Repeated sessions of transcranial direct current stimulation (tDCS) with vertical jump training improve vertical jump performance in elite athletes

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1. Introduction

Vertical jump performance depends on a combination of muscular, biomechanical, and neural factors[1], and is a focus of training for athletes across many disciplines, such as ski jumping. Transcranial direct current stimulation (tDCS) has been shown to increase cortical excitability, increase motor evoked potential amplitude, and accelerate motor learning[2]. In particular, adding tDCS to a motor learning paradigm has been shown to increase both muscle force production[3] and muscular coordination[2] through the optimization of neural output.

Objective: The present double-blinded, randomized, sham-controlled study examined the benefits of adding tDCS to a vertical jump training regimen in a group of Olympic-level ski jumpers.

2. Methods

Demographics

Population 7 male members of the USSA ski jumping team

Age 22.4 ± 3.6 years

Protocol

Design Randomized, double-blind, sham-controlled
Crossover with 7-month washout period

Training 10 sessions over 4 weeks:
- tDCS (sham or real) at start of session
- 10 minutes of vertical jump testing
- 60+ minutes of coached vertical jump training

Testing Maximum countermovement jump on the "slippery feet" platform (figure at right)

Stimulation

Type Transcranial direct current stimulation (tDCS)

Device Halo Neurostimulation System (Halo Neuroscience)

Treatment 2 mA amplitude, 20 min duration

Sham 30 sec ramp up and down, 0 mA thereafter

Montage Anode over Cz, shoulder (extracephalic) cathode

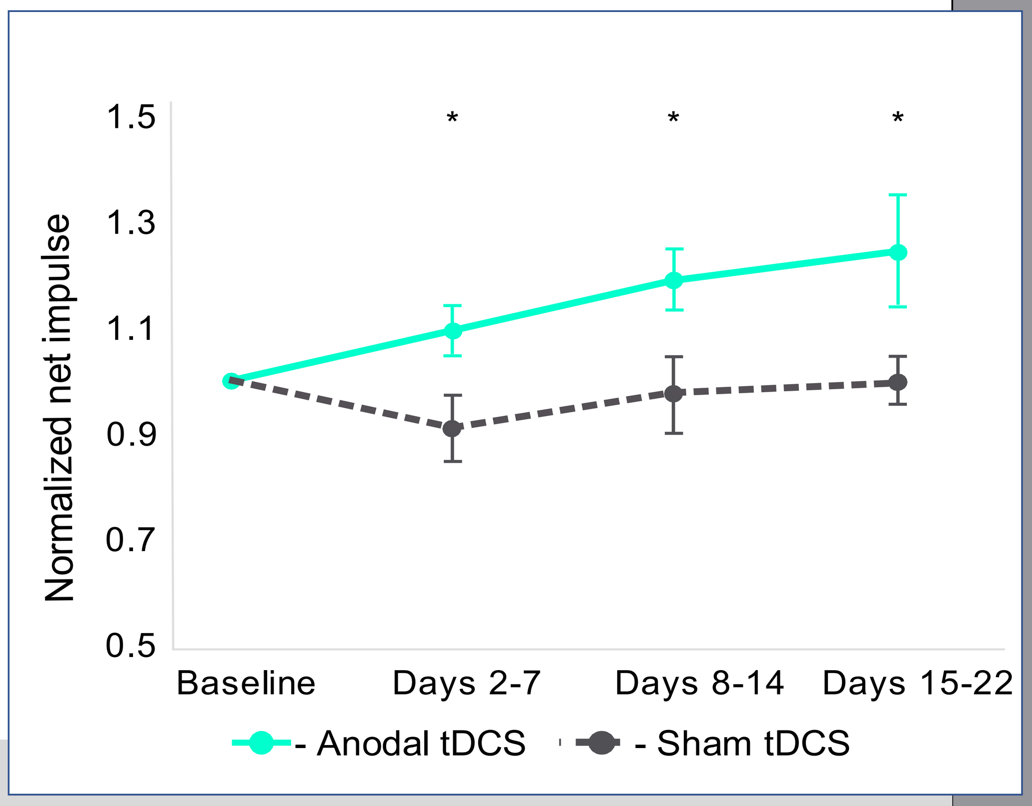
3. Results

Net Impulse

Net impulse is defined as the difference between the integrals of positive and negative phases of the countermovement force profile, and is strongly related to jump performance[4].

