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The effect of walking path configuration on gait in adults with Alzheimer's dementia

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ABSTRACT

Background: Walking is a cognition intensive activity and impaired walking is associated with an increased fall risk in people with Alzheimer's dementia (AD). Walking in a curved path configuration increases complexity of the task, reflects real-life environments and situations when falls occur. The effect of walking path task complexity has not been evaluated in people with AD.

Research question: The purpose was 1) to assess the utility of a curved path walking task to detect differences in gait performance between people with AD and healthy controls and 2) to assess the relationship of cognitive function to gait performance on straight path and curved path walking.

Methods: Participants with AD (n = 14, mean age ± SD = 73.08 ± 9.22) and age and sex matched controls (n = 14, mean age = 72.86 ± 9.53) were recruited. Time to complete a 6-meter straight path and a curved path (Figure of 8 Test) walking task was recorded. Steps taken, accuracy and qualitative measures of smoothness were rated for curved-path walking. Measures of global cognition (MMSE, MoCA) and executive function (Trail making A and B, Digit Span forwards and backwards) were assessed.

Results: Gait was significantly slower in people with AD for both the straight-path (AD = 6.05 ± 1.26 s, Control = 5.09 ± 0.76 s, p = 0.02) and curved-path walking (AD = 11.25 ± 4.87 s, Control = 8.28 ± 2.44 s, p = 0.05). In addition, smoothness scores were significantly lower for people with AD (AD = 1.93 ± 1.26; Control = 3.00 ± 0.00, p = 0.004).

Significance: Walking in a curved path resulted in a significant deterioration in gait quality in the people with AD. Executive function was related only to curved path walking, in which lower executive function scores were associated with longer time to walk.

1. Introduction

People with Alzheimer's dementia (AD) have disturbed walking performance compared to cognitively normal older adults and also have a greater risk for falls and fall-related injuries, such as fractures [1]. Cognitive function plays an important role in the regulation of walking [2] and not surprisingly impaired cognition is associated with increased fall risk in AD [3].

Executive function (EF), a higher order cognitive domain responsible for initiation, planning and attention in goal-directed movements [2], is a key factor in walking. Importantly, impaired executive functioning occurs early in the disease process of AD [4]. People with cognitive impairment have more difficulty performing complex mobility tasks [5,6] and impairment in EF can result in a reduced ability to successfully ambulate in attention-demanding situations such as moving around obstacles, and avoiding falls [7]. Observing people during a gait task while they simultaneously perform a second activity (dual-task paradigm) is an accepted way to assess the interaction between cognition and mobility to provide [8,9] insights into the mechanisms of higher order motor control. Dual-task testing is considered ecologically relevant as most daily activities require the performance of 2 or more simultaneous tasks and represent situations that are likely to lead to falls.

Gait deficits that are sub-clinical in people with AD using standard assessment protocols become observable under dual-task testing of walking in a straight-path while performing a secondary cognitive task [10].However, when people with AD are unable to complete secondary cognitive tasks in dual-task gait testing protocols due to cognitive decline, disease-specific language difficulties or illiteracy, deficits may not be detected in the absence of the added cognitive challenge.

Increasing the complexity of the gait task is another means of evaluating the effect of cognition on performance [5]. Straight path walking provides a low cognitive challenge and may not relate to walking in more complex real-world environments [11]. Whereas,

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curved path walking reflects real-life situations involving dynamic stability that require individuals to navigate through their environments such as around furniture [11]. The cognitive component within a curved path walking task is thought to be embedded within the task itself [11]. Curved path walking involves planning [12] and greater motor skill and control than straight path walking [12,13], tapping into executive function demands. The use of a complex walking pathway to assess gait for people with AD is a potential solution if people are unable to complete a concurrent cognitive task in a dual-task walking protocol.

Skillful walking can be described as smooth and consistent. Smoothness, a measure of motor control in walking, is a function of the integration of sensory information and coordination of walking. Smoothness deteriorates on curved path walking and is associated with increased falls risk in older adults [14]. Quality of motor control, specifically smoothness, provides meaningful information as walking quickly with poor control is a more adverse gait pattern than walking slowly with good motor control [14]. Therefore, curved path walking may be an avenue to assess not only gait speed deficits but also deficits in motor control for people with AD, providing a better understanding of the relationship between cognition and functional gait deficits.

