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ORIGINAL RESEARCH

Nonsignificant Associations Between Measures of Inhibitory Control and Walking While Thinking in Persons With Multiple Sclerosis

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Abstract

Objective: To examine whether inhibitory control measures were associated with the dual-task cost (DTC) of walking in persons with multiple sclerosis (MS) and matched controls without MS.

Design: Cross-sectional study.

Setting: University research laboratory.

Participants: The sample (N=56) included ambulatory persons with relapsing-remitting MS (n=28 [26 women, 2 men]; median Expanded Disability Status Scale score, 3.0) from the local community and controls (n=28) matched by age, sex, body mass index, and education.

Interventions: Not applicable.

Main Outcome Measures: All participants underwent a modified flanker task followed by 4 trials of the timed 25-foot walk. The first 2 trials involved walking as quickly as possible only (single-task condition), and the second 2 trials involved walking as quickly as possible while naming alternate letters of the alphabet (dual-task condition). Walking speed under single- and dual-task conditions was used to compute a DTC of walking.

Results: Persons with MS demonstrated a similar DTC of walking compared with matched controls, but performed more poorly on inhibitory control measures. Interestingly, inhibitory control measures were not associated with DTC of walking in the MS sample (all $|\rho|<.26$, $P>.19$), but were associated with DTC of walking in controls (all $|\rho|>.42$, $P<.03$).

Conclusions: Inhibitory control based on modified flanker performance might not be associated with DTC of walking in persons with MS. Archives of Physical Medicine and Rehabilitation 2015;96:1518-24

Walking and cognitive impairment are common, interrelated features of multiple sclerosis (MS). Persons with MS have worse walking[1] and cognitive[2] performance than controls without MS, and there is evidence that these performance deficits are interrelated,[3,4] perhaps based on co-occurring damage in neural regions that are important for both functions.[5] If these tasks are associated based on similar neural regions, then it may be difficult to simultaneously perform well in these spheres of neurobehavioral function. Indeed, performing a cognitive task during ambulation has deleterious effects on walking performance and could result in falls or injury.[6,7] We have referred to this as cognitive-motor interference (CMI).[8]

One paradigm for examining CMI involves walking while thinking (ie, dual-task paradigm). Dual-task paradigms typically involve performing a single motor task (ie, walking; single-task condition), and then the same motor task while simultaneously performing a cognitive task (ie, walking while thinking; dual-task condition).[9] CMI can be expressed by calculating a dual-task cost (DTC) metric (ie, percent reduction in walking under single- vs dual-task conditions). There is evidence for a DTC of walking in MS and matched controls.[10]

The neuropsychological correlates of the DTC of walking are not well understood in persons with MS. This is important because identifying the associations between specific cognitive functions and DTC of walking might support development of rehabilitative cognitive interventions that can potentially reduce DTC of walking and its consequences.[11] To date, 2 studies have examined the neuropsychological correlates of DTC of walking in MS. One

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study[12] reported that Symbol Digit Modalities Test (SDMT) performance was associated with DTC of self-selected gait velocity ($r=-.32$) in 82 persons with mild to moderate MS disability, but after controlling for disability status, SDMT scores did not explain a significant amount of variance in the DTC metric. The other study[13] reported that SDMT scores were not associated with a similar DTC measure ($r=.01$) in 96 ambulatory persons with MS with a broad range of disability, and that the interaction of SDMT scores and timed 25-ft walk (T25FW) performance did not explain a significant portion of variance in DTC of walking.

The examination of cognitive processing speed (CPS) (ie, SDMT[14]) as a sole neuropsychological correlate of DTC of walking might be a limitation of previous research, given that dual tasking during walking seemingly involves inhibitory control processes (ie, interference control, response inhibition, or higher-order decision making).[15] Perhaps when faced with competing demands (ie, walking and cognitive tasks), persons with MS cannot optimally divide attentional resources between walking and cognitive tasks, resulting in the slowing of walking and an increased risk of falling. Indeed, there is evidence that persons with MS have difficulty dividing attention,[2] and there is consistent evidence in other populations, such as healthy older adults, that measures from modified flanker tasks are associated with dual-task walking performance.[16] The MS studies[12,13] noted above failed to recruit healthy controls for comparing the magnitude of DTC of walking and associations with neuropsychological measures. Such comparisons could provide important information relative to the generalizability of potential rehabilitative interventions for reducing DTC of walking in MS. Those studies[12,13] examined DTC of walking at a self-selected walking speed, rather than fastest walking speed (ie, T25FW), which might underestimate real-world CMI.[10]

