THE EFFECT OF CHANGING NECK SENSORY INPUT ON NEURAL PLASTICITY AND SENSORIMOTOR INTEGRATION FOLLOWING MOTOR SKILL ACQUISITION

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INTRODUCTION

- With growing use of technology, such as laptops and cell phones, the neck is often bent forward with increased likelihood of cervical extensor muscle (CEM) fatigue[5]
- CEM fatigue leads to decreased awareness of the position of the upper limbs in 3D space[4]
- Individuals with subclinical neck pain have an altered response in a part of the brain, called the cerebellum (CB), when learning new motor skills[2]
  - This suggests that altered sensory feedback from the neck, due to pain or fatigue, may change CBI-primary motor cortex (M1) interactions[2]
- Neuroplasticity refers to the ability of neurons to change the way they respond to different inputs[1,3]
- Transcranial Magnetic Stimulation (TMS) is a technique that involves noninvasive stimulation of the neurons in the brain[3]
  - Different techniques can be used to study either activation or inhibition[1,3]
  - TMS is used over M1 to activate efferent neurons, producing a motor-evoked potential (MEP) which can be recorded using electromyography electrodes located over the target muscle[1,3]
- Cerebellar inhibition (CBI) can be used to measure changes in inhibition in the pathway between the CBI and M1[1]
  - The technique involves TMS application over the ipsilateral cerebellum 5 to 8 ms prior to the application of TMS over the contralateral M1[1]
  - Results in reduction in peak to peak amplitude of the MEP[1]
- Further research is needed to determine if CEM fatigue affects upper limb sensorimotor integration similarly to neck pain

OBJECTIVE

I. To determine if CEM fatigue influences excitation of the CBI-M1 pathway for the first dorsal interosseous (FDI) hand muscle
II. To understand if the ability to learn an upper limb motor tracing task can be affected by CEM fatigue

METHODS

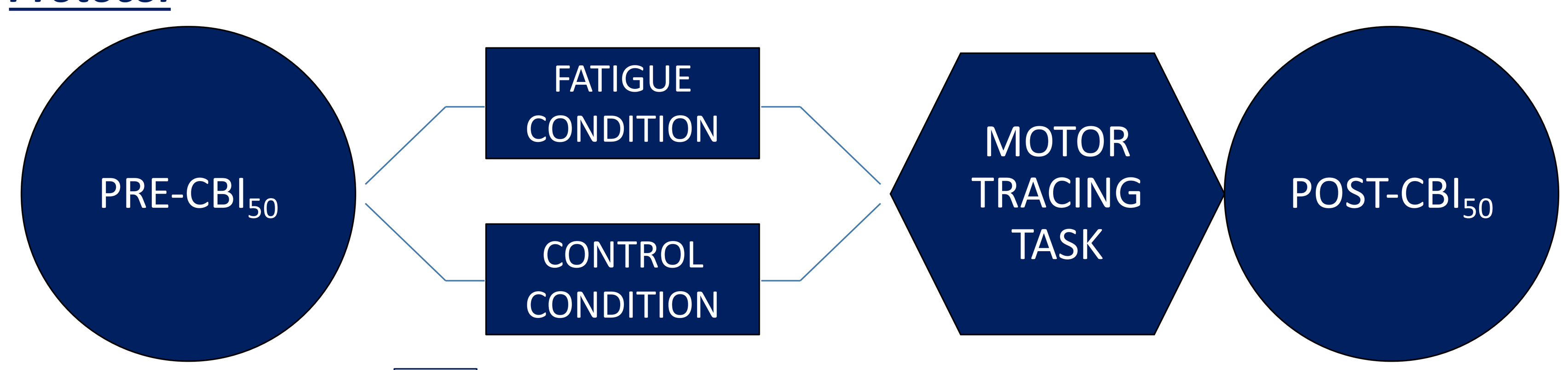
Subjects

- 16 healthy, right-handed participants between the ages of 18-30 years
  - The Edinburgh Handedness Inventory (EHI) Questionnaire was used to determine right hand dominance
- Participants were randomly divided into either a control group or a CEM fatigue group
  - CEM fatigue group: 4 female, 4 male
  - Control group: 4 female, 4 male

