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Spinal direct current stimulation enhances vertical jump power in healthy adults.

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Introduction

Transcutaneous spinal direct current stimulation (tsDCS) is a simple, non-invasive tool that affects sensory, motor and pain conducting spinal circuits by modulating neural pathways and segmental reflex activity. Effects persist after stimulation in a dosage dependent manner and these effects depend on polarity: anodal DCS increases the excitability of the underlying neural structures, whereas cathodal DCS decreases it.

tsDCS is considered safe, with no adverse events or tissue damage reported in the literature (1).

To date, tsDCS research has focused on neurophysiological outcomes including; spinal reflex behaviours (2,3), somatosensory pathway conduction (4) and motor unit recruitment (5).

The spinal cord is the final common pathway for all motor behaviours: locomotor spinal reflex circuits adjust via ascending and descending CNS inputs to modulate and produce appropriate motor behaviour i.e. standing, running, walking or jumping (6).

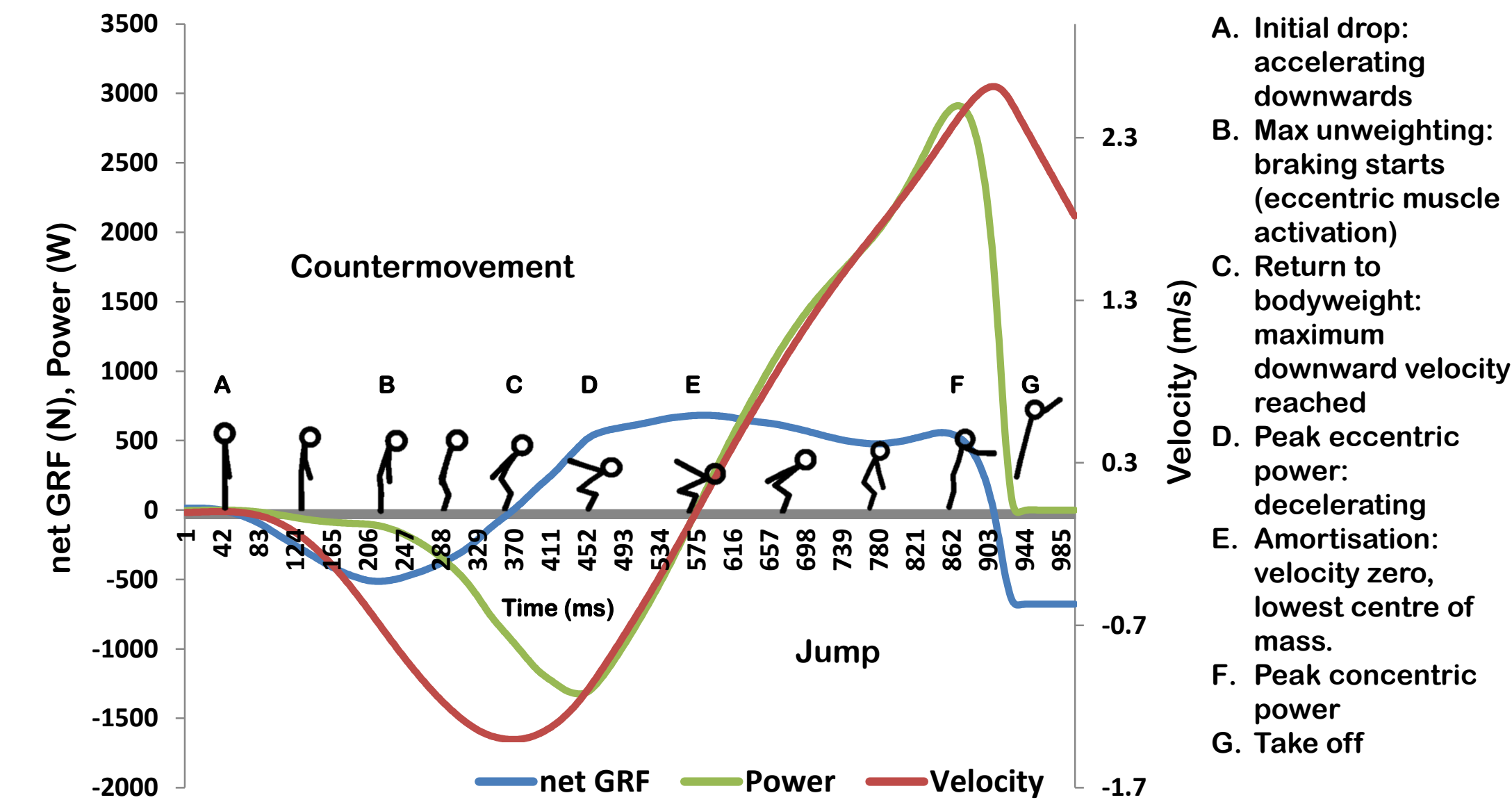
This bi-directional activity also determines the long term neuromotor adaptations associated with motor skill acquisition, sport and athletic training and the impact of CNS trauma and rehabilitation.

