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PROCEEDINGS #26. THE EFFECT OF COOLING ELECTRODES ON TDCS TOLERABILITY

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1. Abstract

Cooling of electrodes may theoretically impact tDCS in several ways: 1) tolerability (mild sensations typically during tDCS) may change in skin temperature; 2) temperature related to changes in skin conductivity may alter current flow to the brain; 3) storage of electrodes, especially when pre-saturated, under cool conditions may enhance shelf-life. While tDCS has been showed to not significantly increase skin temperature as a result of current passage, the intial temperature of the sponge will influence the skin (e.g. cool the skin). In a single-blind, randomized, cross-over trial, we compared tolerability during tDCS using room temperature (25-35 °C) vs chilled sponges (3-5 °C). A conventional TDCS dose of 2 mA, 20 min, 5x5 cm electrodes in the M1-SO montage was used. Primary outcomes were subjective pain VAS during tDCS, as well as tolerability questionnaires and visual inspection of the skin after tDCS. We report no significant difference in these measures between the room temperature and cooled electrodes conditions.

2. Introduction

While transcranial Direct Current Stimulation (tDCS) is considered a well-tolerated technique [1],[2], mild side-effects that are common are largely associated with sensation at the skin [3],[4], [5]. Skin sensation is, in turn, determine by stimulation dose [6] and electrode design and preparation [7]. Despite resulting attention to electrode design [8], [9], [10], [11], [12], the role of electrode temperature in tDCS tolerability was not previously assessed. It has been shown that the passage of current during tDCS does not produce an incremental increase in skin surface temperature compared to sham stimulation [13], [14] but not if controlling starting electrode temperature effects tolerability.

The aim of this study was to investigate the effect of reducing sponge electrode temperature, from room to “refrigerated” levels (~30 to ~ 4 °C), on the tolerability of tDCS. In a single-blind cross-over design subjects reported discomfort through pain VAS during tDCS and completed a tolerability questionnaire after tDCS [15]. Skin erythema and integrity was assessed by expect to score of processed images of the skin after and before tDCS [16].

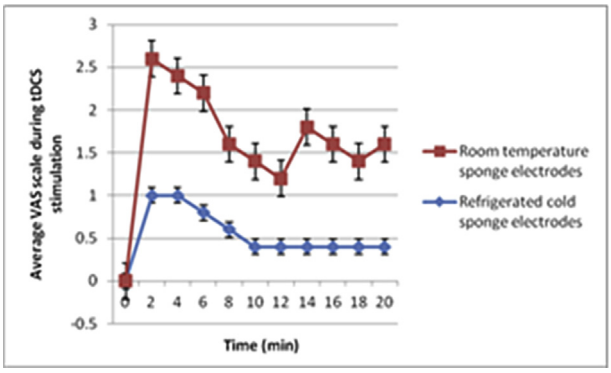

Fig. 2. Average VAS scale during tDCS stimulation at each time point.

Reducing sponge temperature has further theoretical implications beyond tolerability. Changing skin conductivity has been proposed to alter the path of current through the skin and across the head, thereby changing brain stimulation [17]. Storage of sponges under refrigerated conditions can enhance shelf-life especially as single-use pre-saturated electrodes are adopted. While these issues are not assessed here, tolerability of cold sponge is an important step. More broadly, should initial sponge temperature influence tolerability, it may be an important variable to control and report for tDCS reproducibility.

3. Methods

A single- blind, randomized, cross-over trial was conducted to determine the effect of cold electrodes (3-5°C) vs room temperature sponges (25-35°C) of tDCS on subjective VAS pain. Sessions were separated by twenty-four hours. tDCS was applied (1x1 tDCS. Soterix Medical, New York) with a current intensity of 2 mA and duration of 20 minutes with sponge size of 5 cm x 5 cm (EasyPads, Soterix Medical). The temperature of the electrode was measured before and after stimulation by placing a temperature probe (Fluke 52 digital thermometer, Fluke Corporation, Everett, WA) between the sponge and the rubber in the middle of the electrode.

The cathode electrode was placed on the Super Orbital region and the anode electrode at C3 (the common M1-SO montage). During tDCS stimulation, the subjects reported their pain score every 2 minutes using Visual Analog Scale (VAS). The Visual Analog Scale (VAS) was represented by a horizontal line with 10 increments, from 0 - no pain to 10 - severe pain, with cartoon faces further mapped to a brief description and a visual representation. Tolerability was also assessed using tDCS adverse event pre-questionnaire and post-questionnaire. For the adverse event reporting form, the subjects were asked to report severity from 1-absent to 5-extreme for sensations such as skin tingling, skin itching, and headache.

