RHYTHMIC AUDITORY STIMULATION IMPROVES COST OF TRANSPORT AND ASYMMETRY AFTER STROKE

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Introduction

There is a U-shaped relationship between walking cadence and the metabolic cost of transport (COT), such that walking at either a slower or faster cadence than optimal will increase metabolic cost (i.e., speed and mass-normalized energy consumption)[1]. While able-bodied individuals self-select an energetically-optimal walking cadence that approximates the resonant frequency of the leg, individuals post-stroke walk at slower cadences, leading to an increased COT. Additionally, spatiotemporal walking asymmetries characteristic of post-stroke walking may also contribute to a higher COT[3].

Rhythmic Auditory Stimulation (RAS) is an emerging gait therapy that has been shown to improve post-stroke walking[4]. Our group recently demonstrated that a music-based digital therapeutic could automate the delivery of a progressive and individualized RAS protocol. We found that a single 30-minute digital RAS session could meaningfully improve post-stroke walking speed by way of increasing cadence[5]. To expand upon this work, and drawing on the known relationship between walking cadence, spatiotemporal asymmetries, and the COT, the primary aims of this study were to evaluate if a single session of digital RAS locomotor training could improve the COT (ml O_2/kg/m) and spatiotemporal walking asymmetries after stroke. We hypothesized that there would be improvements in both COT and spatiotemporal asymmetries following digital RAS training. A second exploratory aim was to investigate if changes in each outcome (i.e., percent change in COT or spatiotemporal asymmetries) could be predicted by baseline measures (i.e., baseline speed and COT, or spatiotemporal parameters, respectively).

Methods

Participants completed one 30-minute digital RAS session. Indirect calorimetry (K5, Cosmed) and kinematic data (Qualisys) were collected concurrently during two, 3-minute speed-matched treadmill trials before and after training. Treadmill speed for both trials was set to each participant's comfortable walking speed measured prior to training, to isolate biomechanical and energetic changes from changes in speed. Indirect calorimetry data were converted into COT (ml O_2/kg/m) using standard methods[3]. Thirty seconds of steady state metabolic data (based on SD[6] and visual inspection) from the final 90 seconds of each walking bout were averaged to calculate pre-and post- COT. Step length, step time, stance time, and swing time were calculated using twenty steps time matched to the metabolic data. Asymmetry measures were calculated as the absolute difference in pre- to post-metrics divided by the sum.

Statistical analyses were calculated using RStudio Version 1.3.1056. To answer our primary aims, Wilcoxon Ranked Sum Tests were conducted between pre- and post-session measures of COT and spatiotemporal asymmetries. For exploratory analyses, we investigated Spearman's rank-order correlations between percent change in COT and baseline measures of speed and COT, and between percent change in spatiotemporal asymmetries and baseline spatiotemporal parameters for individual limbs. Alpha was set at 0.05.

Results and Discussion

Data were available from 10 individuals post-stroke (56.7±14 yrs. old, 8.9±5 yrs. post-stroke, 3 females, 6 right paretic). Training resulted in an average 9% reduction in the COT (p = 0.027) and ~20% reductions in step time, stance time, and swing time asymmetries (p's < 0.027) (Fig. 1). Changes in step length asymmetry were not observed ($p = 0.16$). Percent change in cost of transport was predicted by baseline COT ($\rho = -0.85$, $p = 0.004$), but not by baseline walking speed ($\rho = 0.43$, $p = 0.22$). More specifically, a higher COT prior to training was associated with a larger improvement after training. There were no baseline predictors of percent change in temporal asymmetries.

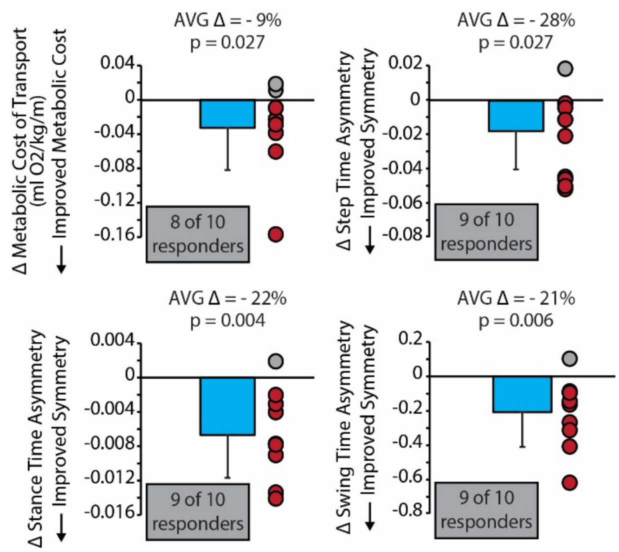

Figure 1: A majority of participants significantly improved metabolic cost of transport, step time asymmetry, stance time asymmetry, and swing time asymmetry after a single session.

Significance

A single session of digital RAS significantly reduced COT and concurrently improved post-stroke spatiotemporal asymmetries. Taken together with our previous finding of improvements in overground walking speed, the music-based digital therapeutic may be a useful paradigm for retraining gait patterns after stroke.

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