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Correlates of dual task cost of standing balance in individuals with multiple sclerosis

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ABSTRACT

Cognitive and balance dysfunction are common symptoms in individuals with multiple sclerosis (MS). Although traditionally seen as separate impairments, performing a concurrent cognitive task while maintaining an upright posture results in individuals with MS increasing their postural sway (i.e. dual task cost (DTC) of balance). However, the factors relating to this phenomenon are not clear. This investigation examined the demographic, clinical and cognitive correlates of DTC of balance in individuals with MS. Sixty-two persons with MS completed both quiet standing and dual task balance trials on a force platform. Additionally, they provided demographic information and performed clinical tests of balance, spasticity, fall risk and cognitive processing speed. Dual task cost was calculated as the percentage change in sway area from the baseline to dual task force platform conditions. Overall, there were no significant correlations between DTC of balance and any of the outcome measures in the entire sample. In contrast, postural sway in the baseline and dual task condition were found to correlate with disability, fall risk, balance performance, fatigue, cognitive processing speed and age. Secondary analysis revealed different correlates of DTC of balance in those with low versus high baseline sway. The results suggest that the change in standing balance with the simultaneous performance of cognitive task may only be informative in individuals with minimal balance dysfunction.

Introduction

Deficits in balance and cognition represent two prevalent impairments in individuals with multiple sclerosis (MS) [1,2]. Balance dysfunction denotes one of the earliest reported symptoms in cases of MS and has been observed even in the absence of clinical disability [3,4]. Similarly, cognitive impairments also arise early in the disease process and occur in approximately 50% of individuals with MS [5].

Traditionally, balance impairment in MS was believed to be influenced mainly by physiological factors including visual, somatosensory and vestibular impairments; muscle weakness; and spasticity [6,7]. However, recent evidence suggests that balance in individuals with MS can also be negatively affected by the addition of a concurrent cognitive task (i.e. dual task) [4,8–10]. These alterations in postural control while engaged in a cognitive task are indicative of cognitive–motor interference. Commonly, cognitive–motor interferences is quantified as dual task cost (DTC) by calculating the percentage change in outcome measures from single task performance to dual task performance.

Cognitive–motor interference, especially during balance tasks, represents an important topic of scientific inquiry as it has been linked to falls in clinical populations [11,12]. Specific to MS, a recent study revealed that DTC of walking is associated with physiological fall risk [13]. Due to the potential link between cognitive–motor interaction and falls, DTCs of standing balance represent a potentially important rehabilitation target. In order to maximize the potential for successful rehabilitation, the underlying mechanisms of DTC in balance need to be identified.

The factors related to DTC in upright balance for individuals with MS are relatively unclear. One small study ($n = 13$) found evidence that DTCs during balance tasks were related to self-reported fatigue [14] while another [8] determined the DTC of standing balance in individuals with MS was not related to disability level. Additionally, walking function and cognitive processing speed are associated with DTC of walking in MS [15,16]. Consequently, the purpose of the current study was to identify the correlates of DTC of standing balance in individuals with MS. We examined the relationship between demographic, cognitive and clinical balance measures to DTC of standing balance.

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Based on previous literature [14–17] we hypothesized that the DTC of posture would be related to balance, cognitive function, fatigue and physiological fall risk.

Methods

Participants

This cross-sectional investigation utilized a convenience sample of 62 community-dwelling individuals with a neurologist confirmed diagnosis of MS who participated in an ongoing fall prevention program. Participants had to be over the age of forty, fallen in the previous year, be relapse free for 30 days and be able to stand independently for 30 s.

Procedures

All procedures were approved by the local Institutional Review Board. After arrival at the testing facility participants were informed of the testing procedures, given the opportunity to ask questions then provided written informed consent. Participants provided demographic information, completed questionnaires and performed static balance assessments on a force platform (Bertec Inc., Columbus, OH). Balance, spasticity and cognition were also assessed using clinical measurement tools.

Outcome measures

Demographics

The demographic variables of interest included age, education level, assistive device use and disability level. Disability was indexed by self-reported expanded disability status scale (SR-EDSS) as measured by the self-administered Kurtzke questionnaire [18].

