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The attentional demands of ambulating with an assistive device in older adults with Alzheimer's disease

S.W. Muir-Hunter[a,b,*], M. Montero-Odasso[b,c]

[a] School of Physical Therapy, University of Western Ontario, London, ON, Canada
[b] Department of Geriatric Medicine, Schulich School of Medicine & Dentistry, University of Western Ontario, London, ON, Canada
[c] Gait and Brain Lab., Parkwood Hospital, London, Ontario, Canada

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ABSTRACT

Ambulation with a mobility aid is a unique real-life situation of multi-tasking. These simultaneous motor tasks place increased demands on executive function in healthy young and older adults, but the demands have not been evaluated in people with Alzheimer's disease (AD). Mobility problems are common among adults with AD, leading to provision of a mobility aid to optimize independent activity. The study objectives were: (i) to determine the dual-task cost (DTC) associated with the use of a mobility aid in straight and complex path walking, and (ii) to evaluate the association between executive function and ambulation with a mobility aid in older adults with AD and age-sex matched cognitively normal controls. Fourteen people (mean age ± SD, 72.6 ± 9.9 years) with a diagnosis of probable AD (MMSE range 12–25) and controls (mean age ± SD, 72.9 ± 9.5) walked at a self-selected pace and using a 4-wheeled walker in a 6 m straight path and a Figure of 8 Test. Ambulation with the walker in a straight path produced a low DTC that was not different between the groups. Ambulation with the 4-wheeled walker in the complex path produced a significantly different DTC in the group with AD at −38.1 ± 23.5% compared to −19.7 ± 21.4% ($p = 0.041$). Lower scores on executive function were associated with longer times across test conditions. Ambulation with a 4-wheeled walker, in particular maneuvering around obstacles, requires greater attentional costs in dementia. Future research should explore the timing for safely introducing mobility aids in AD and the role of improving executive function.

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1. Introduction

Falls among older adults are a significant public health problem and have substantial consequences on an individual's quality of life and independence. An emerging area of falls research is the role of cognition in postural stability; a timely focus as the prevalence of dementia, and its attendant increased health care needs and utilization, is expected to increase dramatically in coming years [1].

Ambulation with a mobility aid is a unique real-life situation of multi-tasking; the performance of these simultaneous motor tasks places increased demands on brain resources related to executive function [2]. Executive function, which comprises the set of cognitive processes that use sensory information to modulate behavior, is required for planning movements, dividing attention, and responding to changes in the environment [3]. Increased attentional demands have been observed in healthy young adults [4] and older adults [5] using mobility aids suggesting that executive resources are necessary for their proper use. The use of a mobility aid requires high levels of motor control and may challenge cognitive function to generate responsive motor patterns to multiple sensory inputs and environmental conditions [2].

Decreased executive function is an early symptom in Alzheimer's disease (AD) [6] and a proven risk factor for falls [7]. In addition, gait and mobility impairments are common features in community-dwelling older adults living with dementia [8]. Older adults with cognitive impairment demonstrate decreased gait velocity and increased gait instability while multi-tasking, which are also associated with an elevated fall risk [9]. Rehabilitation interventions to reduce risk can include individualized exercise programs and the prescription of a mobility aid to compensate for deficits and allow maintenance of independent ambulation.

The use of a mobility aid is also associated with an elevated fall risk in older adults [10]. Mobility aid use could be a proxy for the

* Corresponding author at: University of Western Ontario, School of Physical Therapy, Elborn College, Room 1588, London, Ontario N6G 1H1, Canada.
E-mail address: susan.hunter@uwo.ca (S.W. Muir-Hunter).

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presence of intrinsic functional limitations, such as balance or gait problems; but, the elevated risk remains even when those factors have been taken into account [10]. Additional considerations that would link mobility aid use to an elevated fall risk include interference with lower extremity movement during balance recovery to a perturbation, it prevents the use a person's hands to effectively reach for support when there is a loss of balance and it increases cognitive demands related to attentional processing and neuromotor control [2].

Observing people during a gait or balance task while they perform a secondary task (the dual-task paradigm) is an accepted way to assess the interaction between cognition and mobility [11]. Cognitive demands relative to the cognitive capacity or reserve of the individual influence physical task performance. If the demands of executing two tasks simultaneously exceed the cognitive capacity, then overall performance will be degraded [12]. The configuration of the walking pattern in the dual task testing protocol is also relevant in the evaluation of functional abilities. Gait performance under a straight path condition is considered a low challenge activity, while curved or complex path walking can provide meaningful information about daily life walking ability, including adaptation of walking patterns to negotiate obstacles, change directions, or plan a path [13].