It is not known whether tsDCS delivered over the lumbosacral cord has any effect on gross motor power. In this unique study, we investigated the immediate and short term influence (up to 3 hours) of 15 min of sham and active anodal tsDCS on explosive vertical countermovement jump (VCJ) power and posterior root-muscle (PRM) lower limb reflexes (7) in healthy individuals.

We aimed to induce short term neuroplasticity in the lumbosacral cord that would influence VCJ power production and PRM reflex excitability.

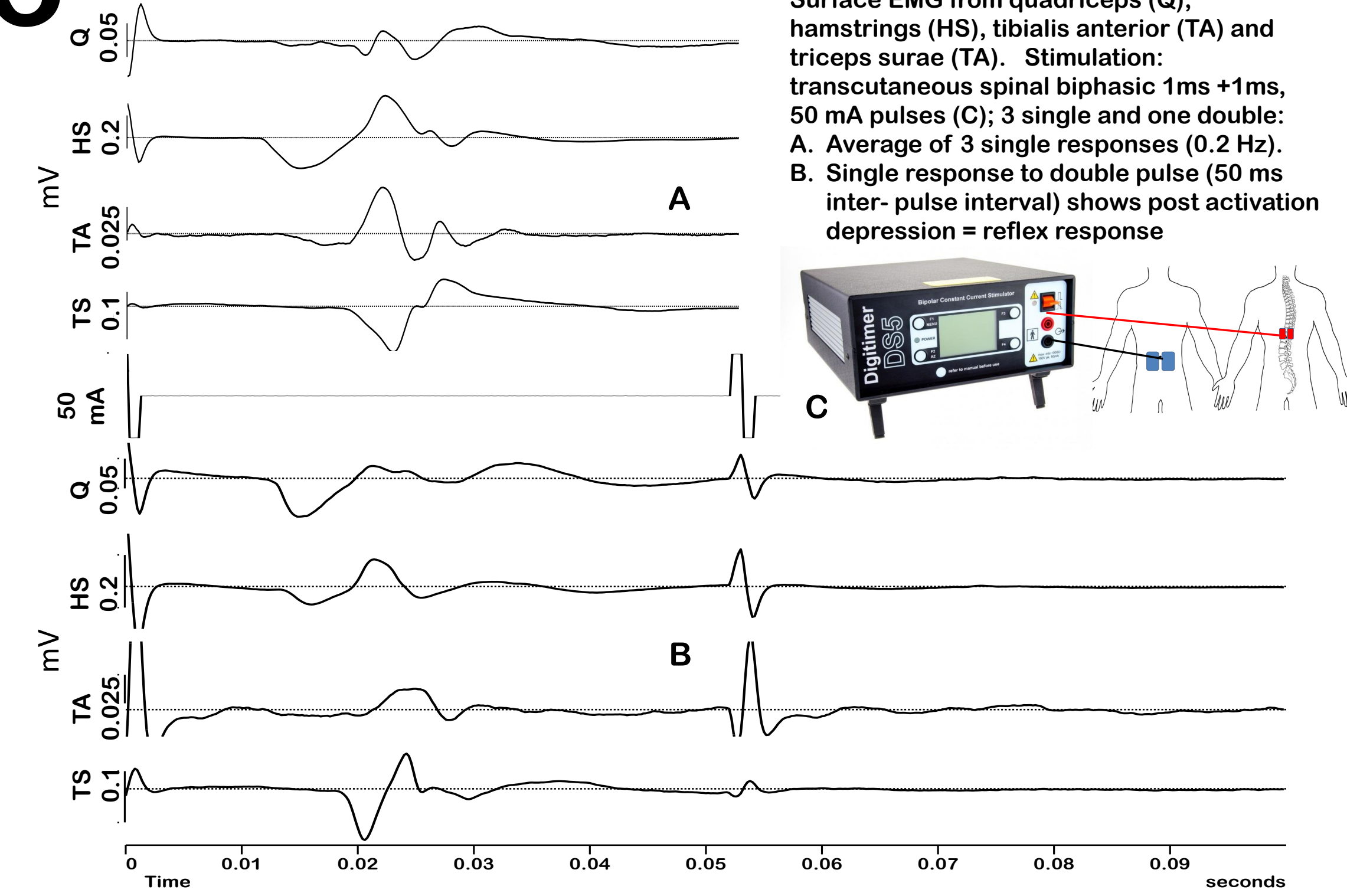
tsDCS modulation of spinal locomotor reflex circuits in the absence of any physical activity may have potential for rehabilitation where mobility is limited or absent, for example, after sporting or combat injury, or for neuro-modulation in patients with brain or spinal cord injury.

