Using fNIRS to determine dual task walking brain activation changes in adults with and without neurological disease: systematic review and meta-analysis.

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Background

- Functional near infrared spectroscopy (fNIRS) is an optical neuroimaging technique for assessing cortical activity through the hemodynamic response of the brain [1].
- fNIRS has been used to record hemodynamic responses [2], especially while dual task walking.
- There is a considerable amount of literature on fNIRS measuring cortical activity while dual task walking.
- However, no systematic review has taken a quantitative approach of measuring brain activation changes, using fNIRS, while dual task walking, and how activation changes differ among older adults with and without neuromuscular disorders.

Objective

This study systematically reviewed and quantitatively synthesized brain activation differences using fNIRS in adults with and without neuromuscular disease while dual-task walking.

The objectives are to examine: 1) changes in cortical activation patterns between different dual tasks; 2) activation differences between different populations.

Search Strategy: Database search was conducted till December 2019 in PubMed, Web of Science, Scopus, PsychInfo. Keywords included “dual task”, “walking”, “adults”, “neuroimaging”, “functional near infrared spectroscopy”.

Authors independently assessed the articles to determine their eligibility. Interrater agreement was determined by ICC value, authors showed moderate correlation (ICC=0.846).

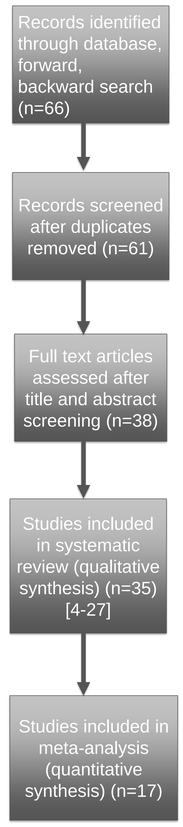

Figure 1 represents flow diagram of screening process [3].

Study Selection Criteria

Inclusion criteria:

a) Population: Adults in the range of 18-75 years old with or without neurological disease;
b) Outcome measure: Oxygenated haemoglobin (HbO2) measured by functional near infrared spectroscopy (fNIRS);
c) Language: English;
d) Study design: RCT, cohort study, pre-post study, cross-sectional study;
e) Subject: Humans;
f) Timespan: all years.

Excluded criteria:

a) if fNIRS was not used;
b) dual task didn’t involve walking;
c) conference proceeding or review article;
d) same data used by the group in different publications;
e) older adults> 75 years old;
f) non-English publication.

Results

- 35 studies met inclusion criteria for systematic review, out of which 17 studies were included for meta-analysis.
- Oxygenated hemoglobin (HbO2) data was extracted from the articles while individual was walking under single and dual tasks for meta-analysis.

Tasks(pooled effects)	Overall	HOA	PD	Stroke	MS
Single-task walking	6.89**	4.511**	1.37	2.06*	2.64**
Serial Subtraction	7.75**	4.237**	3.797**	6.459**	
Walking-while talking	6.36**	4.836**			3.162**
Obstacle Walking	4.52**	7.411**			

Table 1: Meta analysis results: overall effect sizes, Healthy older adults (HOA) effect size, Parkinson’s disease (PD) effect size, Stroke and Multiple sclerosis (MS) effect size. p<0.01**,*p<0.05.

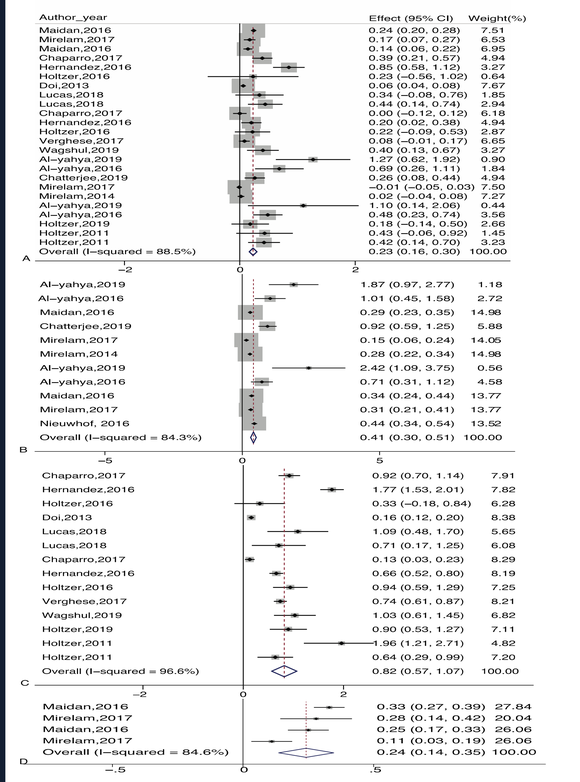

Figure 2 Brain activation differences while doing Single task walking (A), Serial subtraction task (B), Walking while talking (C), Obstacle walking (D).

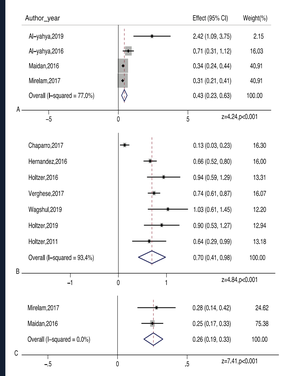

Figure 3 Brain activation differences while doing Serial subtraction task (A), Walking while talking (B), Obstacle walking (C) in Healthy older adults.

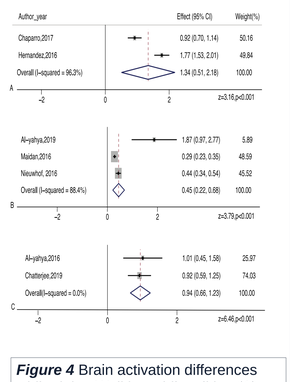

Figure 4 Brain activation differences while doing Walking while talking (A) and Serial subtraction task (B,C) in older adults with Neurological Disease (Multiple sclerosis-A, Parkinson’s Disease-B, Stroke-C).

Results

- Meta-analysis of the studies revealed that single task walking, serial subtraction (SS), walking while talking (WWT) and obstacle walking (OW) were all significant enough in showing neural activation results under prefrontal cortex (PFC).
- Specifically, in case of HOA, WWT is significant with higher effect size and higher number of studies. In case of neurological disorders, SS is more significant than WWT.
- Funnel plot analysis showed publication bias among studies (p<0.05)

Conclusions

- Our results revealed increases in brain activation among dual task walking conditions such as SS and WWT, with effects larger in case of SS.
- Older adults with neuromuscular disease generally showed increase in brain activation suggesting that they had to use more attentional resources during dual task walking, which could lead to increased fall risk and mobility impairments.
- This meta-analysis provided evidence on which dual task is sensitive enough to be used with fNIRS in older adults with or without neurological disease.

Limitations

- Smaller number of studies included in specific meta-analysis.

Future Directions

- Further studies are required to confirm our findings.

Acknowledgement

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