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The effects of different cognitive and motor tasks on the walking dual task cost in Multiple Sclerosis: a case-control study

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BACKGROUND

The dual-task (DT) methodology has increasingly been used to assess the attention needed to walk in people with Multiple Sclerosis (pwMS). Whenever the performance of the gait or the secondary task or both decreases during DT, a cognitive-motor interference (CMI) occurs, revealing the involvement of cortical attention processes while walking. The magnitude of this interference (i.e. slowing down in walking and/or speaking) is also defined as dual-task cost (DTC).
We sought to reveal which DT paradigm may have the greatest impact (highest DTC) on the spatiotemporal gait parameters and the cognitive task performances and whether it can discriminate pwMS from healthy controls (HC).

METHODS

Study design: observational case-control study
Participants: 40 pwMS and 31 age- and sex-matched HC
Setting: REVAL Institute and Overpelt MS clinic, Belgium
DT protocol: testing procedures were performed in 3 different days:
a) DAY 1: collecting the descriptive outcomes, performing neuropsychological examination
b) DAY 2: performing the DT experimental protocol
c) DAY 3: re-perform the same DT experimental protocol of day 2 in order to assess test-retest reliability. At least 1 week from day 2.
We administered randomly sixteen DT paradigms, consisting of walking without and while carrying a cup (WC) during eight different cognitive tasks: subtraction by 3 and 7, digit span (DS) forward and backward, word list generation (WLG) phonemic and semantic, auditory stroop (AS) and clock test (CT).

Outcomes: the DTCs of velocity, stride length, cadence, double support and gait cycle, and the DTCs of each cognitive task. Association between DTCs and motor outcomes (Timed Up and Go, Timed-25-Foot-Walk, Six-Minute Walk, Nine-hole-Peg Tests), and cognition (Brief repeatable battery of Rao, Stroop Test, Trial Making Test A & B, A-B). Cognitive impairment (CI) was defined when at least three tests were pathologically scored (below 2 SD).

MATERIAL

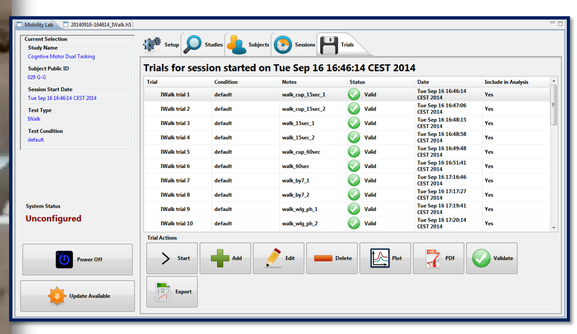
For the cognitive task:
The system called Cognitive-Motor Dual Task software consists of an apparatus able to:
1) Deliver through a wireless headset some cognitive tasks
2) Record through a microphone the answers given by the subject
3) Analyse data collected (offline)
4) Store data in specific patient files

For the motor task:
Wearable sensors are placed on the body (on the ankles, wrists and trunk) to assess the complete gait cycle.

The sensor technology: APDM; movement monitoring solution from mobility lab is used.

Below are reported the illustrations of both systems.

ILLUSTRATIONS



RESULTS

PwMS= F/M: 26/12, mean age 47 12 yrs, EDSS 2.7 2.3; 11 with CI (27.5%)
HC= F/M: 21/10, mean age 47 14 yrs, no subjects with CI.
For the main results of the DT effects (DTC) on the motor and cognitive tasks see figures 1-4.
The correlation analysis found a r value of .31 ($p<.05$) between the DTC of stride length of walking during WLG phonemic and the TMT in PwMS, and a moderate correlation between almost all DTCs of velocity and stride length and the EDSS (r values from .40 to .60, $p<.001$).
A regression analysis showed that TMT form B and EDSS accounted for 36% ($F=15.8$, $p<.0001$) and 29% ($F=8.5$, $p<.05$) of the variance in model predicting respectively the DTC of stride length of WC during WLG phonemic and DTC of velocity of WC during DS-backward.

Figure 1. The DTC of gait velocity for each of the DT paradigms.