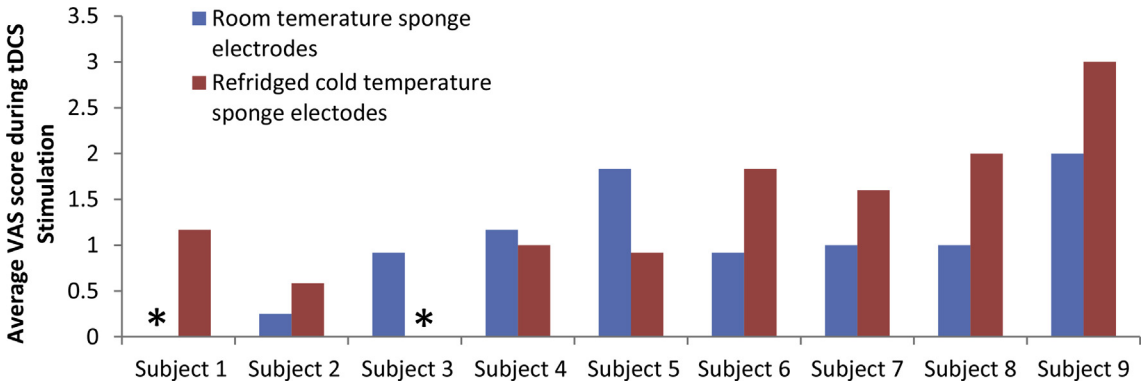

Fig. 1. The average VAS scores during tDCS Stimulation for refrigerated sponge electrode was compared with average VAS scores for room temperature sponge electrode with a sample size of 5. The asterisk (*) symbol represents a missing average VAS score from a subject. The error bars shows the standard error of the mean. The average VAS scores for refrigerated electrode sponge were not significantly different compare to the average VAS scores for room temperature electrode sponge.

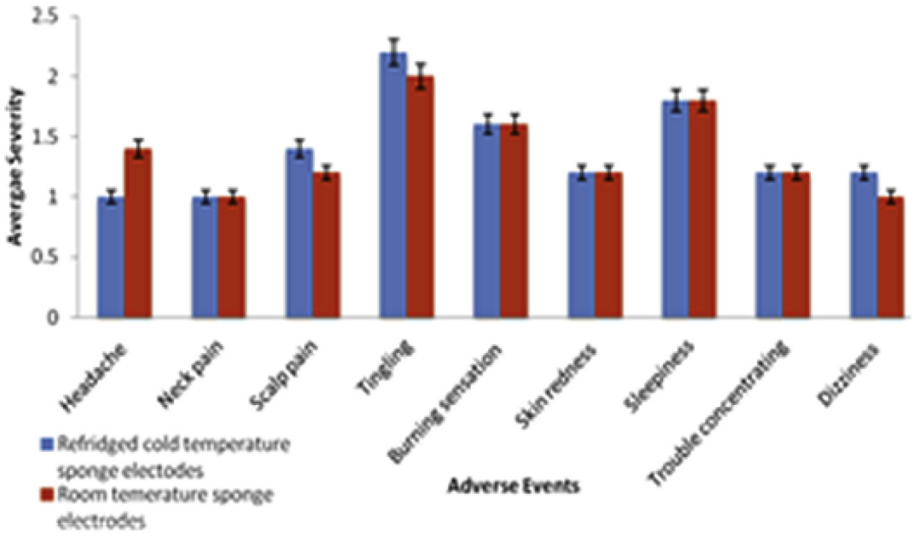

Fig. 3. The adverse severity for headache. Neck pain, scalp pain, tingling, burning sensation, skin redness, sleepiness, trouble concentration, and dizziness were compared between the refrigerated sponge electrode and room temperature electrode.

In order to distract the subjects, the subjects performed lexical decision task using E-Prime Software. On the computer screen, subjects were presented with a mixture of English language words, for example, "true", and pseudo-words, for example, "canorous". Their task was to indicate with a button press, whether the presented stimulus was an English language word or pseudo-word. The performance on this task were not analyzed.

4. Results

There was no significant difference between the VAS scores of the subject using room temperature electrode sponges (M=0.833, SD=0.734) and the VAS scores for the subject using refrigerated electrode sponges (M=0.733,SD= 0.4617).

5. Conclusions

We speculate an important methodological was that ~10 min was spent setting up the tDCS stimulation for each subject. This allowed time for the refrigerated temperature sponges warmed up on the head, and the skin to cool down under the sponges. Evidently, we cannot exclude an effect of temperature on tolerability too small for our sample size, or at other stimulation doses (e.g. 3 mA) and for repeated sessions (e.g. daily), or in a different population (e.g. children). None the less, these results suggest that for the temperature comparison made, cooling sponges does not necessarily affect tolerability significantly. This means cooling sponges does not confer a particular benefit or risk in regards to sensation, and in this sense cooling neutral if done for another purpose such as shelf life or current flow.

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