Human Movement Science 49 (2016) 124–131

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Walking impairs cognitive performance among people with multiple sclerosis but not controls

Matthew B. Downer, Megan C. Kirkland, Elizabeth M. Wallack, Michelle Ploughman *

Recovery & Performance Laboratory, Faculty of Medicine, Memorial University, Rm 400, 100 Forest Rd., St. John's, NL A1A 1E5, Canada

ARTICLE INFO

Article history:
Received 20 February 2016
Revised 7 June 2016
Accepted 22 June 2016

Keywords:
Neurodegenerative disease
Cognitive motor interference
Cognition
Gait
Rehabilitation
Dual-task ability

ABSTRACT

People with multiple sclerosis (MS) complain of problems completing two tasks simultaneously; sometimes called 'dual-tasking' (DT). Previous research in DT among people with MS has focused on how adding a cognitive task interferes with gait and few have measured how adding a motor task could interfere with cognition. We aimed to determine the extent to which walking affects a concurrent working memory task in people with MS compared to healthy controls. We recruited MS participants ($n = 13$) and controls ($n = 10$) matched by age (±3 years), education (±3 years) and gender. Participants first completed the cognitive task (subtracting 7's from the previous number) and then again while walking on an instrumented walkway. Although there were no baseline differences in cognition or walking between MS participants and controls, MS participants demonstrated a 52% decrease in number of correct answers during DT ($p < 0.001$). Mental Tracking Rate (% correct answers/min) correlated strongly with MS-related disability measured using the Expanded Disability Status Scale (EDSS; $r(11) = -0.68$, $p < 0.01$). We propose that compromised mental tracking during walking could be related to limited neural resource capacity and could be a potentially useful outcome measure to detect ecologically valid dual tasking impairments.

1. Introduction

Most often diagnosed during the career and family building years, multiple sclerosis (MS) is an autoimmune demyelinating disease of the central nervous system that, according to the World Health Organization, affects an estimated 2.3 million people worldwide (Browne et al., 2014). With advances in disease-modifying drugs and improved health care, people with MS are living longer (Ploughman et al., 2012, 2014) and there is more interest in rehabilitative treatments that can reduce impairment and disability (Ploughman, Deshpande, Latimer-Cheung, & Finlayson, 2014; Ploughman et al., 2015).

MS is characterized by widespread lesions in white matter causing sometimes subtle motor and cognitive impairments that are difficult to detect (Kirkland, Wallack, Rancourt, & Ploughman, 2015). Some people with MS report having difficulties performing two tasks simultaneously impacting day-to-day activities like conversing with another person while walking outdoors or navigating while driving (Motl & Learmonth, 2014; Pepping, Brunings, & Goldberg, 2013). These challenges could be related to cognitive motor interference (CMI), which occurs when motor and cognitive tasks (such as walking and talking) are combined (Al-Yahya et al., 2011; Allali, Laidet, Assal, Armand, & Lalive, 2014).

* Corresponding author.
E-mail address: Michelle.ploughman@med.mun.ca (M. Ploughman).

http://dx.doi.org/10.1016/j.humov.2016.06.010
0167-9457/

CMI has been described for over 30 years, mainly in older age groups (Teasdale, Bard, LaRue, & Fleury, 1993; Teasdale, Stelmach, & Breunig, 1991) and more recently among people with other neurological conditions such as stroke, Parkinson's disease and Alzheimer's disease (Bloem, Grimbergen, van Dijk, & Munneke, 2006; Patel & Bhatt, 2014; Sobol et al., 2015). The theory is that postural control and cognition compete for a common pool of attentional resources and when one task is made more challenging or there is a reduction in the capacity of the network, the available resources reach their limit (Stins & Beek, 2012). Consistent findings using MRI have shown that when performing simple motor behaviors (e.g. walking, standing, reaching) there is activation of cerebellum, basal ganglia and parietal and frontal cortices (Holtzer, Wang, & Verghese, 2014; Mattay et al., 2002). However, in the aging brain or in the brain affected by pathological neurodegeneration, greater cortical and ipsilateral areas (to the moving side of the body) are recruited, likely to compensate for neural deficits (Corbetta & Shulman, 2002; Heuninckx, Wenderoth, & Swinnen, 2008; Sharma & Baron, 2014). Compromised cortical resources have been shown to be associated with CMI. Doi and group reported that in older adults with mild cognitive impairment, increased white matter lesion load measured using MRI was correlated with decreased trunk stability during dual-tasking (Doi et al., 2015). Although most studies examine the impact of CMI on motor performance, it is reasonable to think that the opposite could be true; that a motor task could compromise cognitive processing. For example, Teasdale et al. reported that when standing on an unstable surface, older participants had longer reaction time latencies on a cognitive task compared to a younger age group (Teasdale, Bard, LaRue, & Fleury, 1993).

