Transcranial Direct Current Stimulation Improves the Cycling Performance but Does Not Alter Neuromuscular Function
tDCS, Cycling Performance and Neuromuscular Function

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1 OBJECTIVES

The main neurophysiologic mechanisms that determine performance in physical activities or sports are not well understood. This is mainly due to the lack of technology that permits the study of the human brain *in vivo*. In the last decades some neuromodulation techniques have been developed and, among them, the transcranial direct current stimulation (tDCS) has been attracting attention as it is easily applicable and permits to carry out well controlled studies in humans, and has been shown to be a strategy to enhance physical and mental performance in sports (Davis, 2013).

Therefore, the objective of the present study was to investigate the effects of anodic tDCS on the physical performance and neuromuscular function in cycling exercise.

2 METHODS

A total of 11 physically active subjects aged 26 ± 4 years, weighing 77 ± 15 kg and 177 ± 3 cm tall participated in study. Initially all subjects performed an incremental test in a cyclesimulator (model Velotron DYNAFIT PRO™, RacerMate Inc., USA) to determine the peak power (257 ± 35 W). In the two subsequent visits to the laboratory the subjects were randomly submitted to one of the two stimulation conditions (Anodic tDCS or Placebo tDCS) to verify their possible effect on a time to exhaustion task at 80% of peak power (205 ± 28 W). This study was approved by the local Institutional Research Ethics Committee.

Stimulation was carried before each test during 13 min, with a current intensity of 2.0 mA. The time between tDCS and the test was 10 min. Sessions were separated by a minimal interval of 48h. We used the 10-20 International System for EEG electrode placement. The active electrode (9x4 cm) was placed on the scalp having its center in the region Cz 4.5 cm on each side of the head (purpose of stimulating the motor cortex of both hemispheres), and the reference electrode was positioned over the bulge.

Additionally, the electromyographic (EMG) signal of the muscle vastus lateralis (VL) was monitored during tests after stimulation and expressed in mean values of RMS - root mean square (μV) and MF - median frequency (Hz) with a 5-second window period. For EMG signal normalization a test for torque-speed [T–V test] was used (Rouffet and Hautier, 2008).

For the recording the of EMG signal, was used an electromyography model TeleMyo 2400TG2™ (NORAXON Inc., USA) and bipolar active EMG electrodes (modelo TeleMyo 2400™, NORAXON Inc., USA), with interelectrode distance fixed at 2 cm, which were placed in the right leg muscle and fixed with a adhesive tape. Initially, a trichotomy followed by asepsis with alcohol and curettage of the electrode site, to reduce skin impedance, was performed.

The localization of anatomical point for the electrode placement on the analyzed muscle was done according to the standardization proposed by the Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles ISEK: International Society of Electrophysiology and Kinesiology (SENIAM). The sampling frequency of the EMG signals was 2.000 Hz. The signal passing limit was ±5 mV, and the common-mode rejection ratio was 95 dB.

To obtain the values expressed in RMS, the raw EMG signals were submitted to a band-pass digital filter of 20 and 500 Hz and then rectified and smoothed. The MF was determined using Fourier analysis —''Short-Time Fast Fourier Transform'' — and the signals were processed in the mathematical simulation environment MatLab 7.0™ (Mathworks

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Inc., USA). For statistical analysis of the data was used paired Student *t*-test and ANOVA two-way. Significance level was set at 5%.

3 RESULTS

The results demonstrated that there was an increase ($p<0.05$) in exercise time when individuals received Anodic tDCS (491 ± 100s) in comparison to Placebo tDCS (407 ± 69s). These results were confirmed by the size effect (anodic x placebo = 0.77). When the magnitude-based inference was applied, the anodic stimulation condition was most probably positive to individuals when compared to placebo conditions.

However, no significant differences were found for the parameters of neuromuscular function - EMG signals RMS (Figure 1A) and MF (Figure 1B) - among the two experimental conditions.

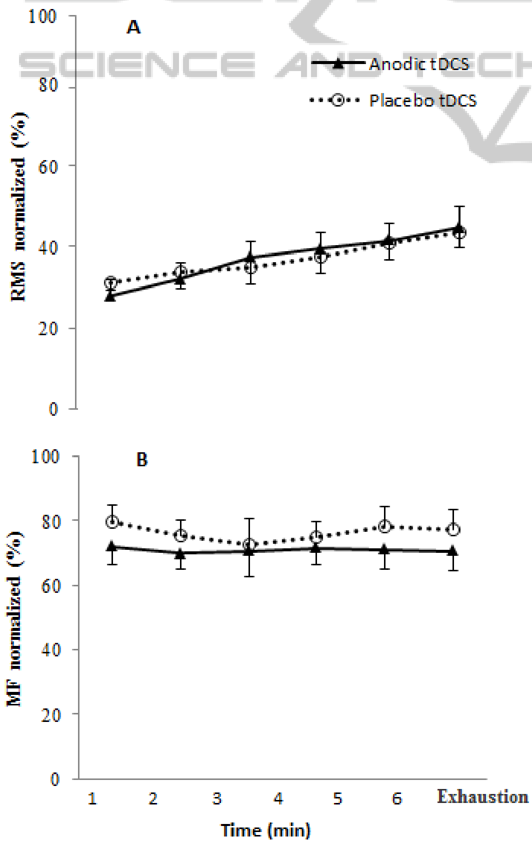

Figure 1: EMG signal of the muscle vastus lateralis (VL) monitored during the tests and expressed as mean values of RMS and MF in the conditions Anodic tDCS or Placebo tDCS.

4 DISCUSSION

The increase in exercise time with application of anodic current has been shown previously in isometric exercise of the upper limb. Cogiamanian et al. (2007) showed that anodal stimulation (1,5 mA), applied for 10 min after a fatigue test increased tolerance to an exercise performed subsequent to stimulation without changes in EMG. These findings are in agreement with those found in this study. Furthermore, some authors have shown that tDCS can improve performance on other tasks increasing muscle strength. Tanaka et al. (2009) have shown that, in healthy subjects exerting pinch strength in the toes, the anode tDCS causes increases in strength both during and after 30 min of stimulation. More recently, in another study with patients who have suffered stroke, Tanaka et al. (2011) found an improvement in knee extension strength of the paretic leg during application of anodal tDCS, but after 30 minutes there was no difference (Tanaka et al., 2011). Thus, it may be concluded that anodic TDCS increases exercise time. However, the mechanisms responsible for the greater exercise tolerance are speculative. It is possible that the increase in intracortical facilitation causes the individual to support longer in exercise.

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