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Huaqing Liang

Tippawan Kaewmanee

Alexander S. Aruin

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Young Adults Can Learn to Predict Unexpected Posterior Perturbations Using an Auditory Cue

Huaqing Liang, Tippawan Kaewmanee, and Alexander S. Aruin
 Department of Physical Therapy, University of Illinois at Chicago, USA. Email: hqliang3@gmail.com

Introduction

To reduce the effect of an expected postural perturbation, central nervous system uses anticipatory postural adjustments (APAs), which include the activation and inhibition of the postural muscles and a slight shift of the center-of-pressure (COP) position [1].

The generation of APAs majorly relies on the availability of visual information, and is learned through past experience. Hence, such protective mechanism to maintain balance is not implemented when perturbation comes from one's back unexpectedly.

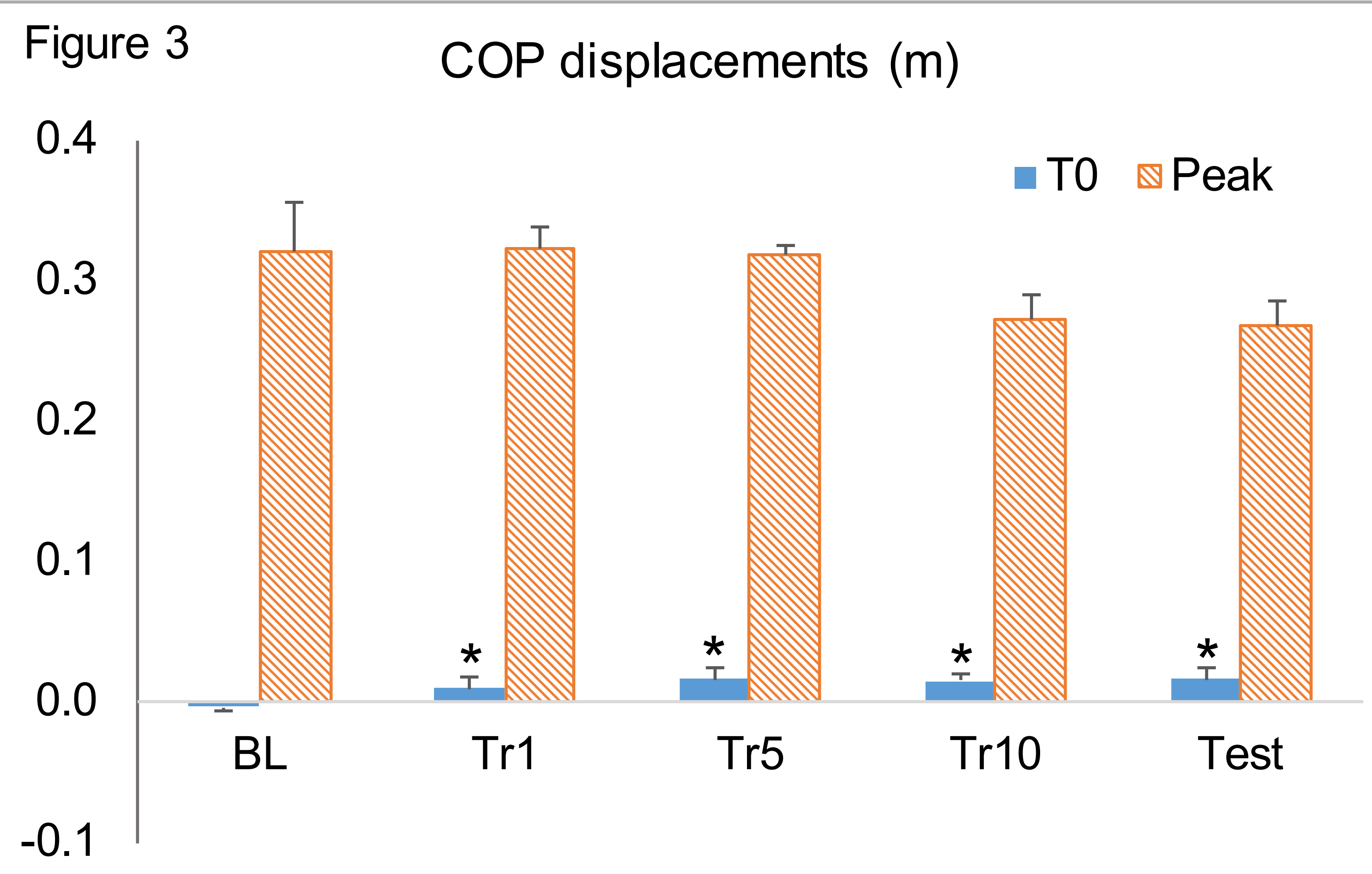
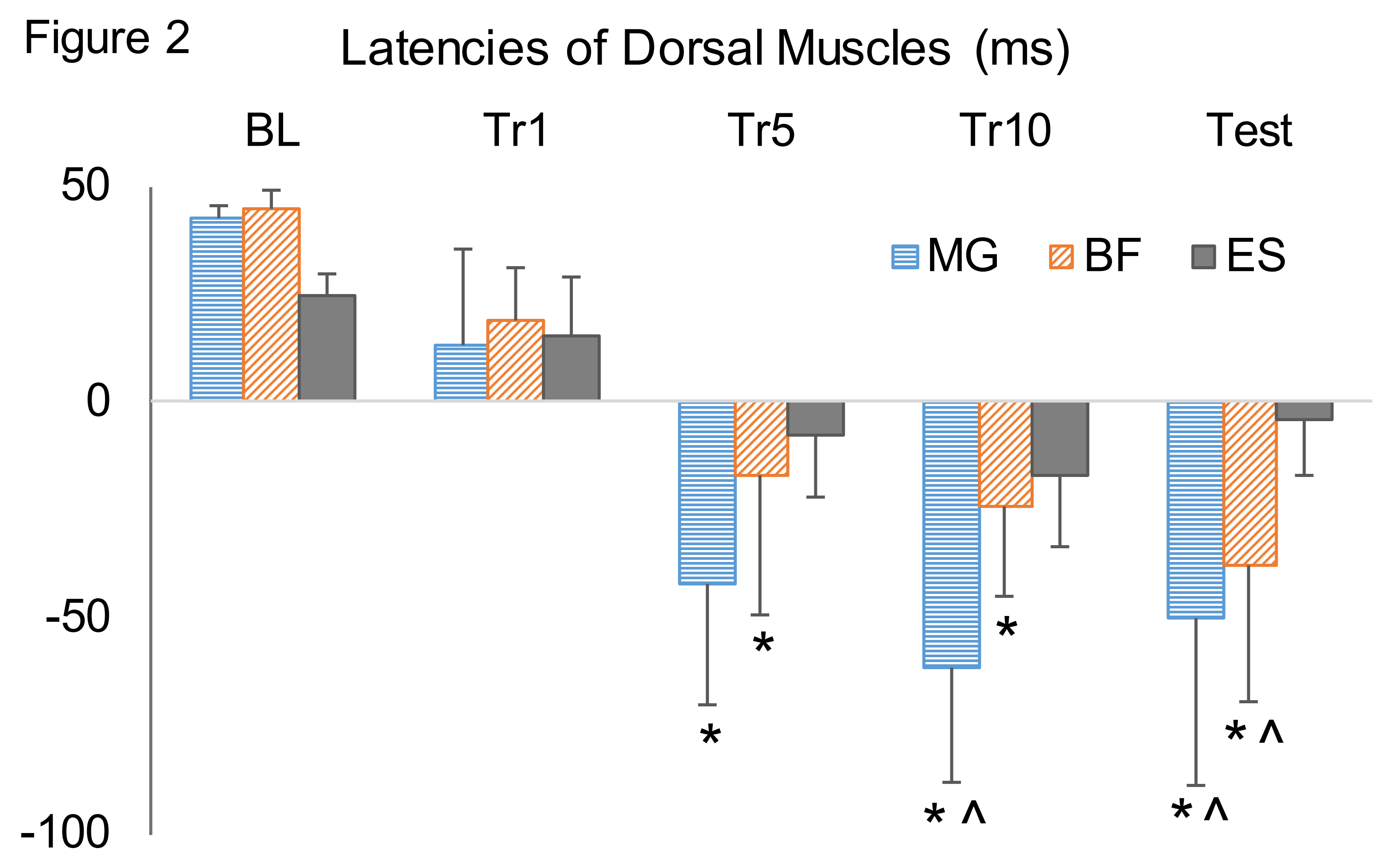
Our previous work showed that young adults could rely on an auditory cue only to generate APAs for a front perturbation similar to that when vision was available [2]. So the purpose was to evaluate whether adults could learn to generate APAs for an external perturbation coming from the back relying only on an auditory cue.

