

Anodal tDCS of the lower limb M1 does not acutely affect clinical blood pressure and heart rate in healthy and post stroke individuals

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Abstract

Transcranial direct current stimulation (tDCS) is a non-invasive brain stimulation technique increasingly investigated as an adjunct modality to enhance the effects of motor therapy. Although the safety of tDCS in relation to cognition, sensation and perception has been well reviewed, there still exists limited information regarding its effects on blood pressure and heart rate. As tDCS is being largely used in conjunction with stroke rehabilitation, it is important that we understand the effects of tDCS on autonomic function in the stroke population. In this retrospective study, we examined the acute effects of tDCS of the lower limb motor cortex in healthy and post stroke individuals using clinical measurements of blood pressure and heart rate. Fifteen minutes of 1 mA anodal tDCS did not cause any clinically detectable changes in blood pressure or heart rate. This is the first study to report the cardiovascular autonomic effects of tDCS of the lower limb M1 in healthy and post stroke individuals. Further studies are needed to examine if these safety effects are preserved during repeated applications of tDCS.

Keywords: tDCS; autonomic function; stroke; safety

Introduction

Transcranial Direct Current Stimulation (tDCS) is a non-invasive brain stimulation technique demonstrated to modulate neuronal excitability, and enhance cognitive and motor function in neuromotor and neuropsychiatric conditions [1,2]. The simplicity, low cost and high safety of tDCS makes it a potentially promising adjunct modality to be used in conjunction with therapy in the clinic or at home. The safety of tDCS in relation to cognition, sensation and perception has been well reviewed. tDCS of the motor cortex within the current safety guidelines is reported to have relatively minor adverse effects [3,4]. However, safety reports on the effects of tDCS on cardiovascular autonomic function are limited and results are conflicting [5]. Some studies suggest that tDCS may shift autonomic function towards a more sympathetic tone [6, 7], while other studies reported no change in sympathovagal balance [8,9]. Most of the above studies have used spectral analyses of ECG to examine heart rate variability and blood pressure. Although this type of analyses provides a comprehensive investigation of autonomic function, it is not

always feasible or time-saving to monitor patients using ECG especially when delivering tDCS in the outpatient clinic or at home. In addition, to the best of our knowledge, there is no information yet on the effects of tDCS on autonomic function in stroke survivors. Since autonomic function is compromised in individuals post stroke and as tDCS is being increasingly used for stroke rehabilitation [10], it is important to clarify its effects on cardiovascular function in stroke. Also, as most tDCS studies focus on the upper limb motor cortex (M1) or pre frontal areas, autonomic effects of tDCS of the lower limb M1 in healthy individuals or patients has never been examined. This is important to study due to basic differences between the upper and lower extremities in anatomical location of motor maps, differences in sensorimotor organization and differences in motor task performances (lack of fine control and more automated movement for the lower limb) which may result in a differential response of tDCS. Hence in this study we examined the effects of tDCS of the lower limb M1 on cardiovascular autonomic function using clinically used measurements such as heart rate and blood pressure in healthy and stroke participants.

Methods

This post hoc analyses combined data from four different studies from our laboratory with similar tDCS parameters. Data from 31 young healthy adults (15 females, 16 males; age range 20 – 34 years) and 19 individuals with stroke (8 females, 11 males; 50 – 75 years) were included. Stroke participants' who had only one stroke with no other significant medical conditions, and well managed hypertension were recruited. Healthy participants with no history of neurological, cardiovascular or other metabolic conditions participated. All research methods were approved by University of Illinois' Institutional Review Board.

tDCS

tDCS was administered using a constant current stimulator (Chattanooga Ionto Iontophoresis System, TN) for 15 minutes at 1 mA. The active electrode (5 cm x 2.5 cm) saline-soaked sponge electrode was placed on the motor hot-spot (determined using transcranial magnetic stimulation) of the non-dominant/affected

tibialis anterior muscle. The reference electrode (7 cm x 5 cm) rectangular carbonized electrode was placed on the contralateral supraorbital area. All participants performed a visuomotor task using ankle dorsiflexion and plantarflexion during tDCS. This motor task has been explained previously[11-13]. All healthy individuals participated in one session of anodal tDCS. Individuals with stroke participated in 2 sessions: anodal tDCS and sham tDCS. During sham stimulation, current was ramped up at the beginning of stimulation but no actual current was delivered.

Heart Rate and Blood Pressure Collection

Heart rate and blood pressure measurements were collected while the patient was seated at four different time points: prior to the administration of tDCS (PRE), twice during stimulation (5 and 10 minutes - DUR5 and DUR10), and immediately after end of tDCS (POST). A clinically available Omron 10 Series Automatic Blood Pressure Monitor (Omron, Illinois) was used on the right (or unaffected) arm to measure blood pressure. A Polaris heart rate chest monitor (Polar Electro Inc, NY) was used for heart rate measurements.

Data analyses

Heart rate (HR; beats per minute), systolic (SBP, mm Hg) and diastolic (DBP, mm Hg) blood pressure were the dependent variables. A repeated measures ANOVA was conducted using SPSS v21 (IBM, Illinois) to examine the main effects of Time (PRE, DUR5, DUR10 and POST) for each dependent variable in healthy individuals. A 2-way repeated measures ANOVA was conducted to examine the main effect of Time (PRE, DUR5, DUR10 and POST) and condition (tDCS, Sham) for each dependent variable in individuals with stroke. A significance level of 0.05 was adopted.