2 Vertical countermovement jump (VCJ)

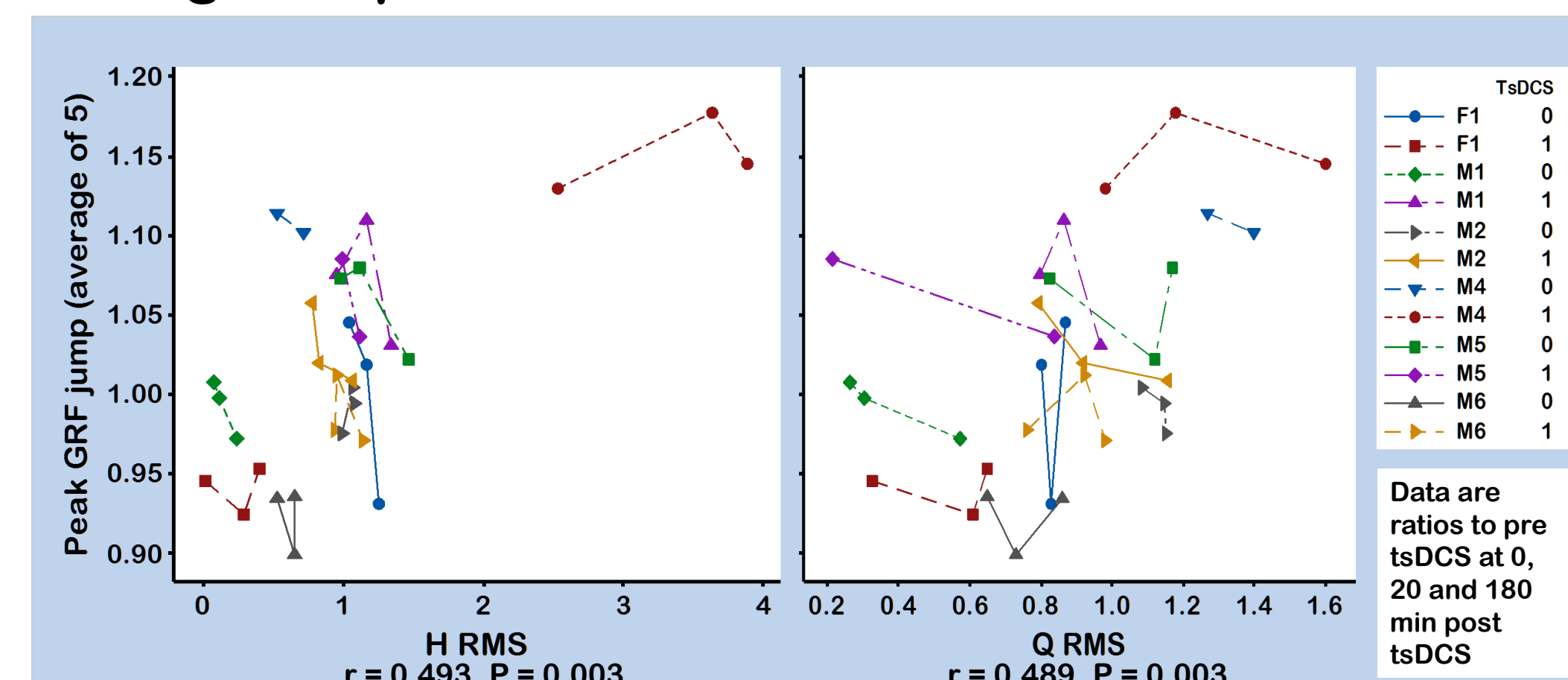


After a warm up stepping on/off a low stepper, 12 healthy adults (2 female) aged mean (SD) 29 (11), BMI 23 (2) completed 5 maximal effort VCJs with 20 s rest between efforts. This was repeated 0, 20, 60 and 180 min after each double-blinded sham and active tsDCS treatment (minimum of one week apart). Impulse, velocity and power were calculated from net ground reaction force (GRF) and work calculated as the area under the power curve. All power data were analysed as a ratios to pre tsDCS values using a GLM (Minitab 17).

