Central Control in Motor Imagery During a Tongue Press Task: A Proof of Concept Study

Teresa Drulia ◆ Erin Kamarunas◆ Sarah Szynkiewicz◆ Lindsay Griffin◆ Morgann Henn

TCU

James Madison University 1908

Samford University

Emerson College

INTRODUCTION

Mental practice using motor imagery (MP-MI) is the mental rehearsal of a motor movement without activation of physical motor movement with the goal of improving motor execution and motor learning.[1] MP-MI may include imagery inclusive of visual, auditory, tactile, gustatory and kinesthetic inputs for mental simulation.[2-3] MP-MI has been used to promote recovery of upper and lower extremity function; specifically, MP-MI increases motor learning, control and strength and may be most effective when used in conjunction with traditional therapy methods.[4-5] Increases in strength are attributed to central changes rather than peripheral changes, particularly for early gains in strength recovery.[6] The mechanisms driving the changes in motor behavior are not yet defined; however, neural substrate activation is similar in MP-MI and physical exercise tasks with evidence of neuroplastic changes in imaging studies after MP-MI in healthy adult and patient groups.[7]

MP-MI may have the potential to impact tongue strength in the aging and disordered swallow.[8] Recent findings examining the effects of MP-MI on maximum isometric lingual pressures and regular effort saliva swallows in typically aging adults found MP-MI in conjunction with physical exercise significantly increased maximum lingual pressures and saliva swallow lingual pressures.[9]

PURPOSE

This study examined whether peripheral muscle activation and task duration were different for a motor imagery tongue press task compared to physical tongue presses.

RESEARCH QUESTIONS

1. Do typically aging persons demonstrate differing submental muscle activation when completing a tongue press task using motor imagery compared to a physical tongue press task?

Hypothesis: Typically aging persons will demonstrate minimal submental muscle activation when completing a tongue press task using motor imagery compared to physical exercise.

2. Do typically aging persons demonstrate varying tongue press task durations using motor imagery compared to physical exercise?

Hypothesis: Typically aging persons will demonstrate similar task durations in motor imagery and physical tongue press tasks.

PARTICIPANTS

Thirteen healthy, typically aging participants (7 females) completed the study. Mean age=65.7 years (range: 60-75). Participants for this study were a subset of participants from a larger randomized controlled pilot study.[9] Participants scored >2.5 on the Kinesthetic and Visual Imagery Questionnaire (KVIQ-10, short version) to confirm at least moderate imagery skills.

METHODS

Instrumentation

- Electromyography (EMG) electrodes (Norotrode 20) were adhered to the neck at the mid-line, posterior one-third of the submental muscles; a grounding ECG electrode was placed on the right clavicular region of the participant. EMG sampling rate was set at 10 kilohertz (kHz).
- Participants pressed a hand-held button push (5 volt pulse generator) to mark the onset and offset of tongue press trials. Participants pressed the button when beginning the task and continued pressing until discontinuation of the tongue press trial.
- Digital signals were synchronously recorded in PowerLab 16/35 and analyzed using LabChart 8 software (ADInstruments, Inc.).

Experimental Task

Participants completed 20 blocked trials of:

- Physical lingual maximum force tongue presses to hard palate for 2-3 seconds
- Motor imagery (MI) of lingual maximum force tongue presses to hard palate for 2-3 seconds

Tasks were completed in counterbalanced order. Interstimulus intervals of 20 seconds were given between each trial. Participants received training to the task, but durational cues were not provided during trials.

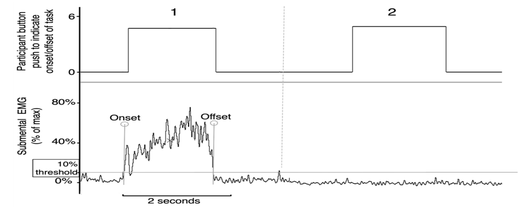
DATA ANALYSIS

EMG signals were bandpass filtered at 10-500 Hz, rectified, and smoothed (Bartlett window, 999 samples). The signal was then normalized to percent of maximum effort with the maximum value recorded during the session set to equal 100% and average value at rest set to 0%. Onset and offset of active signals were set at 10% change from baseline (Figure 1). EMG amplitudes were analyzed with a root-mean-square envelope.

