

# Cortical Control of Static and Dynamic Postural Balance during Reactive and Voluntary Tasks

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## Purpose

To investigate the cortical contribution in static and dynamic standing:  
• Hypothesis: Reactive task involves less cortex-muscle coupling

## Introduction

- Postural balance is governed by both the reflexive and voluntary responses by the subcortical and cortical network, respectively.
- Previous studies have demonstrated coherence in the frequency domain during voluntary contraction between motor cortex activity recorded by electroencephalography (EEG) and muscle activity measured by electromyography (EMG) [1].
- Certain band frequencies are evoked during specific tasks, such as the beta-band coherence during isometric contractions and gamma-band coherence in isotonic contractions [1].
- Studying the synchrony between cortex and muscle signals help reveal the cortical mechanism that enable postural control.

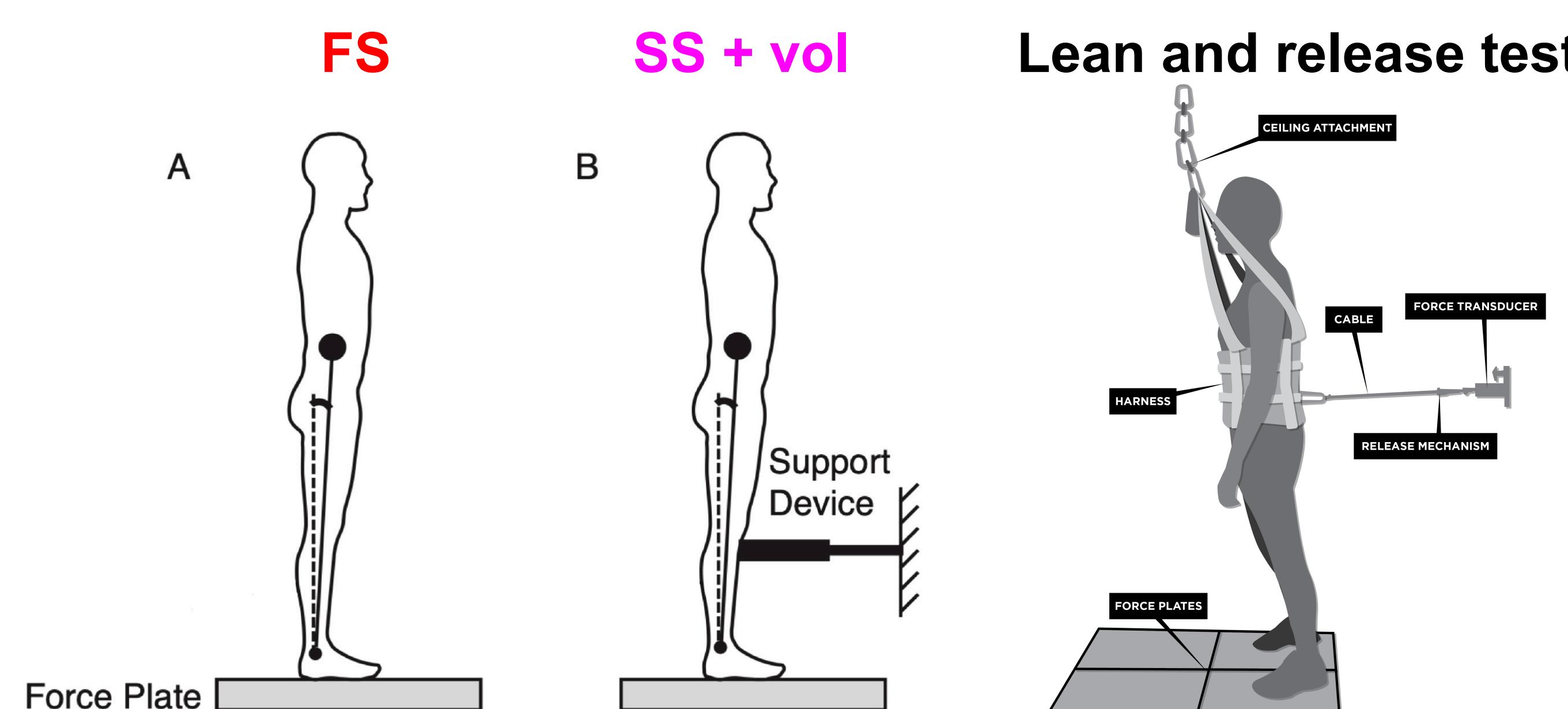
## Methods

### Experiment:

Participants: Male able bodied (AB) individuals

### Tasks:

- Static Balance (n = 1)
  - 1) Quiet standing with eyes open (FS)
  - 2) Voluntary soleus contraction with supported device [2] (SS + vol)
- Dynamic Balance (n = 2)
  - 1) Lean and release test [3] (non-anticipated)
  - 2) Lean and release test [3] with counting down (anticipated)



### Measurements:

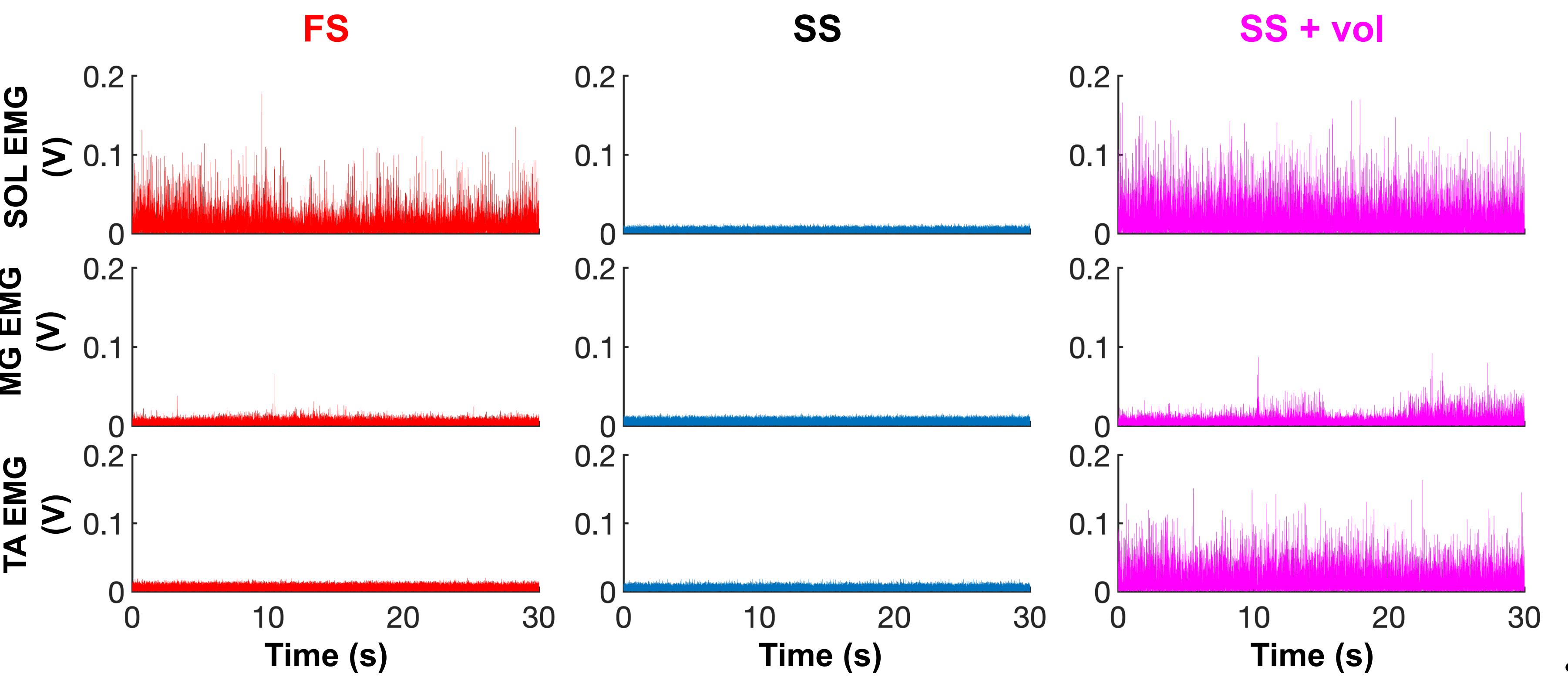
- EEG (19 ch) – here, only Cz (sensori-motor cortex) was analyzed
- Right leg EMG recordings of tibialis anterior (TA), medial gastrocnemius (MG) and soleus (SOL) muscles