FATIGUE CONDITION: Participant holds a 2 kg weight against gravity using cervical extensor muscles until fatigue

CONTROL CONDITION: Similar posture to fatigue protocol with head supported (no neck fatigue)

Protocol



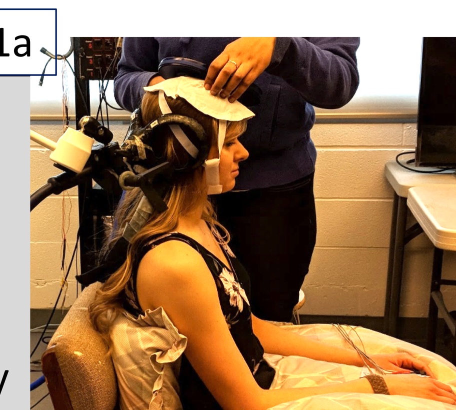


Figure 1a: The double-cone coil is held against the cerebellum on the ipsilateral (right) side in relation to the right hand, between the bony prominence on the posterior skull (inion) and the bony surface behind the ear (mastoid process) at the level of the inion.

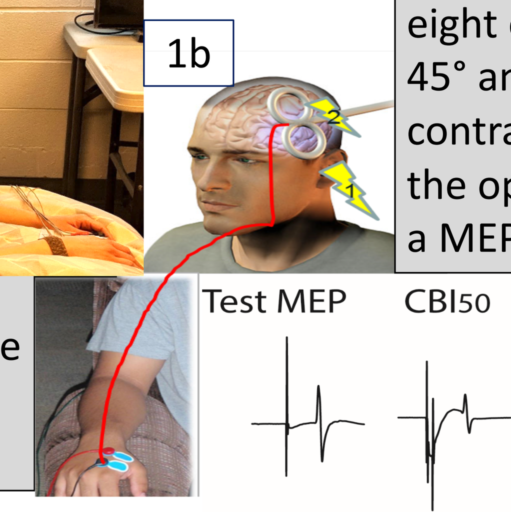


Figure 1b: The figure-of-eight coil is positioned at a 45° angle over the contralateral (left) M1 at the optimal site to produce a MEP in the right FDI

Figure 2: TMS figure-of-eight coil for M1 stimulation placed on top of the Monostim stimulator (right). TMS double-cone coil for CB stimulation placed beside the Bistim stimulator (left).

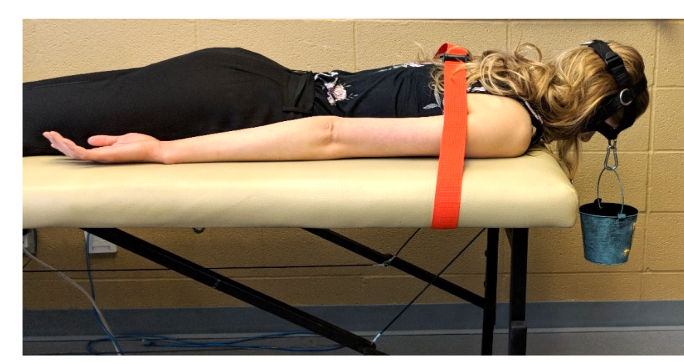


Figure 3: Participant in fatigue condition holds 2 kg weight against gravity until failure to induce CEM fatigue.

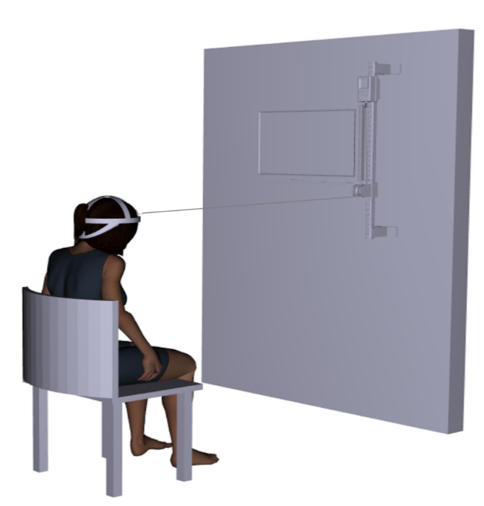


Figure 4: Participant in fatigue condition pulls against a force transducer using their neck muscles to measure CEM strength prior and following CEM fatigue.