DATA ANALYSIS

Figure 1

SEMG Signal for Physical and Motor Imagery Tongue Press Task



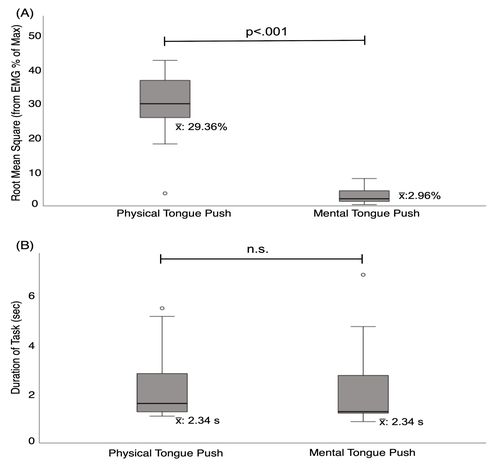
Note. 1=Physical tongue press trial; 2=MI tongue press trial. Trials were from same participant. The MI tongue press demonstrates no appreciable activation of submental musculature and similar duration to physical tongue push.

RESULTS

Paired t-tests were completed to determine the differences in maximum tongue press amplitude and task duration with compared to physical tongue presses. MI tongue presses had significantly less submental muscle activation (M = 2.96%, SD = 2.49) compared to physical tongue presses (M = 29.36%, SD = 10.24), a significant mean decrease of 26.40%, 95% CI [20.25, 32.55], $t(12) = 9.35$, $p < .001$, d = 2.59. There was no significant difference for task duration between MI tongue presses (M = 2.34 s, SD = 1.78) and physical tongue presses (M = 2.34 s, SD = 1.54), 95% CI [-.45, .45], $t(12) = 0.019$, $p = .985$, $d = .005$ (Figure 2).

Figure 2

Differences in Muscle Activation Amplitude and Duration for a Tongue Press Task



DISCUSSION

Typically aging participants exhibited limited submental musculature contraction when completing a motor imagery tongue press task compared to contraction observed in a physical tongue press. This finding supports the theory that functional motor changes demonstrated following treatment using MP-MI are likely from a central nervous system mechanism rather than from peripheral changes. Further, the task duration for motor imagery and physical tongue presses were similar, suggesting a possible overlap of central motor planning for these two task modalities.

Additional research is needed to determine the potential independent or adjunctive role of MP-MI in tongue strengthening and other swallowing related tasks for typical aging persons in preventative care and patient groups needing dysphagia management. The current study enhances our knowledge of the underlying mechanism of MP-MI in a swallowing-related task. In this small group of participants, results appear to be promising for MP-MI of tongue presses as a task for promoting central nervous system plasticity. Future directions should include investigation of motor imagery mechanisms underlying other swallowing and swallowing-related tasks. Additionally, best methods for most effectively enhancing central input when using motor imagery related to swallowing in the training of healthy older persons and patients need to be identified.

REFERENCES

1. Slimani M, Tod D, Chaabene H, Miarka B, Chamari K. Mental imagery on muscular strength in healthy and patient participants: a systematic review. J Sports Sci Med 2016;15:434-450.
2. Dickstein R, Deutsch J. Motor imagery in physical therapist practice. Phys Ther 2007;87:942-953.
3. Jeannerod M. Mental imagery in the motor context. Neuropsychologia 1995;33:1419-1432.
4. García Carrasco D, Aboitiz Cantalapiedra J. Effectiveness of motor imagery or mental practice in functional recovery after stroke: a systematic review. Neurologia. 2016;31(1):43-52. doi:10.1016/j.nrl.2013.02.003
5. Slimani M, Tod D, Chaabene H, Miarka B, Chamari K. Effects of Mental Imagery on Muscular Strength in Healthy and Patient Participants: A Systematic Review. J Sports Sci Med. 2016;15(3):434-450.
6. Burkhead LM, Sapienza CM, Rosenbek J. Strength-training exercise in dysphagia rehabilitation: principles, procedures, and directions for future research. Dysphagia 2007;22:251-265.
7. Ruffino C, Papaxanthis C, Lebon F (2017) Neural plasticity during motor learning with motor imagery practice: review and perspectives. Neuroscience 341: 1-78.
8. Szynkiewicz SH, Nobriga CV, O'Donoghue CR, Becerra BJ, LaForge G. Motor imagery practice and increased tongue strength: a case series feasibility report. J Speech Lang Hear Res 2019;62:1676-1684.
9. Szynkiewicz, SH, Kamarunas, E, Drulia, T, Nobriga, CV, Griffin, L, & O'Donoghue, CR. A randomized controlled trial comparing physical and mental lingual exercise for healthy older adults. *Dysphagia*. Advance online publication. 2020. https://doi.org/10.1007/s00455-020-10164-5