Walking-related adjustment in electrocortical activity associated with inhibitory control: young adults rely to a higher degree on later stages of the inhibitory processing network.

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INTRODUCTION

A research field with major clinical implications is centered on walking while individuals engage in cognitive tasks. Behavioral studies using a dual-task approach have provided robust evidence for a mutual influence suggesting that motor and cognitive functions are supported in part by common neural processes [1].

A new line of research on human locomotion has deployed EEG recordings [2-4], which allows for temporally precise measures of information processing well-suited to probe for differences in the reliance on higher-order cognitive processing stages in performing a task while walking. Based on a pilot study by our group (De Sanctis et al., 2012), we predicted that walking, particularly at rapid pace, would alter the spatio-temporal N2/P3 componentry associated with inhibitory control.

METHODS

Participants: 16 neurologically healthy individuals (10 male; age 18-34 years) participated in the experiment. Written consent was obtained from all participants

Stimuli and Task: Participants performed a GO/NOGO task, responding to every presentation of an IAPS picture [5], while withholding responses to the second instance of any stimulus repeated twice in a row. Stimuli duration was 600ms and inter-stimulus-interval varied randomly from 800 to 1200ms.The probability of GO and NOGO trials was 0.85 and 0.15, respectively. Participants were asked to sit, walk slowly (2.4 km/hr), or quickly (5 km/hr) on a treadmill (LifeFitness TR-9000). Participants completed 4 blocks for each of the 3 conditions presented in a pseudorandom order.

Data collection: Brain activity was recorded at 512 Hz using a 72-channel EEG system (BioSemi). Automatic artifact rejection criterion of 75 μV was applied, rejecting trials with more than six artifact channels.
Minimal contamination of the evoked response from muscles and eye movements was confirmed by computing the Fast Fourier Transform on the epoched GO trials for all three conditions.

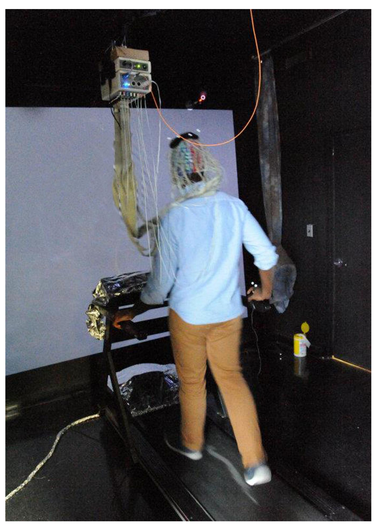


Figure 1: Illustration of a participant walking on the treadmill wearing an EEG cap while performing the GO/NOGO-task.

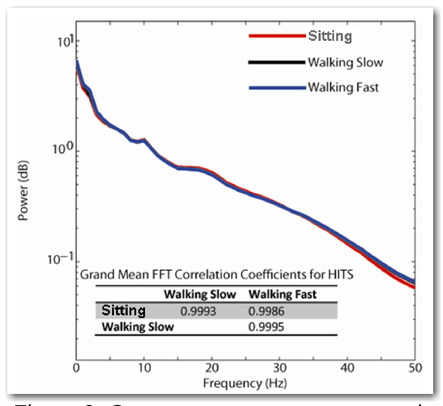


*Figure 2: Group mean spectra computed for each condition**. Color code incorrect***

	Sitting	Walking Slow	Walking Fast
Signal to Noise	34.08644	31.04795	29.87904

BEHAVIORAL RESULTS

Table 1 shows reaction time, hit and correct rejection rates for performing the GO/NOGO task while participants were sitting, walking slow and walking fast. The ANOVA for RT and accuracy revealed no difference between conditions.