Method

Six young adults (mean age 31.5 ± 4.1 years) participated in this pilot study. They were instructed to stand on a force plate, look forward and be prepared for a pendulum hitting their shoulders bilaterally from the back. An additional weight (3% of the body weight) was attached to the pendulum (Figure 1). At first, the participants received perturbation with no cues provided (baseline, BL, 5 trials). Then they received training (Tr, 50 trials) when an auditory cue signalling the moment of the pendulum release was provided via headphones. After a resting period of 5 minutes, they were tested by receiving the perturbation with the same auditory cue (Test, 5 trials).

An accelerometer attached on the pendulum was used to identify the moment of impact (T0). Muscle activities were recorded from the right tibialis anterior (TA), medial gastrocnemius (MG), rectus femoris (RF), biceps femoris (BF), rectus abdominus (RA), and erector spinae (ES). Muscle latency was identified as the first time point within a 50ms window that the EMG amplitude was consistently greater (activation) than or smaller (inhibition) than its baseline value (-500 to -350 ms) \pm 2SD. The COP displacements in the AP direction at T0 and its peak value after T0 were identified.

Data were organized and averaged into 5-trial blocks. Data from the BL, one block from the beginning (Tr1), middle (Tr5), and the end (Tr10) of training, and the Test were used for further analysis. A series of one-way repeated measures ANOVAs were conducted. Statistical significance was set at $\alpha = 0.05$.