### Metrics:

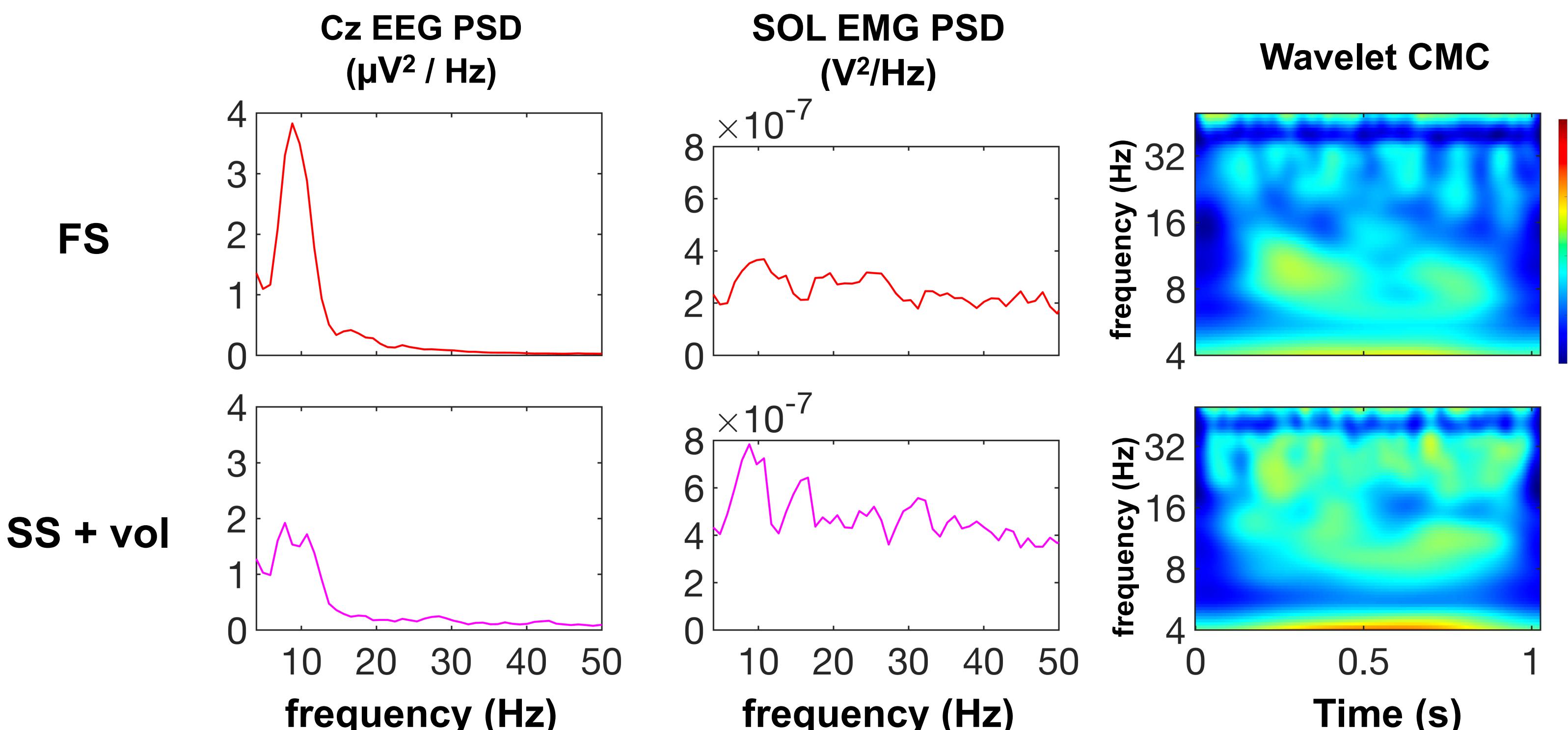
- 1) Cortico-muscular coherence (CMC)
- 2) Instantaneous Amplitude Correlation (IAC)