There has been no research evaluating the "cost" on gait performance of using a mobility aid in older adults with dementia. Moreover, whether the use of assistive devices generates a "cognitive cost" on gait performance in older adults with AD is unknown though it is hypothesized that ambulation with a mobility aid for people with dementia will be associated with a high attentional load. We hypothesized the use of a mobility aid in older adults with AD will adversely affect gait performance and be most affected under the test condition of walking with a mobility aid on a curved path test condition. The study objectives were: (i) to determine the dual-task cost associated with the use of a mobility aid in straight path and complex path walking in older adults with Alzheimer disease and age-sex matched cognitively normal controls, and (ii) to evaluate the association between executive function and the functional performance on ambulation with a mobility aid.

2. Methods

2.1. Study subjects

A convenience sample of adults with a diagnosis of mild to moderate Alzheimer's disease was recruited from a day program for community-dwelling older adults with dementia. Referral to the day program is based on a confirmed diagnosis of dementia by a geriatrician according to the criteria of the National Institute of Neurologic and Communicative Disorders and Stroke-AD and Related Disorders Association (NINCDS-ARDRA) [14]. Inclusion criteria: age greater than 50 years, medically stable, English speaking, no physical impairments that would necessitate use of a mobility aid, had not used a walker previously and able to understand simple instructions. People were excluded if they had any neurological, musculoskeletal, or cardiorespiratory impairment that could compromise safe administration of the testing protocol. All participants or their caregivers provided written informed consent prior to participation in the study.

Control participants were recruited by newspaper advertisement and from a community fitness program. The inclusion criteria for the control group were: no subjective memory complaints, normal performance on cognitive tests, absence of functional impairment, and ability to walk independently. The control participants were matched to the participants with dementia on sex and age, plus or minus 2 years. This study was approved by the Research Ethics Board for Health Sciences Research Involving Human Subjects.

2.2. Medical and cognitive assessments

Sociodemographic information, co-morbidities, physical activity level, activities of daily living (instrumental and basic), Falls Efficacy Scale-International [15] and medications were recorded. Cognition was assessed using the Mini-Mental State Examination [16] (MMSE; score 0–30). The severity of dementia was categorized according to the MMSE score: mild dementia, MMSE >20 points; moderate dementia, MMSE = 10-20 points; and severe dementia, MMSE $<$10 points. Executive function was measured using the Trail Making Test [17] (TMT). The TMT has two parts: Part A (TMT-A) requires participants to draw lines sequentially connecting 25 numbers, and Part B (TMT-B) requires them to draw lines sequentially alternating between numbers and letters (e.g., 1, A, 2, B, . . .). The TMT assesses visual search ability, scanning, speed of processing, mental flexibility, and executive functioning [18]. Results are reported as the time in seconds required to complete the task; a longer completion time indicates greater impairment. The TMT is sensitive to a variety of neurological impairments and processes [18].

2.3. Gait assessment

In the straight path walking, participants were timed while walking at a self-selected usual speed for a 6 m distance, with one meter at either end to allow for acceleration and deceleration. In the complex path walking, Fig. 8 Walk Test [19] protocol was used and reliability for this test has been demonstrated in older adults with dementia [20]. Participants start in standing, midway between two cones placed 1.52 m apart and walk in a figure-of-8 path around the cones. The total time and the number of steps was recorded. The dual-task test condition required the person to perform both walking configurations using a four wheeled walker.

2.4. Sample size

Based on previous data from our research in people with dementia (dual-task cost: 15% in cognitively normal older adults, 38% in older adults with dementia) [9], a sample size of 12 participants was needed for a power of 80% with α error of 5% to detect a 15% difference in dual-task cost.

2.5. Data analysis

Baseline characteristics of demographic and mobility variables were calculated as means and SDs or frequencies and percentages, as appropriate. For the first objective, a two-way repeated measures ANOVA using a general linear model evaluated the time to complete each walk in each configuration and the number of steps in the complex path (3 models). When interactions were non-significant main effects were assessed. The dual-task cost percentage for time to complete the straight path and complex path, and the number of steps in the complex path were evaluated with unpaired *t*-tests between the controls and the people with AD. The *dual-task cost* (DTC), as a percentage, was calculated as [(single task value–dual task value)/single task value] $\times$ 100% for each walking condition, straight and curved path walking, under single and walking with the wheeled walker and the number of steps to complete the complex path with a walker for each group. A negative DTC indicates that gait performance was decreased under the condition of using the wheeled walker. For the secondary objective, linear regression analyses between executive function (Trail Making Test B) and the time to complete each walking test in

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