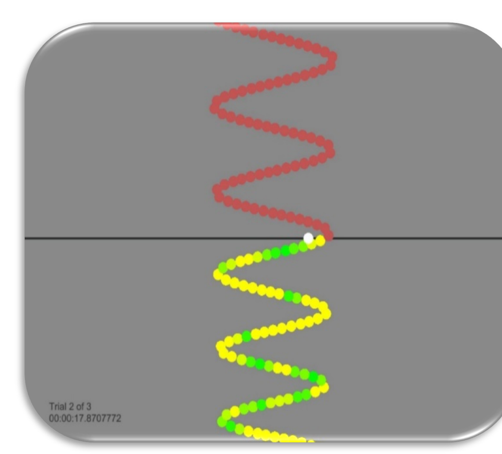


Figure 5: Motor tracing task of varying patterns completed by both groups, on a computer using a touch pad.

RESULTS

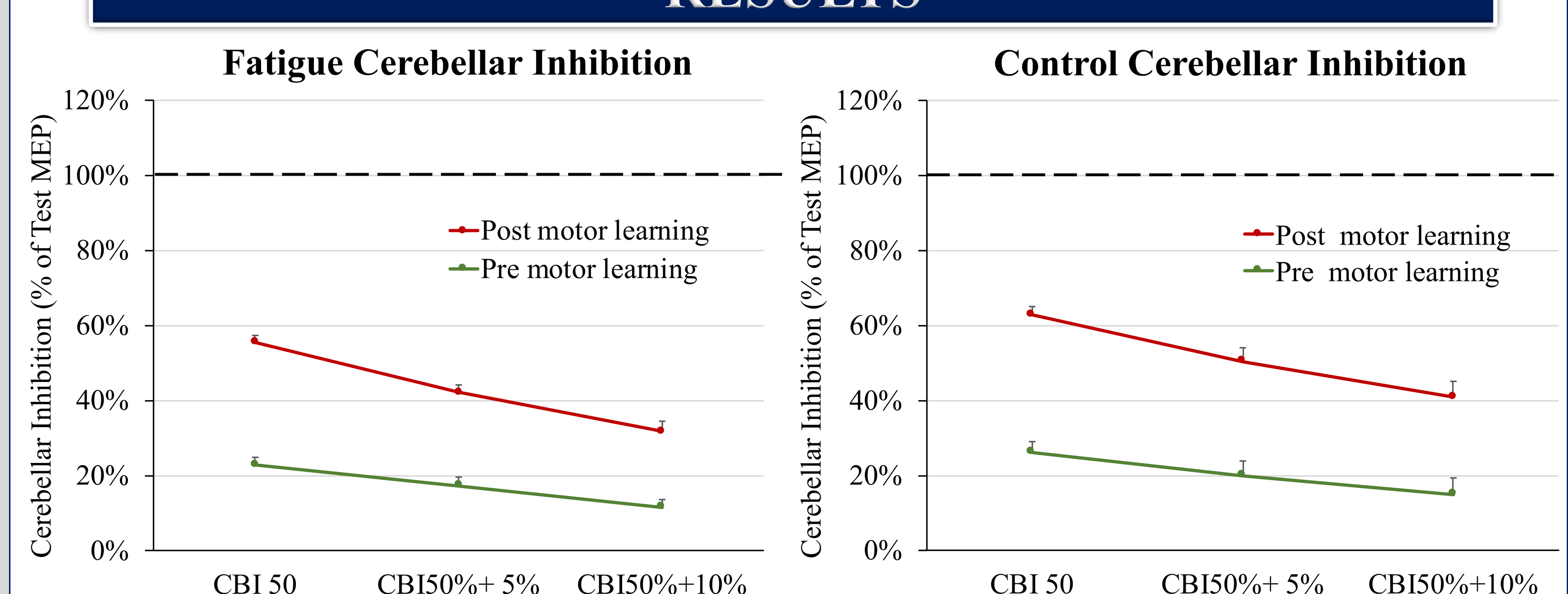


Figure 6: CBI in the fatigue group (left) and CBI in the control group (right) prior and following learning the motor tracing task. Error bars represent standard error of mean.