Balance assessment

Four 30 s balance trials were completed. No assistive devices including braces were used during force platform based balance assessment. For the first two trials participants stood on the force platform with eyes open, feet shoulder width apart and arms by their sides. For the third and fourth trials, participants stood in the same position with their eyes open and also performed a concurrent cognitive test. The cognitive test utilized for this experiment was a modified word list generation (WLG) task [8]. Semantic (e.g. listing animals) and phonemic (e.g. listing 'H' words) tasks were used to limit potential learning effects during the dual task conditions.

Center of pressure (COP) data was exported from the force platform software and processed using a custom MATLAB (Mathworks Inc., Natick, MA) script. Overall, total sway area of the COP was calculated and averaged over similar trials for each participant. DTC was determined by calculating the percentage change from single task to dual task conditions. A negative DTC represents an increase in sway from single to dual task conditions. Additionally, the DTCs of other posturography variables including COP mean velocity and 95% confidence ellipse were calculated. For the sake of brevity and the congruence between these measures, only sway area is reported.

Clinical assessments

Balance was assessed using the berg balance scale (BBS) [19]. The BBS consists of 14 tasks common in everyday life and has been a reliable measure for individuals with MS [20]. Each task is rated on a 0–4 scale and the overall outcome is the sum of scores on all items with a maximal score of 56. Additionally, balance confidence was determined through the activities specific balance confidence scale (ABC) [21]. This scale consists of 16 items that require participants to identify their confidence of performing several activities based on a 0% (no confidence) to 100% (full confidence) scale.

Spasticity of the ankle joint was assessed by a trained researcher utilizing the modified Ashworth scale (MAS) [22]. The MAS gives an indication of muscle hypertonia on a scale of 0 (normal muscle tone) to 4 (muscle fixation). For the purpose of this analysis the largest MAS value between right and left ankles was utilized.

Physiological fall risk was quantified through the short form of the physiological profile assessment (PPA) [23]. The PPA was developed for use in older adults and has been validated in individuals with MS [24]. Five physiological factors including vision contrast, reaction time, lower limb proprioception, knee extensor strength and postural sway on a compliant surface are quantified in the short form PPA. The results of these assessments are combined together for the calculation of an overall fall risk z-score for each participant with greater score indicating increased fall risk.

Fatigue was quantified through the modified fatigue impact scale (MFIS) [25]. This scale contains 21 items that assess the participant perceived impact of fatigue on daily activities over the previous four weeks on a 0 (never) to 4 (almost always) scale. Responses on the MFIS are evaluated as a total sum of response values with higher scores representing a greater impact of fatigue on activities of daily living.

Cognitive assessment

The symbol digit modalities test (SDMT) was utilized for the assessment of cognitive ability. The SDMT is a commonly used assessment of cognitive function in individuals with MS [26]. The main outcome of the SDMT is the total number of correct responses in 90 s.

Statistical methods

Statistical analyses were performed in SPSS version 20 (IBM Inc., Chicago, IL). Descriptive statistics were computed for all outcome measures and included mean and standard deviation in addition to minimums and maximums. Normality of the outcome measures was examined using the Shapiro–Wilk test of normality.

Spearman rank-order correlations were performed to analyze the relationship between the DTC of sway area and the other outcome measures. This technique was utilized due to the non-normality of multiple outcome measures and also to reduce the influence of possible mild outliers and non-linearity on the correlations. A secondary correlation analysis utilizing these methods was performed to examine possible relationships between postural sway in each condition (baseline and cognitive) and the other outcome variables.

An analysis comparing individuals with low baseline sway to those with high baseline sway was also performed. Sway groups were determined with a median split of baseline sway area. Group differences were analyzed with the Mann Whitney U non-parametric test. The relationships between DTC of balance and outcome measures in each sub group were analyzed with Spearman rank order correlations. The significance threshold was set at $P \leq .05$ for all statistical analyses.

Results

Overall the sample consisted of 46 females and 16 males. Age ranged from 42 to 76 years with a mean of 60.9 years (SD = 7.2 years). Self-reported disability (SR-EDSS) ranged from 0 to 7 with a median value of 6 (IQR = 2). 25 participants required no assistive devices, 21 walked with a cane and 16 utilized a walker for