tDCS applied over the DLPFC modulate nicotine intake in tobacco smokers.

Objectives

1. To determine the effect of transcranial direct current stimulation on smoking craving during 3 days successive sessions.
2. To explore the effects of transcranial direct current stimulation on cognition and safety aspects by using CANTAB and adverse events questionnaire.

Methodology

Study design: The study was a double-blinded sham-controlled experimental trial. First, each subject signed a written informed consent. Then, Fagerstrom Test for Nicotine Dependence (FTND) questionnaire was filled to evaluate the addiction level for each subject. After that, each subject took the test of Cambridge Neuropsychological Test Automated Battery (CANTAB) to assess his cognitive function. And then the subject received transcranial direct current stimulation over the dorsolateral prefrontal cortex for three consecutive days. After each session the subjects took a questionnaire for potential side-effects. After finishing the third session each subject underwent CANTAB test again to assess the cognitive function after the stimulation.

Participants: Twenty-two male subjects took part in the study, with mean age was 24.4 years. Participants were randomized into the following two groups: active tDCS group, 12 participants; sham tDCS group, 10 participants.

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Inclusion and exclusion criteria: Inclusion required subjects to be cigarette smokers who are willing to quit smoking. Subjects must be at the age of 18 years or older. With no history of neurological or psychological disorders such as epilepsy or strokes or any previous head surgeries. Participants were excluded if they presented with any skin disorder at or near stimulation locations (where electrodes are placed), such as eczema, rashes, or other skin defects.

Transcranial direct current stimulation (tDCS):

Small electrodes, were placed over the right DLPFC at F4 (cathdoal) and area, (F3; return electrode). During cathdol stimulation, direct current was delivered from a current-control circuit in the battery-driven stimulator within the control box device. The current was set at 1.5mA intensity and applied for 20 minutes for 3 consecutive days. For the sham stimulation, electrodes were placed in the same position and participants received a short ramp up (20sec total up / down) at the beginning and end of the stimulation period.

Cognitive function assessment

We performed a brief battery of cognitive testing assessing attention and working memory to evaluate whether the cortical stimulation can affect the cognitive functions such as (1) Pattern recognition memory (PRM); (2) Attention switching task (AST) before the first and after the last session. Each subject performed a training session in order to get familiar with the tests. Subjects were familiarized with the cognitive function tests for the first time by the investigators.

Evaluation of Adverse Effects:

In addition all subjects completed the Transcranial Direct Current Stimulation Adverse Effects Questionnaire at the end of each session to evaluate potential common adverse effects of tDCS such as headache, neck pain, tingling, skin redness at the site of stimulation that are reported as the most common adverse effects of tDCS. This form also allowed us to investigate other side effects not tested there.

Data analysis

Data was analyzed using SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Categorical data was expressed as absolute numbers and percentages. Numerical data was expressed with mean, median and standard deviation (SD). Two-tailed P values less than 0.05 were considered statistically significant.

Results:

Wilcoxon signed-rank test was used because the data have two samples (pre-stimulation & post-stimulation) with repeated same measure (number of smoked cigarettes) and the sham was not normally distributed. We compared between the two groups in three different time intervals; 6 days and 18 days. In the 6 days' interval (3 days before stimulation and 3 days following stimulation), the number of smoked cigarettes was reduced similarly in active as well as in sham group with significant difference between before and after stimulation (p=0.007). Furthermore, when 18-days data were compared (7 before and 10 after the first session of stimulation), the active group showed a significant change after stimulation (p=0.004). This change is also notable in the sham group with a significant difference between before and after stimulation (p=0.005). Moreover, there is no statistically significant difference when we compared the reduction percentage between the active and sham groups in 6 days' interval or 18 days' interval with (p=0.76) and (p=0.649) respectively.

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Conclusion

Despite existing availability for tobacco addiction treatments, there are still smokers, who are unable to quit with standard pharmacological and behavioral therapies. Brain stimulation techniques represent novel and potentially useful treatment modalities for tobacco addiction. However, our results from this work suggest that modulation of right DLPFC with cathodal tDCS did not show a significant difference between active and sham groups. Despite the limitations; this is the first study trying to evaluate the effect of non-invasive brain stimulation on the smoking cessation in the middle eastern region.

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Graphs & Tables

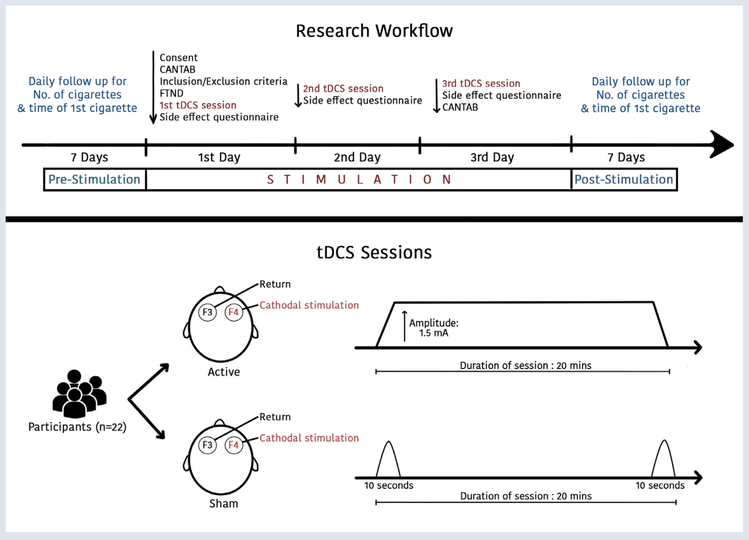


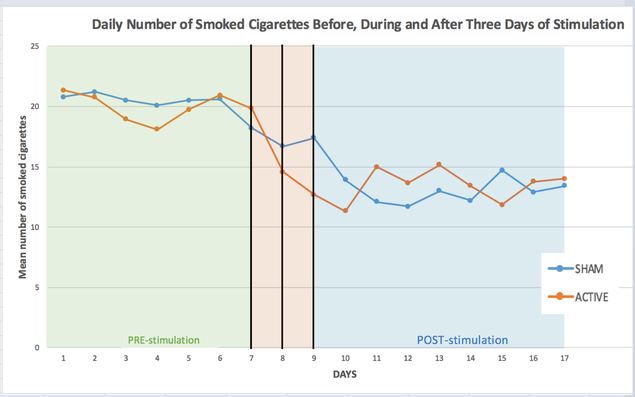
Table 5. Comparing number of smoked cigarettes between mean number after 4 months of stimulation and before starting of stimulation/immediately after stimulation

	Mean after 4 months	Pre-stimulation		Immediately Post-stimulation	
		mean	*p* value	mean	*p* value
All smokers (n= 18)	21.5 (11.01)	20.5 (8.31)	0.586	15 (8.27)	0.01
Active group (n=10)	21.6 (10.26)	20.1 (7.27)	0.445	15.8 (6.95)	0.013
Sham group (n=8)	21.4 (12.7)	21 (9.97)	1.000	14.1 (10.12)	0.017

Table 2. Number of smoked cigarettes pre-stimulation and 11 post-stimulation analyzed by Wilcoxon signed-rank test.

	Pre-stimulation (mean)	Post-stimulation (mean)	*P* value
Active stimulation [a]	19.94	13.49	0.004
Sham stimulation [a]	20.27	13.77	0.005
Active stimulation [b]	20.17	13	0.007
Sham stimulation [b]	19.77	14.467	0.007

a. 18 days' follow-up.
b. 6 days' follow-up



Acknowledgment

"The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding this work through the Undergraduate Research Support Program, Project no. (USRSP-17-16)."