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A comparison of two walking while talking paradigms in aging

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ABSTRACT

Background: Our study aimed to [1] compare dual-task costs in gait and cognitive performance during two dual-task paradigms: walking while reciting alternate letters of the alphabet (WWR) and walking while counting backward by sevens (WWC); [2] examine the relationship between the gait and cognitive interference tasks when performed concurrently.
Scope: Gait and cognitive performance were tested in 217 non-demented older adults (mean age 76 ± 8.8 years; 56.2% female) under single and dual-task conditions. Velocity (cm/s) was obtained using an instrumented walkway. Cognitive performance was assessed using accuracy ratio: [correct responses]/[total responses]. Linear mixed effects models revealed significant dual-task costs, with slower velocity ($p < .01$) and decreased accuracy ratio ($p < .01$) in WWR and WWC compared to their respective single task conditions. Greater dual-task costs in velocity ($p < .01$) were observed in WWC compared to WWR. Pearson correlations revealed significant and positive relationships between gait and cognitive performance in WWR and WWC ($p < .01$); increased accuracy ratio was associated with faster velocity.
Conclusions: Our findings suggested that dual-task costs in gait increase as the complexity of the cognitive task increases. Furthermore, the positive association between the gait and cognitive tasks suggest that dual-task performance was not influenced by task prioritization strategies in this sample.

1. Introduction

The walking while talking protocols are widely used to study how attention and motor-control processes affect walking in normal aging and in various disease populations [1]. Poor dual-task gait performance has been linked to adverse clinical outcomes such as frailty, falls [2], disability, and mortality [3] in older adults supporting its clinical utility. Under these dual-task conditions, individuals are asked to walk while performing a cognitive interference task such as repeating digits [4] or reciting names [5]. Changes in cognitive and gait performance during dual compared to single-task condition is quantified as a measure of dual-task costs, and is considered to reflect the effect of increased attention demands on walking [6]. Previous researchers have reported that dual-task costs in walking were greater among older adults compared to young adults, indicating an aging or disease effect [7,8]. More recently, increasing evidence suggests that such age-related dual-task costs in gait performance are task-specific [9,10].

Cognitive tasks used in walking while talking paradigms include, but are not limited to, reciting alternate letters of the alphabet and counting backwards by sevens [11]. While both of these cognitive tasks have been shown to cause significant gait changes among healthy older adults, their effect on gait has not been directly compared [12]. Previous research has suggested that increasing the level of complexity on cognitive tasks in walking while talking paradigms induced greater decline in gait, and showed a stronger relationship with risk of falls [2]. Thus, defining and contrasting different dual-task paradigms may have practical implications for the design of fall-risk assessments. The comparison between counting-backwards and reciting-the-alphabet tasks, in particular, might provide important information regarding the nature of dual-task effects. Specifically, while reverse sequences (i.e., counting backwards) is cognitively more challenging than forward sequences (i.e., reciting the alphabet) [13], the differential effect of these two tasks on gait is not well understood. Moreover, the cortical networks for linguistic (i.e., superior part of Broca's area and the premotor cortex) and numeric tasks (i.e., temporo-parietal regions) are distinct [14]. Hence, investigating the differential effect of the counting and letter tasks on gait control

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could also help advance our understanding of the localization of brain substrates of gait.

When examining walking while talking paradigms, a potential methodological issue is whether dual-task costs in gait performance can be attributed to limited attention resources or to task preference (for instance, prioritizing the cognitive task over the walking task). Our recent study indicates that attention/executive resources moderate dual-task costs in gait and cognitive performance [15]. While prior studies suggested that older adults may have an innate preference for preserving walking over talking during a walking while talking task [7], greater decrements in gait performance have been noted when older adults were instructed to pay more attention to the cognitive task than when they were instructed to pay equal attention to both concurrent tasks [12]. These initial reports raise interesting questions regarding the influence of explicit instructions on dual-task performance. Available studies on walking while talking paradigms generally emphasize on their impacts on gait, and relatively few studies have examined the effect of walking on cognitive performance [16]. The relationship between gait and cognitive interference task, when assessed simultaneously, can shed light on the possible influence of task prioritization strategies on dual-task performance.

