Assessment of a Wearable Biofeedback System to Elicit Temporal Gait Asymmetry using Rhythmic Auditory Stimulation

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I. Introduction

Temporal gait asymmetry (TGA) is commonly observed in individuals facing mobility challenges. Rhythmic auditory stimulation (RAS) can improve temporal gait parameters by promoting synchronization with external cues [1]. While biofeedback for gait training, providing real-time feedback based on specific gait parameters measured, has been proven to successfully elicit changes in gait patterns, RAS-based biofeedback as a treatment for TGA has not been explored.

This study focused on assessing three different feedback strategies, open- and closed-loop methods, using both constant and incrementally changing RAS. Furthermore, this study aimed to first test and evaluate the proposed RAS-based BFB system and strategies with able-bodied (AB) participants. This understanding is important for identifying any distinctions among strategies before evaluating such changes in individuals with mobility impairments (e.g., lower-limb prosthesis users). Since AB individuals typically exhibit temporal symmetry, this study aimed to induce TGA using RAS.

II. Methods

Ten able-bodied participants (seven females and three males; 25.3 ± 8.8 years; height 170.5.9 ± 7.91 cm; weight 66.7 ± 11.7 kg) were recruited to participate in this study. Participants were equipped with two systems: (1) the developed RAS-based BFB system and (2) a wearable motion capture system to collect secondary gait parameters, including spatial and kinematic gait parameters.

After setup and calibration, participants were instructed to conduct 3 walk trials using three distinct RAS-based BFB strategies: constant open-loop (COL), variable open-loop (VOL), variable closed-loop (VCL). Temporal symmetry was modulated through changes in the stance-time symmetry (STSR). During COL trials, the target STSR (timing between metronomes) remained constant throughout the duration of the trial. Target levels of 1.0, 0.9, 0.8, and 0.7 were all separate trials. For VOL trials, the target STSR continuously decreased by 0.3–0.4% every full gait cycle. For VCL trials, the target STSR decreased by 3–4% only when the participant's real-time STSR was within a range (target STSR ± error) for 80% of the time.

III. Results and Discussion

With all three strategies, temporal symmetry was significantly altered compared to baseline at target STSR less than 100%, with average STSR changes ranging from 4% to 10%. The closed-loop strategy yielded the most significant ($p<0.001$) changes when comparing the strategies at different target STSR levels. This suggests that the use of closed-loop systems (compared to open-loop), can result in better adaptation to changes in temporal symmetry using RAS. Additionally, speed and cadence remained largely unchanged during RAS-based biofeedback gait training. Finally, setting the metronome to a target beyond the intended target may potentially bring the individual closer to their symmetry target. These findings hold promise for developing personalized and effective gait training interventions to address TGA in patient populations with mobility limitations using RAS.

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References

1. L.D. Corsby, J.L. Chen, J.A. Grahn, K.K. Patterson, "The Effect of Rhythm Abilities on Metronome-Cued Walking with an Induced Temporal Gait Asymmetry in Neurotypical Adults." J. Mot. Behav. 2022, 54, 267-280.