Net impulse was significantly higher after training with real stimulation compared to sham ($p < 0.05$).

(Top figure at right, error bars show SEM.)

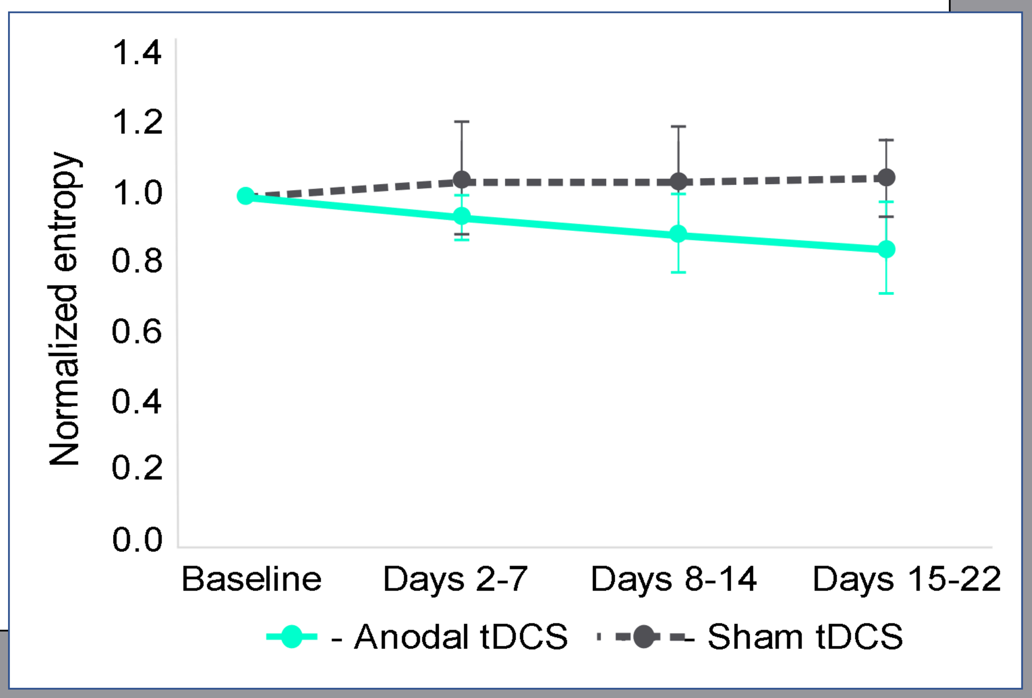


Tortuosity Entropy

Tortuosity entropy (TE) measures the efficiency or smoothness of a movement[5], where lower TE means a smoother movement.

TE did not differ significantly between groups; however, a significant difference was observed in the rate of improvement ($p < 0.05$).

(Bottom figure at right, error bars show SEM.)



4. Discussion and Conclusions

Conclusions These results support the use of tDCS in athletic training. Athletes improved more while training with real stimulation compared to sham stimulation. Increased net impulse, a measure closely correlated with athletically meaningful vertical jump performance, was significant compared to sham throughout the study period. Increased smoothness (decreased TE) was observed in the treatment group but was not significantly different from sham; however, the rate of improvement in TE was significantly different from sham. Possible mechanisms include increased synaptic plasticity[6] and the optimization and coordination of neural drive[3] which has been previously reported with anodal tDCS.

Limitations This study was limited by sample size ($N = 7$), due to the difficulty of recruiting Olympic-level athletes. Due to team roster and schedule shifts unrelated to the study, 3 athletes did not complete the crossover period. Additionally, each athlete underwent his training session at a different point in the off-season and therefore athletes may have been at different levels of overall fitness between the two sessions.

Future Directions Future research should continue to expand tDCS research into elite athletic populations with larger sample sizes, to better characterize the possible benefits of neurostimulation as an athletic training aid.

References

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