- Greater disinhibition was shown at CBI$_{50}$ versus CBI$_{50}$+10% ($P < 0.008$) and at CBI$_{50}$+5% versus CBI$_{50}$+10% ($P < 0.009$)
- No significant difference in cerebellar inhibition between the control and fatigue condition groups

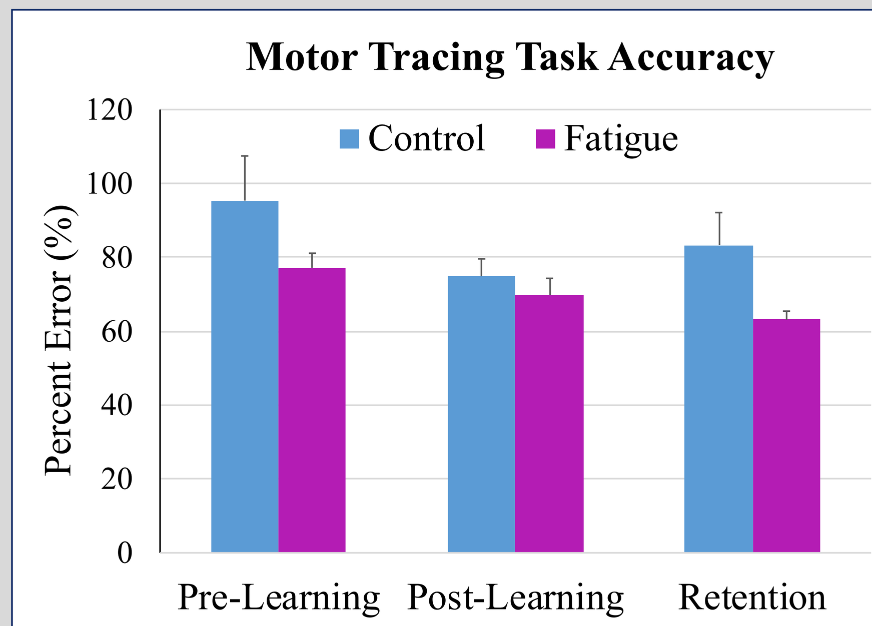


Figure 7: Percent error of motor tracing task. Measured before learning, immediately after learning and 24 hours after learning. Error bars represent standard error of mean.

- Both groups showed decrease in error following learning of the motor task and at retention
- Percent error = distance from optimal trace in relation to dot size

DISCUSSION

- Following the learning of the motor tracing task, both the control group and the neck fatigue group displayed greater disinhibition
- No significant differences were found between the groups in cerebellar inhibition following motor learning → CEM fatigue does not impact CBI-M1 pathway excitability
- Both groups had a decrease in errors following motor learning with the more accurate movement displaying motor skill acquisition → no significant differences in error between groups
- Lack of differences in cerebellar inhibition and movement accuracy between the groups following motor learning indicate that CEM fatigue does not impact the excitability of pathways between the CB and M1, allowing proper sensorimotor integration to occur
- Unlike neck pain, a single session of CEM fatigue is not capable of altering the capacity of the cerebellum to disinhibit when learning a new motor skill
- It may be that chronic neck fatigue due to occupational and/or recreational task demands is required to alter CBI responses

SUMMARY

- Unlike long-term neck pain, short-term neck fatigue does not change sensory input through the excitation of pathways between the cerebellum and the primary motor cortex
- Further research is needed to understand the impacts of chronic CEM fatigue, as well as the impact that it has on other neuronal pathways
- It is important to better understand how neck fatigue impacts motor learning, as it has important implications for sport and ergonomic performance and injury prevention

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