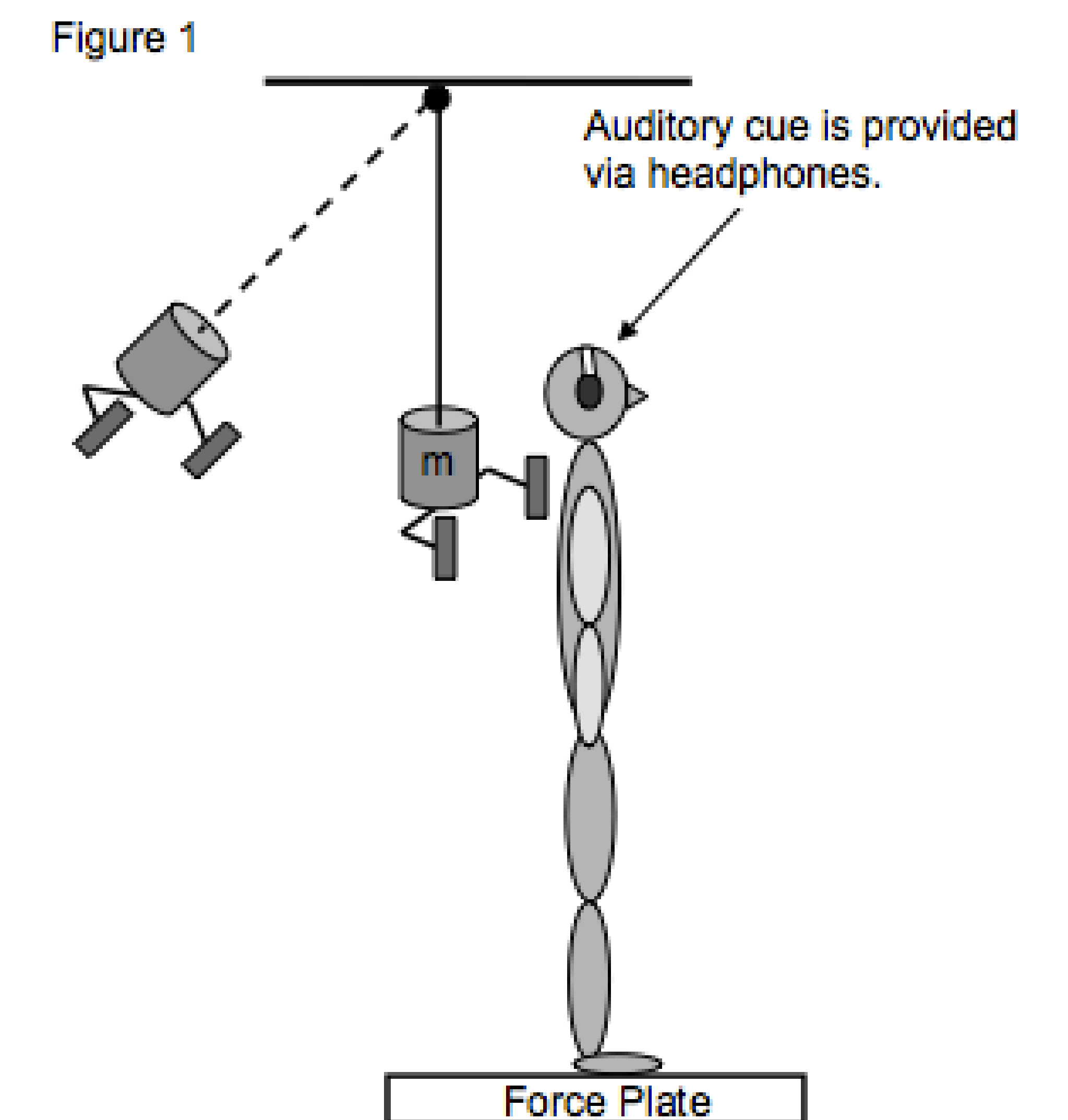


Significance

After only one session of repetitive training, young adults could learn to generate new APA patterns for an unpredictable postural perturbation relying on an auditory cue. Further study will explore the feasibility of using auditory cues for the generation of APAs and reduction of postural destabilization in response to unexpected external perturbations from the back in individuals with balance problems (i.e. older adults).

References

- [1] Bouisset & Zattara. J Biomech 20:735-742, 1987.
- [2] Liang et al. Exp Brain Res (In press) 2020. Doi: 10.1007/s00221-020-05738-6.
- [3] Massion. Prog Neurobiol 38:35-36, 1992.



Results and Discussion

In the BL condition, muscle latencies were detected after T0, COP displacement at T0 was close to zero, and the peak displacement was large. These results suggest that no APAs were generated for an unexpected perturbation coming from the back.

After some training (Tr5, Tr10, and Test), muscle latencies were detected earlier and prior to the physical impact of the perturbation, which were more noticeable for the dorsal muscles (Figure 2). Additionally, from Tr1 through Test, a slight anterior shift of COP was observed at T0 (APA phase), and the peak displacement gradually decreased (Figure 3).

Statistical analysis showed condition effect for latencies of MG and BF, and COP peak displacement (all $p < 0.05$). In Figure 2 and 3, * and ^ denote a difference compared to the BL and Tr1 condition, respectively.

The activation of frontal muscles and inhibition of dorsal muscles prior to the foreseeable frontal perturbations was reported before [3]. After some training (Tr5, Tr10, and Test), we observed an reverse pattern of early activation of dorsal muscles prior to the impact of the posterior perturbation.