The current study examined CPS and inhibitory control measures as potential neuropsychological correlates of DTC of walking in 28 persons with MS and 28 matched controls without MS. We hypothesized that persons with MS and matched controls would have similar DTCs of walking despite persons with MS having worse walking ability based on previous research,[9,17,18] and that inhibitory control, but not CPS, would be associated with DTC of walking in persons with MS and matched controls.

Methods

Participants

This cross-sectional study represents a secondary analysis of baseline data from an examination of acute exercise and cognition in MS.[19] We recruited 28 persons with MS and 28 healthy controls matched on age, sex, body mass index (ie, kg/m^2), and education. The inclusion criteria for those with MS were (1) a definite diagnosis of MS; (2) relapse-free for the past 30 days; (3) ability to read large type; (4) walk with or without a cane, but not a walker/rollator; (5) age between 18 and 54 years; and (6) willingness and ability to complete the walking and cognitive assessments.

List of abbreviations:

ANOVA	analysis of variance
CMI	cognitive-motor interference
CoV	coefficient of variation
CPS	cognitive processing speed
DTC	dual-task cost
EDSS	Expanded Disability Status Scale
MS	multiple sclerosis
MSNQ	Multiple Sclerosis Neuropsychological Screening Questionnaire
SDMT	Symbol Digit Modalities Test
T25FW	timed 25-ft walk

Dual-task paradigm

The DTC of walking was quantified during a T25FW.[20] Participants underwent 4 trials of walking as fast as possible over the 25-ft course. The single-task T25FW (ie, walking only) was performed during the first 2 walking trials, whereas the second 2 walking trials were performed with a concurrent cognitive task (ie, dual-task condition). This cognitive task involved participants naming alternating letters of the Latin alphabet (ie, A, C, E, G, etc) while performing the T25FW. We selected the T25FW as the walking task to intentionally maximize DTC, as presumably, it requires more attentional resources to walk as quickly as possible than at a comfortable walking speed. We instructed participants to divide attention equally on walking and correctly naming alternating letters of the alphabet. The dual-task condition presumably involves a high degree of inhibitory control (ie, processing of nonconsecutive letters and inhibiting prepotent response of naming consecutive letters while walking). We have previously highlighted the acceptability of this paradigm in MS.[8] The primary outcome of the T25FW was walking speed (ie, T25FW speed; m/s[21]) averaged over the 2 single-task and dual-task trials. We averaged the number of correctly provided letters during the 2 dual-task trials (ie, dual-task cognitive performance) and expressed this as correctly provided letters per second of walking (ie, total number of correctly provided letters per time to complete T25FW). We further expressed CMI during the T25FW as the DTC of T25FW speed based on our previous research.[8] This was calculated as a percentage change in T25FW speed—that is ([Single – Dual]/Single)*100—with more negative values indicating larger reductions in T25FW speed under the dual-task condition relative to the single-task condition.

Cognitive processing speed

The SDMT was administered as a neuropsychological measure of CPS.[14] This test is valid, reliable, and highly sensitive for measuring CPS in persons with MS.[2] The main outcome of the SDMT was the number of correct numbers provided in 90 seconds (ie, raw score).

Inhibitory control

The modified flanker task was included as a computerized, neuropsychological measure of inhibitory control.[22] This task has demonstrated excellent reliability ($r=.90$) in studies examining correlates of dual-task performance in older adults.[16] and measures interference control, response inhibition, and decision making.[22] We have described this task in detail previously.[19] This task represents the primary measure of inhibitory control in the National Institutes of Health Toolbox for cognition, and normative data are available elsewhere.[23] Briefly, the modified flanker task requires participants to respond to a centrally presented target stimulus amid congruent (<<<<<) or incongruent flanking