Several disease-related processes exist with the brains of people with MS that could affect available attentional resources potentially contributing to CMI; grey matter atrophy, white matter lesions and damage to normal-appearing white matter (Rocca et al., 2015; Steenwijk et al., 2016). Studies among people with MS have confirmed that disconnection of the cortical networks due to MS-related brain pathology was associated with cognitive impairment (Rocca et al., 2015) and altered postural control (Fling, Gera Dutta, & Horak, 2015). As shown in older adults, people with MS recruit more widespread cortical networks for fairly routine tasks compared to healthy controls (Faivre et al., 2015; Helekar et al., 2010).

Cognition is rarely a target of rehabilitation in MS but several lines of evidence suggest that in healthy individuals (Hamacher, Hamacher, Rehfeld, & Schega, 2015; Thompson, Waskom, & Gabrieli, 2016) and in other neurological disorders, dual-task training can enhance neuroplasticity (Thompson et al., 2016), improve balance (Hamacher et al., 2015) and rhythmicity of walking (Killane et al., 2015). To intervene and manage problems with CMI, we must be able to reliably measure it. Dual-task (DT) testing is one method to quantify CMI by calculating the cost of pairing the two tasks versus completing them alone (Leone, Patti, & Feys, 2015).

Previous research in DT among people with MS has focused on how adding a cognitive task interferes with gait parameters, and few have measured how adding a motor task could interfere with *cognition* (Wajda & Sosnoff, 2015). A recent review of DT in MS found only 2 of 14 studies that measured how cognitive abilities were affected during DT, reporting cognitive costs of 10–14% during DT for people with MS compared to controls (Wajda & Sosnoff, 2015). However, these two studies employed simple cognitive tasks; forward and backward counting, word categories and number recall (Allali et al., 2014; Hamilton et al., 2009). A more recent study described the cognitive cost (16%) of dual-tasking when paired with a balance or a gait task among 60 people with relapsing-remitting MS (Etemadi, 2016). Participants completed the serial sevens task (subtracting 7 from the previous number beginning with 100); a more challenging mental tracking task that mimics real-world information processing demand such as that required to remember a phone number while driving or use a portable device while walking (Al-Yahya et al., 2011; Chiaravalloti & DeLuca, 2008; Logie, 1988; Ploughman, Deshpande, Latimer-Cheung, & Finlayson, 2014).

In this study, we aimed to determine the extent to which walking affects a concurrent mental tracking task (the serial sevens task) in people with MS compared to matched healthy controls. Since we were also interested in developing a simple clinical measure of DT in the future, we wished to examine whether cognitive cost during DT was related to accepted measures of physical and cognitive disability.

2. Methods

2.1. Participants

After receiving approval from the institutional Health Research Ethics Authority, we recruited 13 MS participants from the local MS neurology clinic and 10 healthy controls (HC) by convenience sampling. MS-related disability was measured by a neurologist using the Expanded Disease Severity Scale (EDSS); a scale that ranges from 0 (no symptoms)-10 (death due to MS) in 0.5 increments (Kurtzke, 2015). A score of 6.5 indicates constant bilateral assistance using canes or a walker. The HC participants were matched to MS participants for age (±3 years), education (±3 years) and gender so some HC matched more than one MS subject. We estimated sample size by reviewing previous DT research in MS and based on two studies in the field, samples ranged from 8 to 15 subjects per group (Jacobs & Kasser, 2012; Kelly, Eusterbrock, & Shumway-Cook, 2013).

Participants with MS were included if they were diagnosed with MS by a neurologist using the MacDonald criteria (Selchen et al., 2012); scored $\leqslant$6.5 on the EDSS; were relapse free in the previous three months; >18 years of age; had no musculoskeletal impairments affecting walking ability; were able to walk 30 m with or without a walking aid; and had the ability to provide informed consent. Subjects in the HC group were included if they were >18 years of age, were not diag-