Results

All participants completed the tDCS sessions without any report of adverse events. No significant effects main effects or interactions were noted for any of the variables for the healthy and stroke group ($p > 0.05$). Overall pre-post changes in all variables did not exceed $\pm 3\%$. Means and SEM of HR, SBP and DBP are shown in Figures 1, 2 and 3 respectively.

Discussion

This is the first study to examine the effects of anodal tDCS of the lower limb M1 on BP and HR in stroke survivors and healthy individuals using simple clinical measurements. Our results showed that a single session of lower limb M1 tDCS does not cause any clinically detectable changes in individuals with stroke or healthy controls. Our results support other studies that reported no differences in heart rate and blood pressure in healthy individuals [8,9]. We noticed a trend towards a decrease in HR and BP. Interestingly, this is in contrast to studies that reported a trend towards increase in sympathetic predominance in healthy adults after anodal tDCS of the upper limb M1[6,7]. It is possible that the lower limb M1 could differentially affect autonomic flow due to variations in the termination of the corticospinal and corticobulbar pathways compared to the upper limb M1[14].

There has been a recent surge of the use of tDCS for stroke

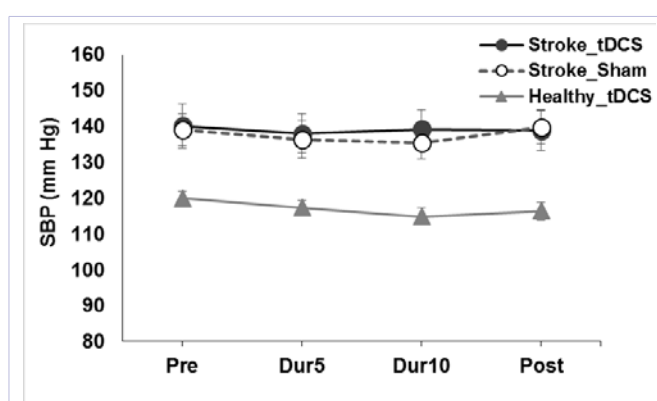


Figure 1: Modulation of systolic blood pressure (SBP) over time for the three groups: healthy individuals who received anodal tDCS (triangles), individuals with stroke who received anodal tDCS (filled circles) and individuals with stroke who received sham tDCS (open circles). The x-axis depicts SBP and y-axis represents the different time points with respect to administration of tDCS: before (PRE), during (DUR5 and DUR10) and after (POST). Data points represent means and error bars represent standard error. No acute changes were noted.

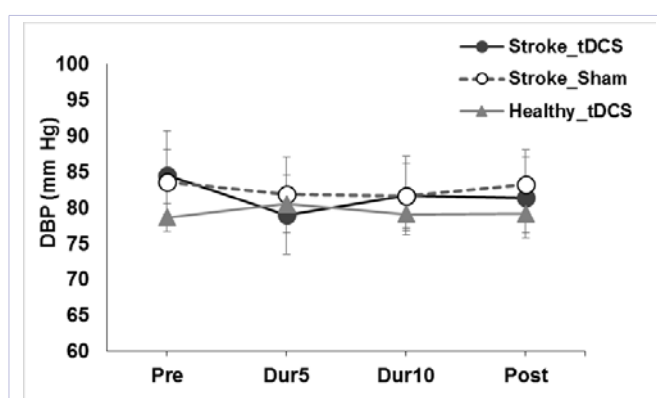


Figure 2: Modulation of diastolic blood pressure (DBP) over time for the three groups: healthy individuals who received anodal tDCS (triangles), individuals with stroke who received anodal tDCS (filled circles) and individuals with stroke who received sham tDCS (open circles). The x-axis depicts DBP and y-axis represents the different time points with respect to administration of tDCS: before (PRE), during (DUR5 and DUR10) and after (POST). Data points represent means and error bars represent standard error. No acute changes were noted.

rehabilitation. As autonomic function is typically compromised in this patient population, it is important to understand the clinical safety of the tool in post stroke individuals. As expected, we noticed a higher baseline BP and HR in patients compared to the healthy controls. However 15 minutes of 1 mA tDCS application did not further compromise these vital parameters. Future studies are needed to characterize the safety aspects of this clinical tool during repeated application, with larger dosages and when used in combination with other exercise regimens.

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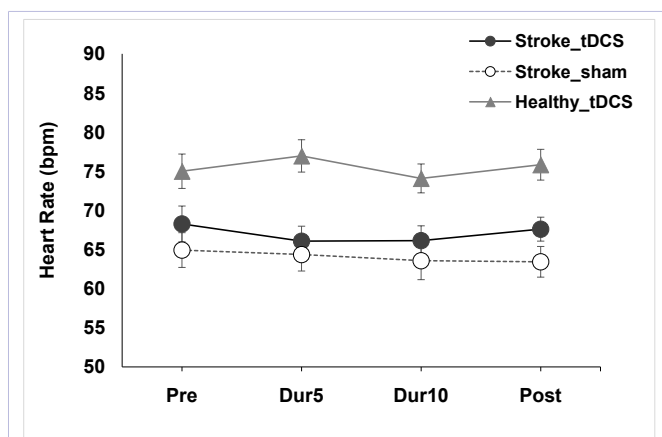


Figure 3: Modulation of heart rate (HR) over time for the three groups: healthy individuals who received anodal tDCS (triangles), individuals with stroke who received anodal tDCS (filled circles) and individuals with stroke who received sham tDCS (open circles). The x-axis depicts HR (beats per minute) and y-axis represents the different time points with respect to administration of tDCS: before (PRE), during (DUR5 and DUR10) and after (POST). Data points represent means and error bars represent standard error. No acute changes were noted.

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