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## 1. Static Balance

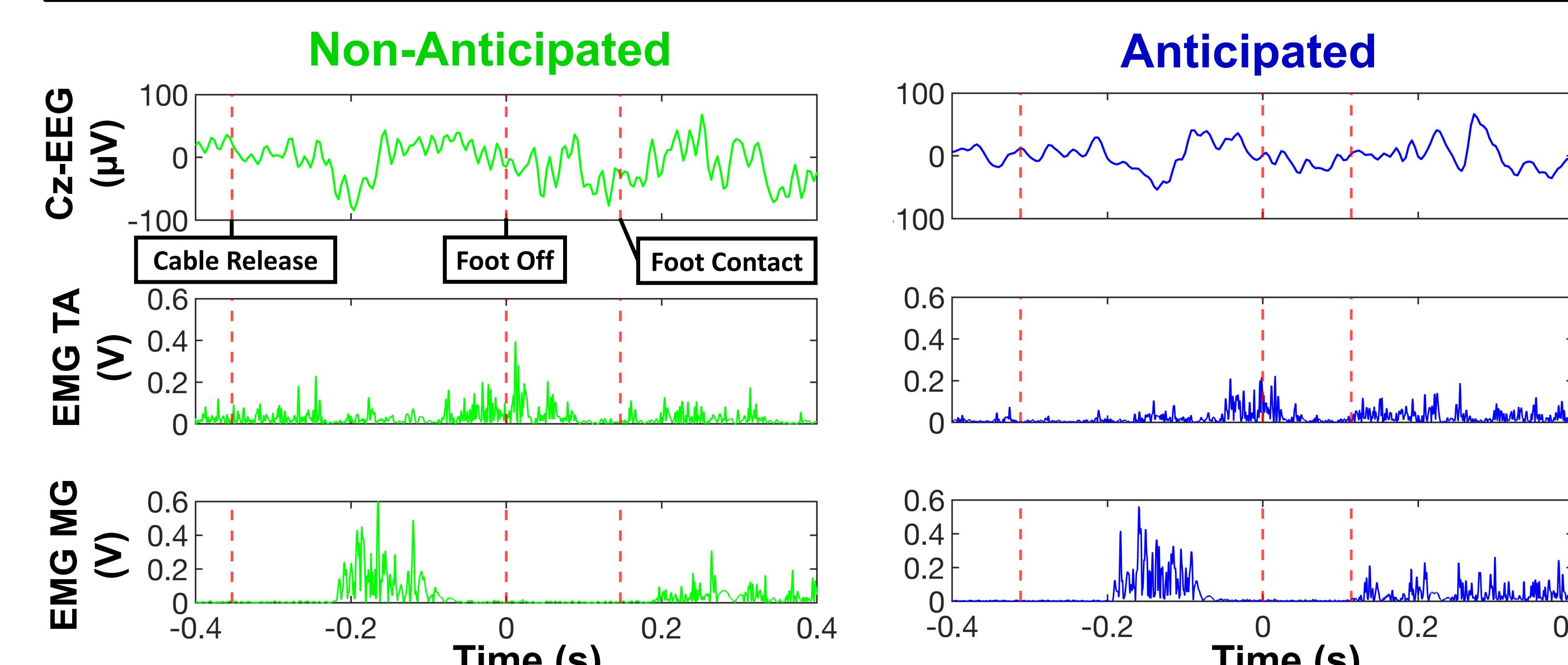


- Natural muscle activation during quiet standing attenuated during SS
- In SS + vol, similar level of voluntary muscle activation was achieved even in the standing posture