Herein, we propose to examine the following two aims in 217 non-demented older adults. First, we compared dual-task costs in gait and cognitive performance using two dissimilar paradigms: walking while reciting alternate letters of the alphabet (WWR) and walking while counting backwards by sevens (WWC). We hypothesized that older adults would show dual-task performance costs in both conditions. Since we predicted that subtracting serial sevens is a cognitively more challenging task than reciting alternate letters of the alphabet, it was also expected that WWC would result in greater dual-task performance costs than WWR. Second, we examined whether performance on the two concurrent tasks was related. Our experimental protocols require participants to equally prioritize the walking and cognitive interference tasks. Although previous works showed that dual-task performance costs indeed varied as a function of task instruction [12,17], it was of interest to determine the existence and directionality of the relationship of the two tasks when performed concurrently. Negative correlations between the gait and cognitive interference tasks would suggest task prioritization, while positive correlations would imply that better attention resource but not task preference influenced dual-task performance.

2. Methods

2.1. Study population

Participants were enrolled in a longitudinal research study entitled "Central Control of Mobility in Aging" (CCMA). The primary aim of the CCMA study is to determine the role of cognitive control processes on mobility and mobility decline in aging. Potential participants (age 65 and older) were identified from a population-list of residents of Yonkers town in lower Westchester County (New York). They were first contacted by letter and then by telephone. A structured telephone screening interview was administered to potential participants to assess eligibility. Exclusion criteria included: inability to speak English, inability to independently ambulate [18], presence of dementia (AD8 Dementia Screening Interview ≥ 2 and the Memory Impairment Screen by telephone <5) [19], significant loss of vision and/or hearing, current or history of neurological or psychiatric disorders, medical procedures (recent or anticipated) that may affect mobility, and receiving hemodialysis. After completing the telephone interview, eligible individuals were scheduled for the first of two three-hour in-person visits at our research center within a four week window. During the in-person visits, participants received comprehensive neuropsychological and mobility assessments by research assistants as well as a structured neurological and gait examination by the study clinician. Following the evaluations, cognitive status (dementia, mild cognitive impairment syndrome, or cognitively normal) was determined at consensus clinical case conferences as described in our previous study [20]. CCMA participants are followed longitudinally at annual intervals. The current study included the initial 217 non-demented participants enrolled in the CCMA study during the 9-month period between July 2011 and March 2012. Written informed consent was obtained from the participants in person according to study protocols approved by the institutional review board.

2.2. Walking protocol

Participants were asked to walk at their "normal pace" on an instrumented walkway with embedded pressure sensors (GAITRite; CIR Systems. Havertown, PA). The participants walked for one trial under three different task conditions: [1] normal pace walking (NW), [2] WWR (i.e., reciting a, c, e . . .), and [3] WWC (i.e., counting 100, 93, 86 . . .). In WWR and WWC, the participants were asked to pay equal attention to both the walking and cognitive tasks to minimize task prioritization effects as previously described [6].

2.3. Measures

GAITRite software was used to calculate quantitative gait parameters based on the recorded footsteps. The program has been reported to show excellent reliability and validity [12,21]. The walkway measures $8.5\,m \times 0.9\,m \times 0.01\,m$ ($L \times W \times H$) with an active recording area of $6.1\,m \times 0.6\,m$ ($L \times W$). The present study utilized velocity (in centimeter per second) as the single outcome measure for the following reasons. First, velocity is the most common quantitative gait measure reported in the literature facilitating comparisons with previous studies [11]. Second, velocity is a statistically robust measure with excellent test-retest reliability in our (reliability of two repeated trials, $r = 0.96$) [3,11,15] and other research centers ($ICC \geq 0.80$) [22]. Third, slow velocity during both normal pace and walking while talking conditions is a risk factor for a range of adverse outcomes, such as higher rates of mortality, increased incidence of hospitalizations, and poor quality of life [11,19].

Baseline comparators of the cognitive tasks in the two dual-task paradigms was obtained in 10-s blocks when stationary: [1] reciting alternate letters of the alphabet (i.e., a, c, e, . . .) while standing and [2] counting Backwards by sevens (i.e., 100, 93, 86, . . .) while standing. Although postural control studies consider standing while performing a cognitive task as a dual-task condition [23], the present study considered this condition as a single-task condition because standing requires minimal cognitive and mobility demands. In these standing conditions, balance was not assessed and subjects were explicitly instructed to focus on the cognitive task performance only. To assess cognitive task performance in the single task conditions, we recorded all responses (correct + incorrect) that were generated within the 10-s limit. In the dual-task conditions, however, we recorded responses (correct + incorrect) that were generated while walking without imposing a time limit. The accuracy ratio (i.e., correct responses/total responses) was calculated to allow for a direct comparison between the single and dual-task conditions and across the two dual-task paradigms.

The administration of the two dual-task walking and three single task conditions was counterbalanced to reduce test order and practice effects.