Author's Accepted manuscript
European Stroke Conference 2017
Berlin, Germany

Rhythm and Gait rehabilitation: a case study using rhythmic haptic cueing for stabilising gait and improving asymmetries

Introduction

Hemiparetic stroke survivors commonly experience gait asymmetries. These asymmetries expose one leg to stronger vertical forces, leading to joint pains and increased risk of fall and fractures. Besides physical health issues, gait rehabilitation is important for independence and thus better quality of life. Regular rehabilitation can significantly improve a person's recovery both in in the acute stages after a stroke and long after returning home.

Research has shown that walking to a regular audio cue can improve gait symmetry. However, audio can be problematic outside of the lab, where it is important to remain aware of the environment, potential traffic hazards and to maintain social engagement. However, with Rhythmic Haptic Cueing (RHC), rhythmic entrainment is communicated through touch rather than sound, and hearing remains unobstructed.

In the present case study, a stroke survivor was asked to walk with and without RHC. Gait was recorded and analysed to find the effects RHC had on step time variability.

Methodology

The study focused on an independently mobile 60-year-old male who suffered a stroke in 2014. He was asked to walk in the lab for 10 meters: without a cue; with cue; and again without - 6 times for each condition. Data were then analysed for any effects of RHC.

The RHC was delivered by the Haptic Bracelets; wearable devices we developed, which were fitted near the ankle. The bracelets vibrate rhythmically on alternating legs while recording gait [1] (Fig. 1 and 2).

Results

During the baseline walk, step times of the right (paretic) and left (non-paretic) legs showed high variability. Interestingly, the participant's condition meant that he could not concentrate on the rhythm and walk at the same time, causing his gait to be more unstable when walking with the RHC. Yet, entrainment (the underlying mechanism to synchronise movements to external rhythm) can occur in two ways: walking and feeling, and feeling and then walking. This led to variability between steps dropping when we switched off the RHC and he walked by remembering the rhythm (Fig. 3).

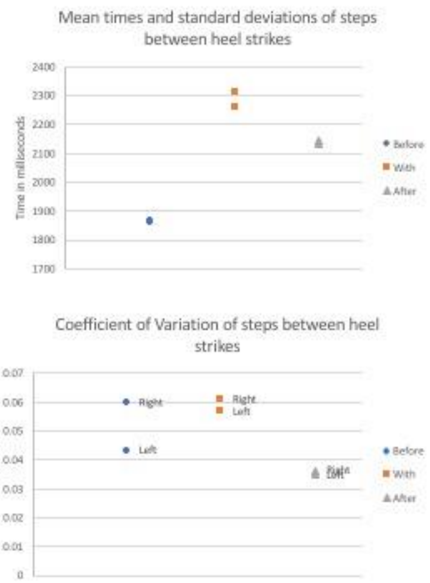
Conclusions

The use of haptic cueing is an innovation with potential to improve gait symmetry after stroke. The system we designed can be used both for delivering the RHC and monitoring gait for analysis. In the present case, the participant's gait was initially destabilized by the rhythm, but became less variable when the cue was followed from memory. Neurological deficits, or even the novelty of following a haptic rhythm, may have attributed to this initial destabilisation. More research is needed to further explore the efficacy and best use of RHC for gait rehabilitation.

1. T. Georgiou, S. Holland and J. Linden van der, "Wearable Haptic Devices For Post-Stroke Gait Rehabilitation," in Ubicomp, Heidelberg, 2016.

Fig. 1 The Haptic Bracelet device fitted on user's leg

Figure 2 Participant walking with the Haptic Bracelets fitted on his legs



Mean times and standard deviations of steps between heel strikes		
Condition	Left Leg (non-paretic)	Right leg (paretic)
Before (No cue)	1868.75 ± 80.96	1858.51 ± 111.20
With cue	2261.05 ± 128.49	2310.51 ± 141.20
After (No cue)	2142.25 ± 74.69	2132.72 ± 77.70

Coefficient of Variation of steps between heel strikes		
Condition	Left Leg (non-paretic)	Right leg (paretic)
Before (No cue)	0.043	0.060
With cue	0.057	0.061
After (No cue)	0.035	0.036

Fig. 3 Means and Coefficient of Variation (CV) of steps. Smaller CV values indicate lower variability.