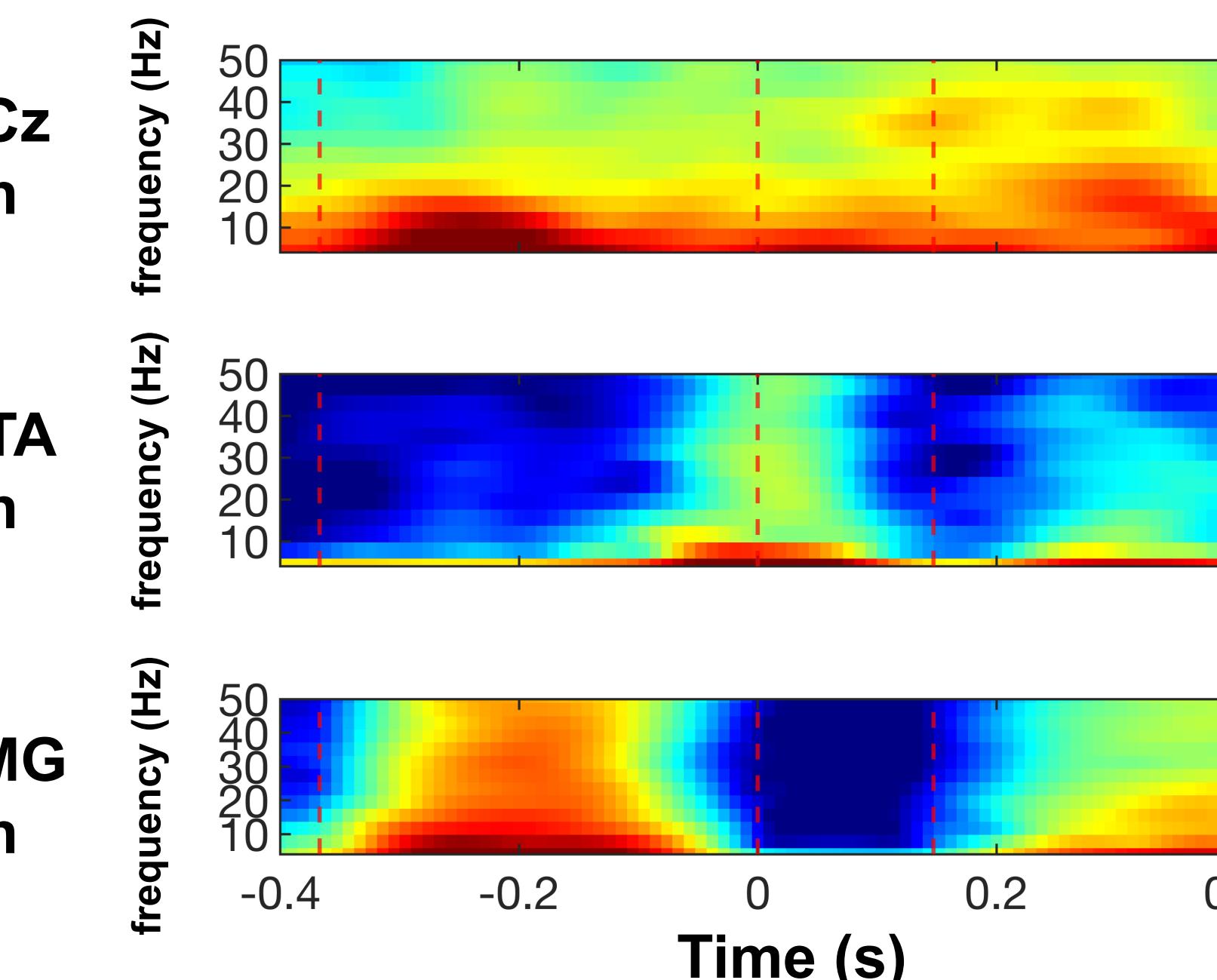
- Unexpectedly, the degree of CMC did not differ between FS and SS + vol