3 Posterior root-muscle (PRM) reflexes

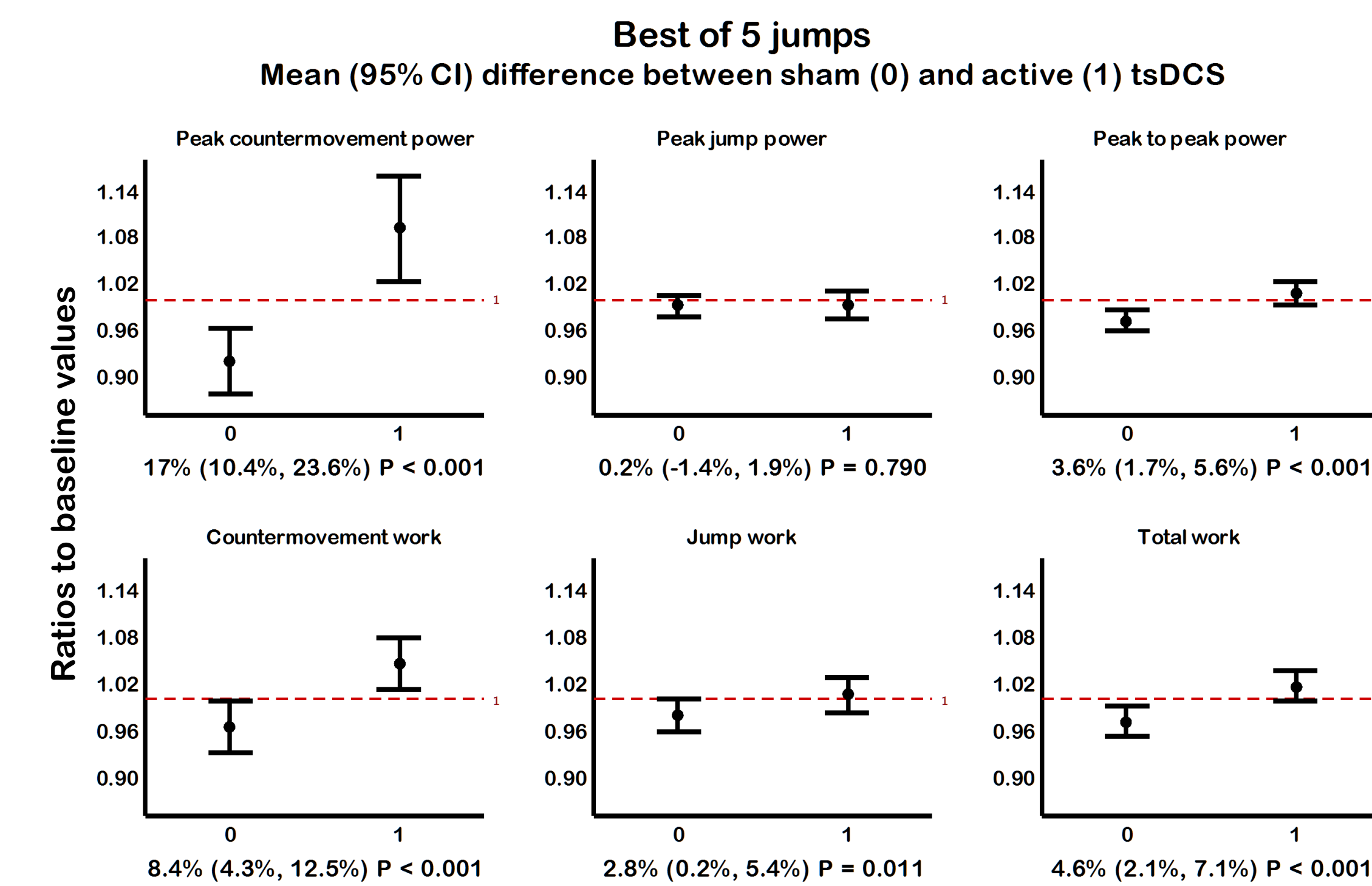