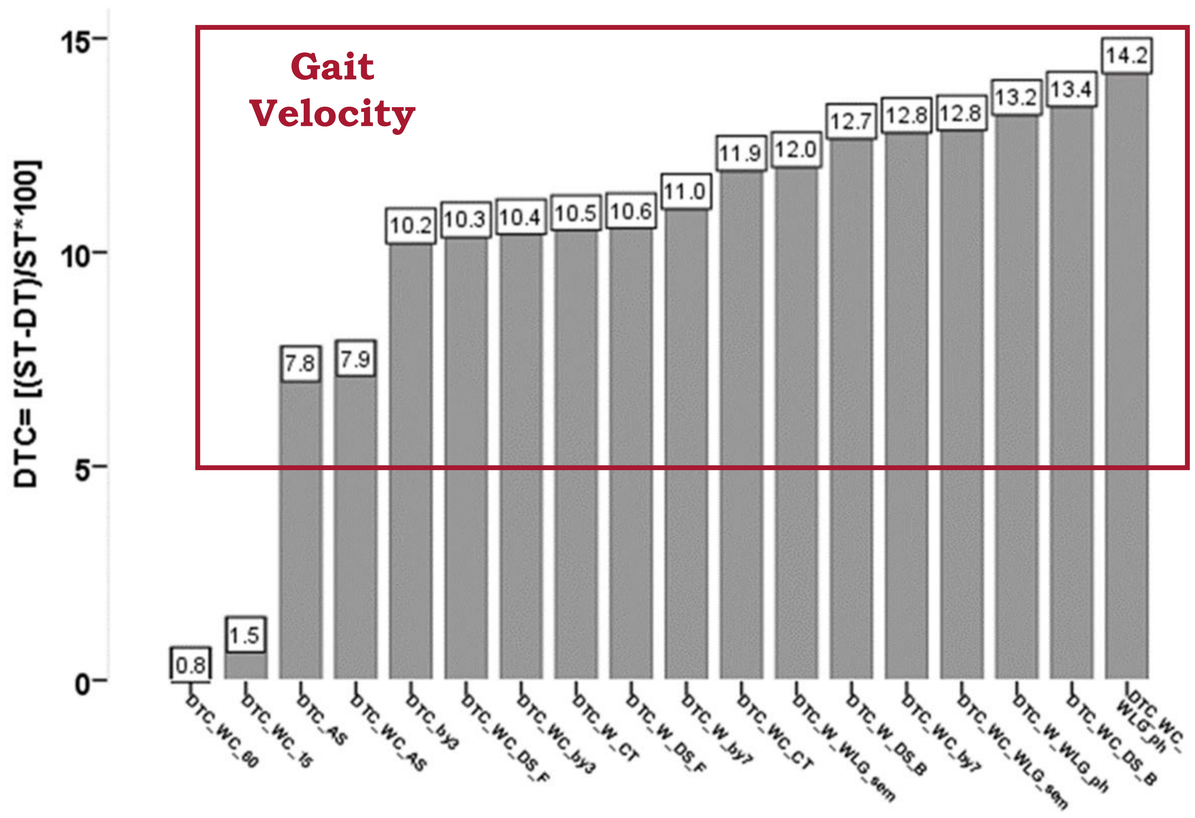


Figure 2. The velocity DTC significantly different between pwMS and HC.