## 2. Dynamic Balance



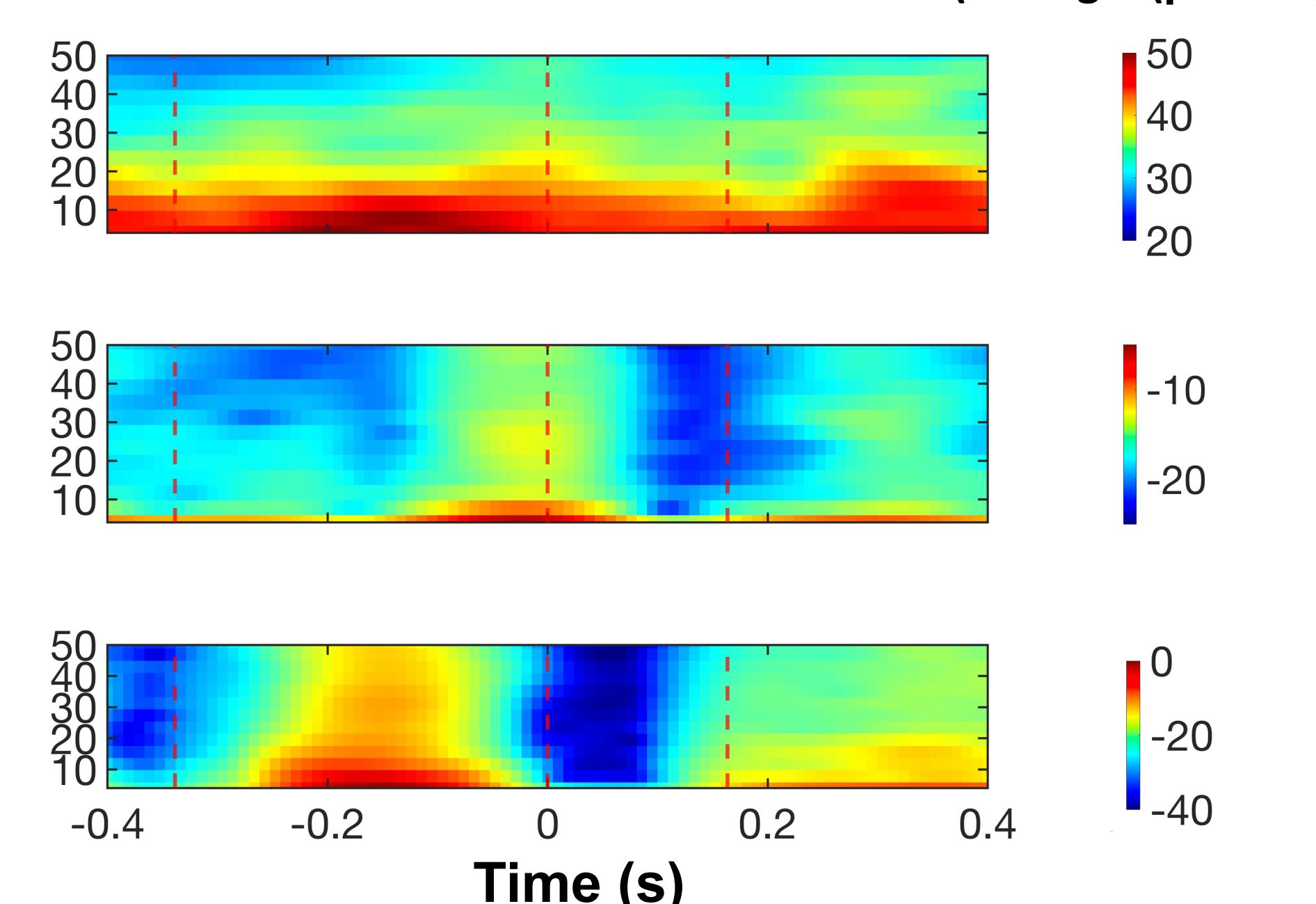
- Consistent presence of depolarization (negative deflection) post cable release
- Similar EMG time series