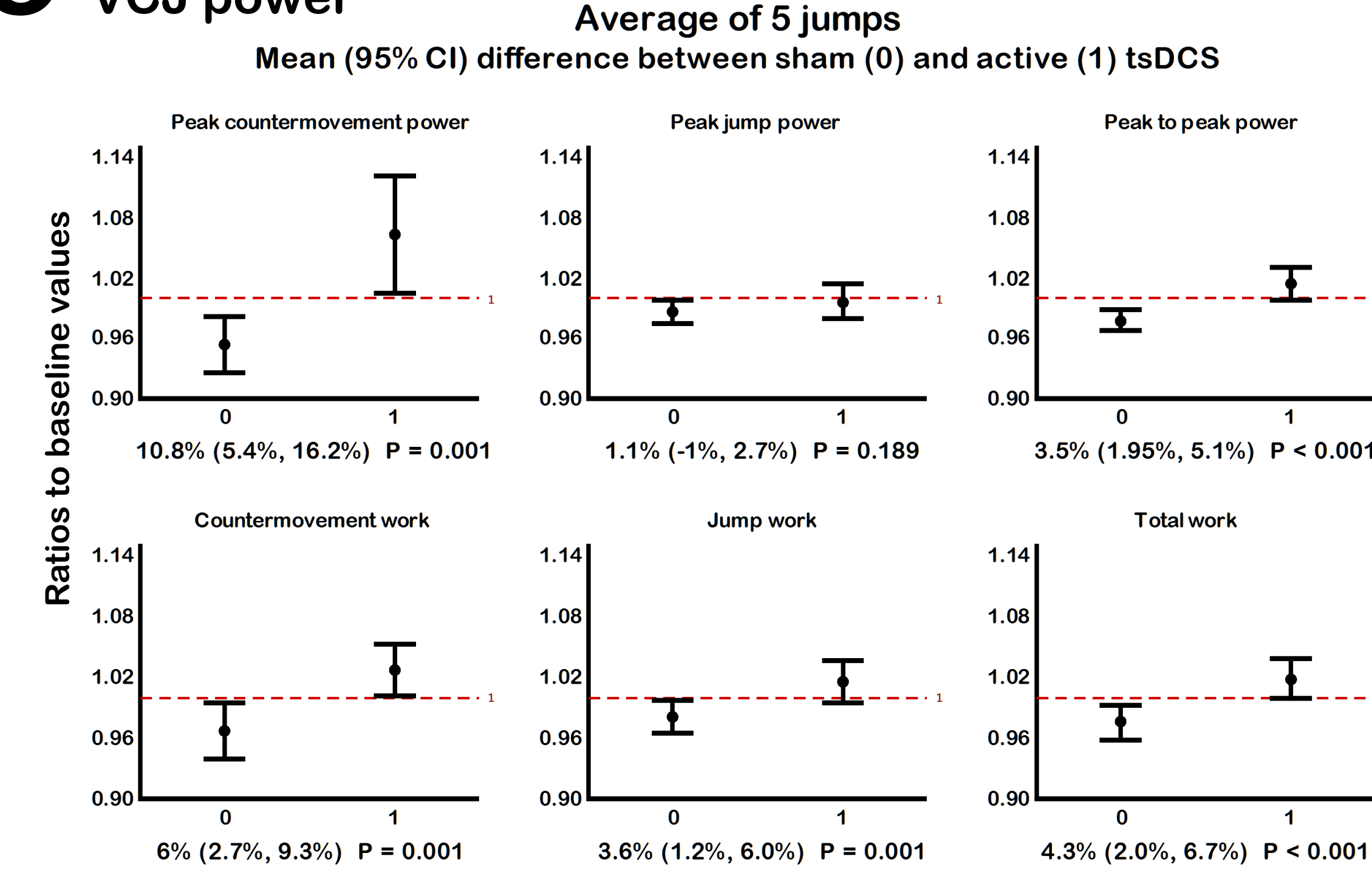