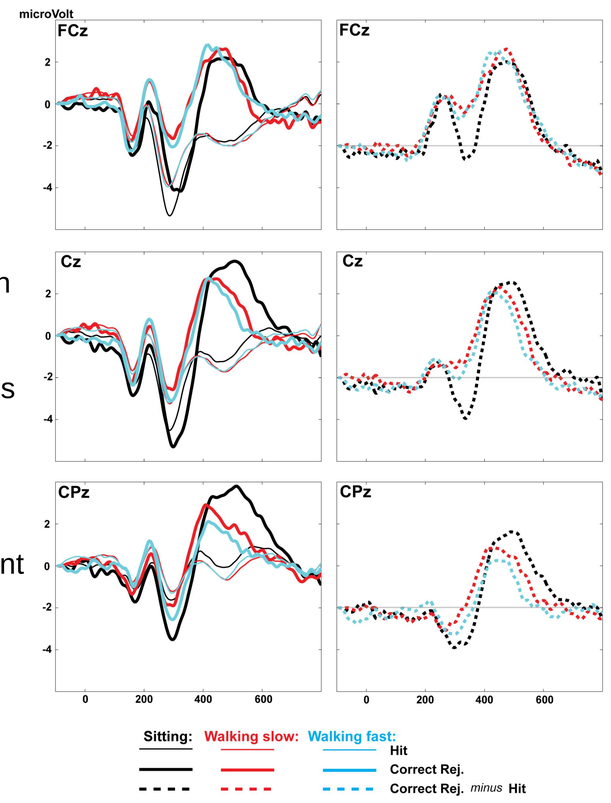
	Sitting	Walking S	Walking F	p-value	Walking Double support	Walking Single support	p-value
Hit in msec.	399.1	408.2	401.2	0.53			
Hit in %	96.4	98.3	98.5	0.49			
Corr. rej. in %	68.6	70.4	69.4	0.6			

ELECTROPHYSIOLOGICAL RESULTS

Figure 3 shows the event-related potentials (ERP) for hit and correct rejection (CR) trials (left column) and the difference waves (CR_{ERP} *minus* Hit_{ERP}; right column) while participants were sitting, walking slow and walking fast.

The ANOVA with factor condition (sitting/walking-slow/walking-fast) and trial (go/nogo) for the N2 at Cz revealed a main effect for condition ($p < .0001$), a main effect for trial ($p < .0001$), and a condition by trial interaction ($p < .018$).
The P3 peak latency at CPz differed between conditions ($p < .0001$), suggesting an earlier onset of P3 related processes while walking. For the mean amplitude between 400-550 ms we found a main effect for trial ($p < .0001$).

The statistical cluster plots in figure 4 comparing differential activity (GO *minus* NOGO) across conditions, revealed significant clusters during the N2/P3 time periods only between sitting and walking.



Statistical Cluster Plots

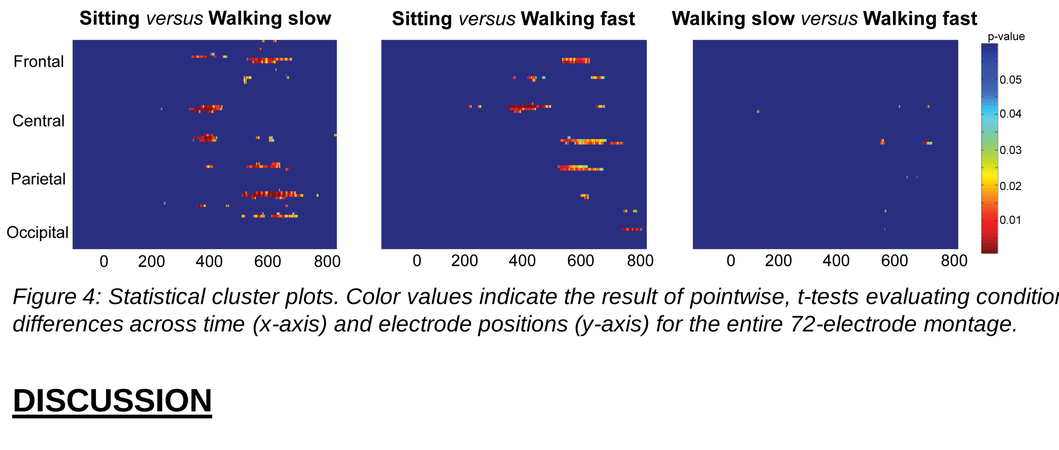


Figure 4: Statistical cluster plots. Color values indicate the result of pointwise, t-tests evaluating condition differences across time (x-axis) and electrode positions (y-axis) for the entire 72-electrode montage.

DISCUSSION

We suggest that the reported neural changes are adaptive, possible indicating reliance on later processing stages of the inhibitory network to optimize performance in dual task situations.
Signal-to-noise ratios were remarkably similar across conditions, pointing to the feasibility of high-fidelity ERP recordings under relatively vigorous activity regimens. There is considerable research and clinical motivation to obtain high quality neuro-physiological measures under more naturalistic environmental settings such as these. Strong links between cognitive load and gait abnormalities are seen in a number of clinical populations. Designs capable of testing neuro-cognitive processes while participants walk provide highly promising methods for gaining insights into the underlying pathophysiology.

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