## Non-Anticipated

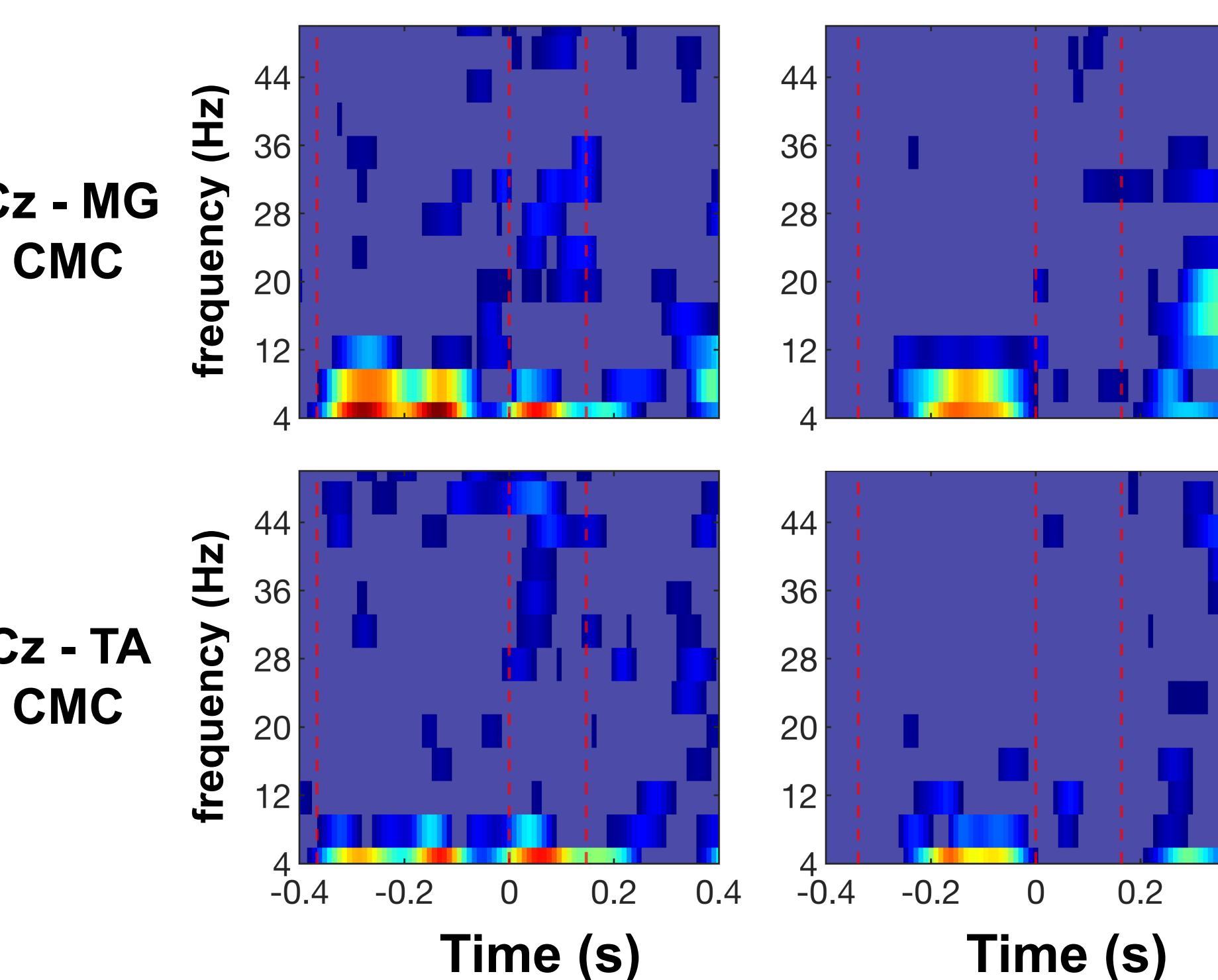


- Similar EEG and EMG time frequency activity

## Anticipated



## Non-Anticipated



- Unexpectedly, the degree of CMC did not differ between the two conditions
- Cz-TA IAC revealed a clear connection in the beta band at foot off for anticipated stepping only

## Conclusion

- 1) Static Balance: No significant CMC in both conditions. Further investigation is needed with more samples.
- 2) Dybamic Balance: IAC showed a clear difference between the two conditions. The result suggested that anticipated stepping involves more cortical contributions in the control as expected. IAC may be useful in non-stationary signal analysis.

### References:

- [1] Gwin, J.T., Ferris, D.P. An EEG-based study of discrete isometric and isotonic human lower limb muscle contractions. *J NeuroEngineering Rehabil* 9, 35 (2012). <https://doi.org/10.1186/1743-0003-9-35>
- [2] Masani, K., Sayenko, D. G., & Vette, A. H. (2013). What triggers the continuous muscle activity during upright standing?. *Gait & posture*, 37(1), 72–77. <https://doi.org/10.1016/j.gaitpost.2012.06.006>
- [3] Matthew G. Heffernan, Jae Woung Lee, Katherine Chan, Janelle Unger, Susan Marzolini, Timothy N. Welsh, Kei Masani, Kristin E. Musselman. (2023) Spatial characteristics of reactive stepping among people living with chronic incomplete spinal cord injury. *The Journal of Spinal Cord Medicine* 0:0, pages 1-9.