4 Changes in PRM reflex RMS moderately correlated to changes in power variables after tsDCS



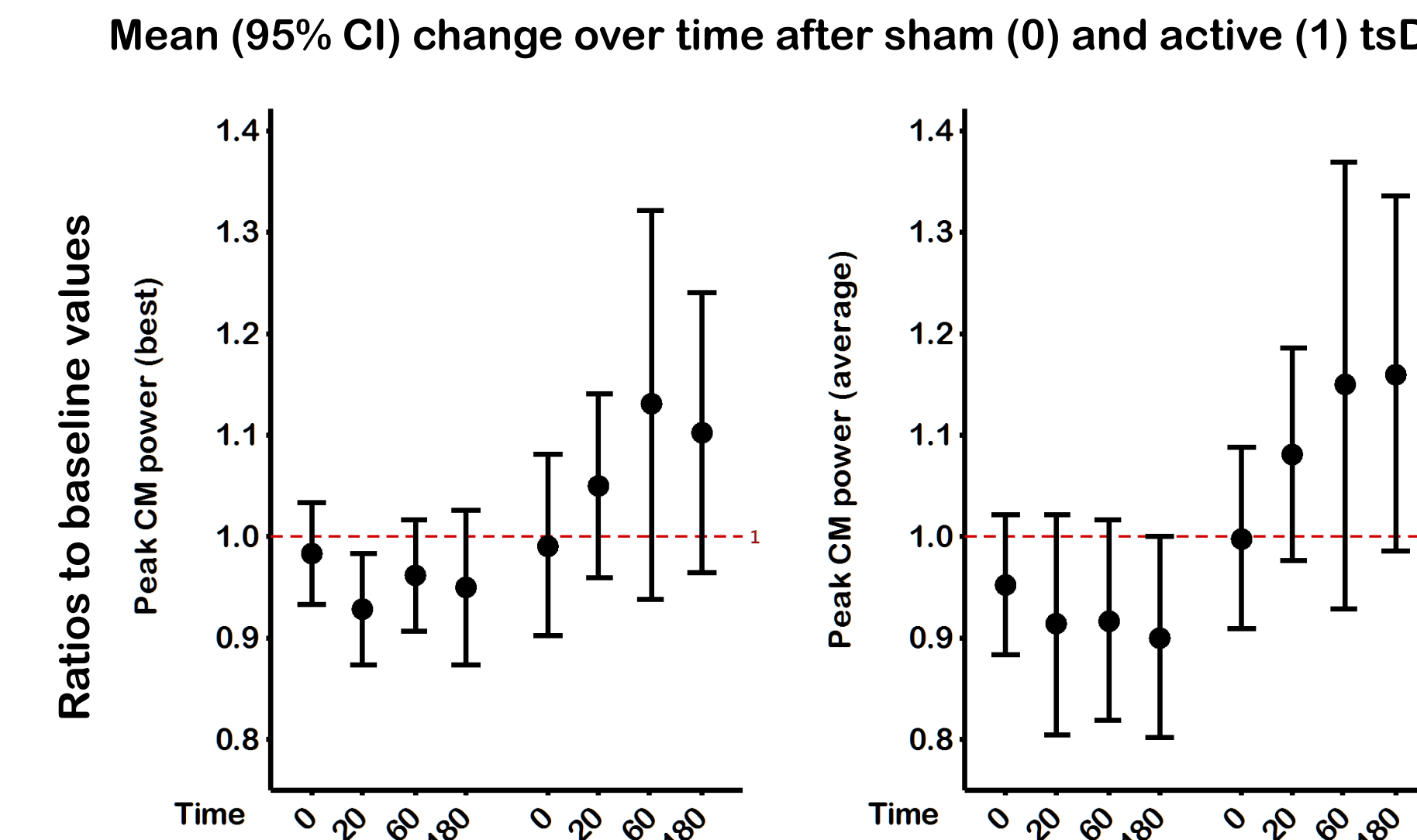
- Changes in hamstring (H) and quadriceps (Q) PRM reflexes were moderately correlated with changes in peak GRF (shown above) and: amortisation GRF ($r = 0.421, P = 0.013$ and $r = 0.349, P = 0.044$ respectively).
- Changes in H PRM RMS were also correlated with changes in CM velocity and power ($r = 0.353, P = 0.041$ and $r = 0.390, P = 0.023$ respectively).
- Changes appear to be due to alterations in force potentiation mechanisms, demonstrated by excitability changes in reflex circuitry after sham and active tsDCS.

