Effect of transcranial direct current stimulation on dual task walking and cortical activity: A feasibility study

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Introduction

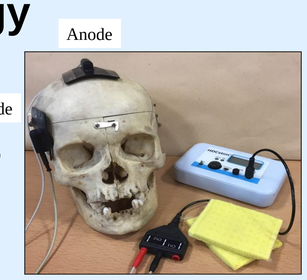
Gait can act as a biomarker to detect early changes in the human brain due to ageing or other pathological changes[1]. Walking with additional tasks requires a dynamic interaction between cortical regions. This is more challenging and impacts gait of older people [2]. A weak direct current stimulation on the motor cortical region may enhance its neuronal function. However, experimental evidence supporting increased cortical activity is still lacking. The aims of this project were to :

1. Explore the feasibility of a study using tDCS together with fNIRS
2. Determine the effect of direct current stimulation on complex treadmill walking with cognitive dual task.
3. Investigate changes in dual task (DT) walking after stimulation of direct current based on the cortical activity.

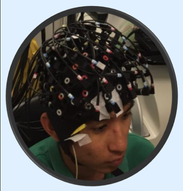
Methodology

Area of stimulation:

Supplementary motor area (SMA) as it is involved in behavioural planning and movement execution [3].
Anode : SMA
Cathode : Contralateral superior part of zygomatic arch



Equipment involved



Functional Near-Infrared Spectroscopy (fNIRS)
-LABNIRS (Shimadzu, Kyoto, Japan)
-detect cerebral oxygenation level in different states; stand still, normal walking and dual task
-Optodes: 3x5, prefrontal + 2x7, sensorimotor area
-41 channels

Transcranial Direct Current Stimulation (tDCS)
-HDCstim (Newronika , Milano, Italy)
-Direct current at 2mA for 10 minutes with 10 seconds ramp (active/sham)
- 5x5cm electrodes were used, sponges soaked with saline solution

Accelerometer
-Axivity (York, UK) ; 100Hz, ±8g, weight: 9grams.
-Records acceleration with gait parameters processed using MATLAB algorithms
-Attached at lower back, L5 vertebrae level

Procedure

This study was approved by Newcastle University ethics committee. A personal information sheet and written informed consent were given to the participants. A structured interview was conducted and health questionnaires were performed. They were also being assessed with;

(1) Beck Depression Inventory **(2)**Falls efficacy Scale **(3)** Montreal Cognitive Assessment

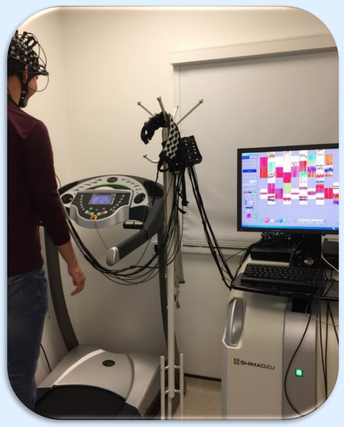
Experiment session:

1) Stand still for 60s, eyes opened followed by 60s eyes closed.

2) 2-minute normal walking followed by 5-minute of alternating 30 seconds normal walking and DT walking. 5 minutes rest

3) 10-minute walking with active or sham tDCS. 5 minutes rest

4) Repeat step no. 2



Data collection, analysis and interpretation.

All data were exported to be processed with algorithms in MATLAB. Future statistical analysis will be carried out using linear mixed models in SPSS with significance set at $p < 0.05$.

Final scientific report and submission

Acknowledgements

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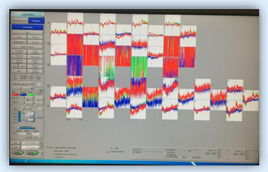
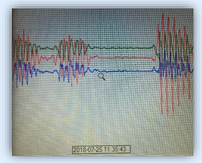
Preliminary Results

- 4 participants were recruited, age 21-22 years
- Mean normal walking pace : 5.05 km/h
- 3 participants received active stimulation
- 1 participant reported to feel a tingling sensation during the stimulation
- Only one reported tiredness after the procedure

Issues arising

- Some of the channels of the fNIRS were contaminated by noise.
- About 3 optodes were blocked by the sponges and these might reduce the availability of data channels for future analysis.


fNIRS data


Accelerometer data

- The numerical memory recall test was the same before and after stimulation.
- 3 participants reported that they felt discomfort as the room was bit warm and 'stuffy'.

Discussion

- It is feasible to use tDCS with fNIRS simultaneously in a study
- No adverse event occurred such as extreme fatigue and headache. However, we cannot extrapolate the findings to older adults as only young adults were tested in this study

Future Work

- A future study is planned with 30 older adults and 30 younger adults.
- Smaller electrodes with 3x1 cm sizes should be used to ensure all the optodes make contact with the scalp.
- The study should be conducted in a larger room with better ventilation.
- Data collected from fNIRS and accelerometer will be analyzed using proposed methods.

References

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2. Beurskens et al. Age-related changes in prefrontal activity during walking in dual-task situations: a fNIRS study. 2014. Journal Article
3. Hiroshima et al. Functional Localization of Supplementary Motor Area. 2014. Neural Med Chir (Tokyo) Journal Article