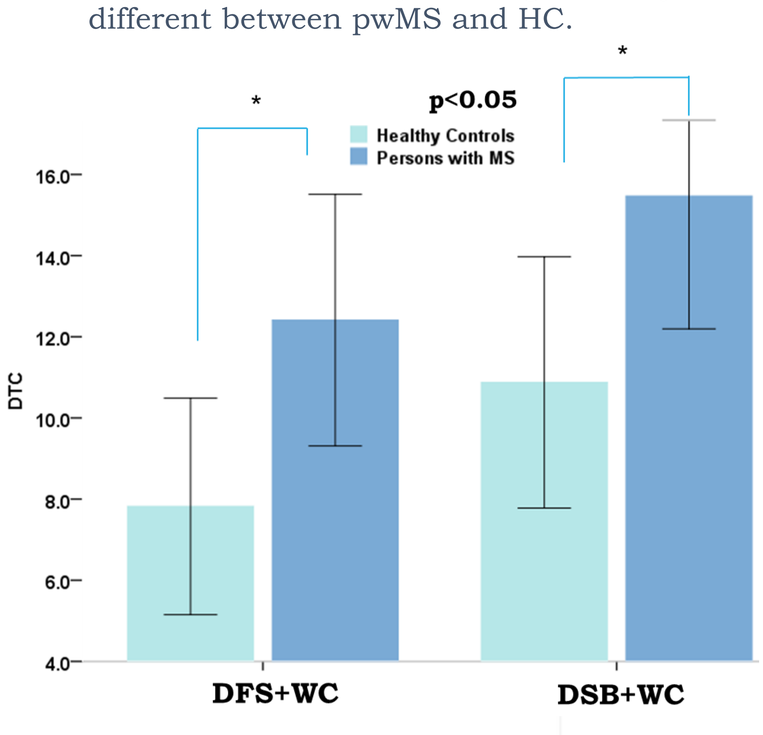


Figure 3. Auditory Stroop RT (incongruent stimuli) DTC significantly different between pwMS and HC.

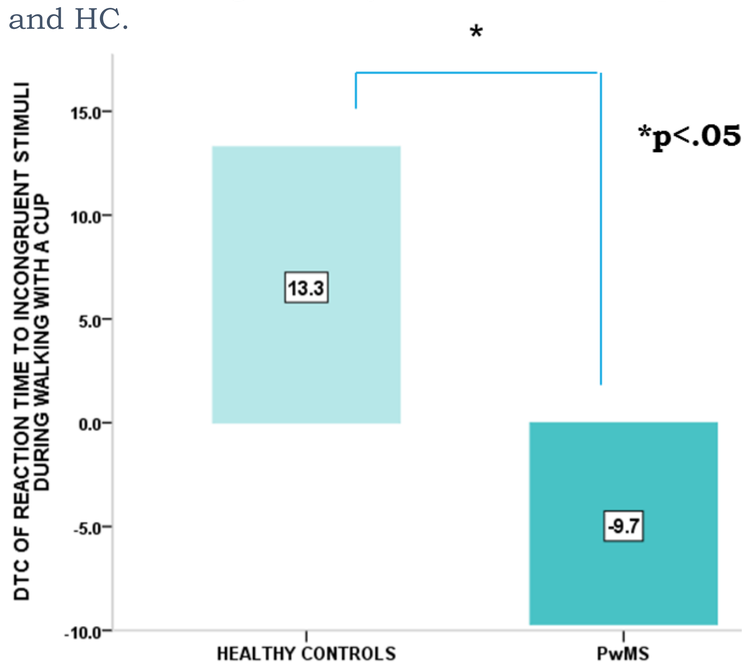


Figure 4. The DTC of the cognitive tasks for each of the DT paradigms. In red we reported the ones with a decreased perfomance when compared with the cognitive task performed in sitting position; while in green we identified the negative DTC that means a better cognitive perfoemance when compared with the performnace of task in sitting position.

DISCUSSION. The type and difficulty level of the added task are likely crucial component in determining the magnitude of the DTC of walking and of the cognitive task during DT in pwMS. The fact that only the DT involving WC during the DS (both forward and backward) and the WLG (the phonemic one) may discriminate pwMS from HC supports our idea that pwMS are still able to do DT at the same "cost" of HC, but only when the added simultaneous task is not difficult enough to overload the central attentional capacity or does not interfere with the kind of primary task. The effect of walking with or without carrying a cup on the cognitive tasks was overall the same on pwMS and age-matched HC, since only the DTC of RT of the answers to the incongruent stimuli of the AS was found to be significantly different between the two groups. This in favor of a "reverse" DTC (higher value in the negative direction) in the HC group who showed a reduction of their answers' RT during walking while carrying a cup compared with pwMS who slightly increased their RT. Both physical and cognitive dysfunctions play a role in predicting DTC values.

References. *Yogev- Seligmann G, Hausdorff JM, Giladi N. The role of executive function and attention in gait. Mov Disord 2008;23:329– 342. Leone C, Patti F, Feys P. Measuring the cost of cognitive-motor during walking in multiple sclerosis. Mult Scler. 2015 Feb;21(2):123-31. Hamilton F, Rochester L, Paul L, Rafferty D, O'Leary CP, Evans JJ. Walking and talking: an investigation of cognitive-motor dual tasking in multiple sclerosis. Mult Scler Oct 2009;15(10):1215–27.*