5 tsDCS-induced fatigue resistance and enhancement of VCJ power



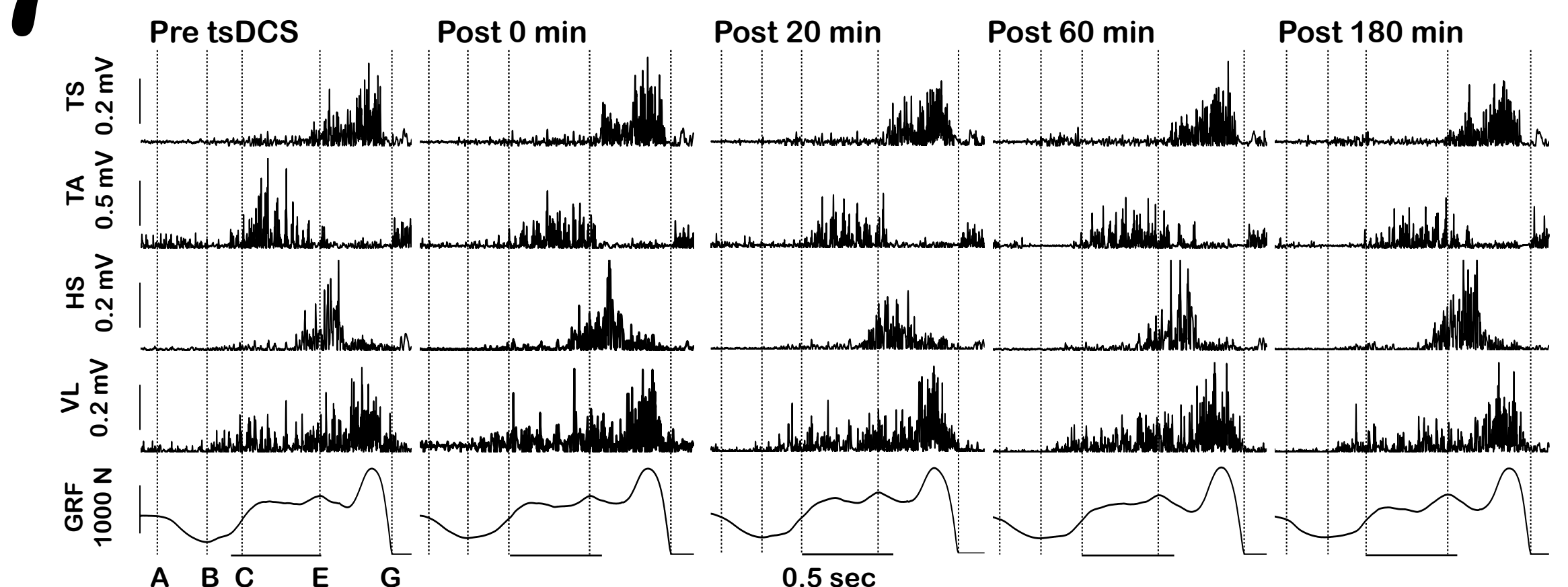
- Anodal tsDCS maintained and/or enhanced VCJ work and power output.
- Sham tsDCS maintained best peak jump power, but resulted in fatigue in all other variables.

6 No return to baseline values at any time post tsDCS



- The significant difference between sham tsDCS fatigue and the tsDCS power/work enhancement persisted without decrement over the 3 hours
- The difference in countermovement (CM) power changes from 0 to 180 min post tsDCS were not significant: best, $P = 0.685$, and average, $P = 0.491$.
- The duration of tsDCS effect beyond the three hour test point is not known.

7 Post hoc: EMG responses during VCJ



Rectified EMG (right leg) and total ground reaction force (GRF) responses during one VCJ at pre and 0, 20, 60 and 180 min post active tsDCS. Data gathered post hoc from subject M1. Triceps surae (TS), tibialis anterior (TA), hamstrings (HS), vastus lateralis (VL). Jump phases are as described in VCJ panel.

iEMG % change	pre tsDCS to post 180		
	Eccentric B-C	Concentric E-G	
TS	121	92	96
TA	87	74	126
HS	108	101	151
VL	71	76	99

Conclusions

- We have shown for the first time that anodal tsDCS counters the fatigue normally associated with repeated maximal VCJ performance.
- We have shown for the first time that tsDCS increases peak eccentric (braking) power and VCJ work.
- The effects of tsDCS last for at least 3 hours without decrement.
- The magnitude of response to tsDCS varies from person to person.
- tsDCS is simple, non-invasive, comfortable, low cost and easy to administer.
- tsDCS-induced fatigue resistance and enhancement of motor power and work in the absence of any physical training has very important implications for rehabilitation after central nervous system injury

Further work

Our laboratory is now investigating the effect of anodal tsDCS on EMG, torque and power production in isolated joint movements. We are also investigating the EMG responses during VCJ in more subjects. We are also investigating genetic factors that may explain the variation in response to tsDCS between subjects.

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1 Transcutaneous spinal direct current stimulation (tsDCS)