There is limited research on the effect of path complexity on gait in people with AD. Curved path walking is a simple and inexpensive test that can provide information in multiple areas to identify deficiency in gait and motor control in people with AD. Therefore, the aim of this study was to assess i) the differences in gait performance, and ii) the relationship between cognitive function and time to complete a straight path and curved path walking task in healthy older adults and people with AD. We hypothesized that people with AD will walk slower than cognitively healthy controls in a curved path configuration and executive function will be related to walking speed only on the curved path walking task.

2. Methods

2.1. Participants

A total of 14 people with AD and 14 age and sex-matched healthy controls were recruited for this study. Participants with AD were recruited from a day hospital program for people 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) [15]. Healthy controls were recruited from a local community-based fitness program for older adults. Ethics approval was obtained from the Health Sciences Research Ethics Board at the XXXXX and participants or their alternative decision-makers provided written informed consent.

Inclusion criteria for people with AD was 50 years of age or older, a diagnosis of mild to moderate AD, living in the community and do not use a mobility aid. The severity of dementia was categorized according to the Mini Mental State Examination (MMSE) [16] score: mild dementia, MMSE $>$ 20 points; moderate dementia, MMSE = 10–20 points; and severe dementia, MMSE $<$ 10 points. For healthy controls inclusion criteria included being 50 years of age or older, no subjective complaints of cognitive problems, normal performance on a range of cognitive tests, absence of functional impairment, ability to walk independently without a mobility aid and no falls in the previous 12 months. Exclusion criteria for both groups included inability to understand English, unable to walk 10 m unaided, focal neurological or motor deficits and musculoskeletal disorders that impair gait and balance.

2.2. Measures

2.2.1. Demographics

Sociodemographic information, co-morbidities, physical activity level, activities of daily living (instrumental and basic), Falls Efficacy Scale-International [17] and medications were recorded.

2.2.2. Cognitive measures

Cognitive function is critical for gait performance and consists of multiple domains. Both overall cognitive function and specific domains of executive function are related to walking. Executive function consists of higher order cognitive domains, including attention, visual scanning, working memory, planning, and cognitive flexibility [2]. Curved path walking requires different motor and cognitive processes over straight path walking, such as navigation and planning. As such multiple forms of cognition were assessed. Global objective cognition was assessed using the MMSE (score 0–30). Executive function was measured using the Trail Making Test (TMT) [18]. The TMT assesses visual search ability, scanning, speed of processing, mental flexibility, and executive functioning [19]. The TMT has two parts: Part A (TMTA) requires participants to draw lines sequentially connecting 25 numbers and assesses complex visual scanning, motor speed and ability, and Part B (TMTB) requires them to draw lines sequentially alternating between numbers and letters (e.g., 1, A, 2, B,. .) and requires additional cognitive processes of set shifting and cognitive flexibility. Results are reported as the time in seconds to complete the task; a longer completion time indicates greater impairment. Attention, concentration and working memory were assessed using the Digit Span Test. Participants were asked to repeat forward or backwards a series of digits that gradually increased in length. The total number of correctly reproduced digits was used as the outcome measure.

2.2.3. Gait performance

Gait performance was quantified as time in seconds to complete a walk in both a straight path and curved path condition. The straight path was 6 m in length and participants were instructed to walk at their usual comfortable pace. The curved path consisted of the Figure of 8 Walk Test (F8WT), which required participants to walk in a figure of 8 pattern around two cones that were placed five feet apart [20]. Participants were instructed to stand midway between the cones and on the command “go”, they walked at their usual pace when ready and stopped upon return to the start position. Gait performance on the F8WT was also assessed by the number of steps taken to complete the test. Walking accuracy was measured by assessing if the walk was completed within 2 feet of the cones (yes or no), which was marked on the course. Smoothness was measure observationally by the researcher on the 3 factors of stopping, hesitating and changing pace as per testing protocol. Each factor was scored from 0 (any difficulty) to 1 (no difficulty), resulting in a total smoothness score between 1 and 3. Higher smoothness scores represent better performance [20]. Reliability of both gait tasks has been established in people with dementia [21,22].

2.2.4. Analytic procedures

Differences between groups on clinical characteristics and demographics were evaluated using *t*-tests and Chi-square tests as appropriate. Paired *t*-test analysis was used to compare the time to complete each walking path configuration between groups. Chi-square tests were used to assess the categorical gait performance variables (i.e., accuracy) for the Figure of 8 Test. Linear regression modeling was conducted to determine the effect of each cognitive test on time to complete the straight path and curved path conditions – seven models for each walking path. The dependent variable was time to complete the walk and the independent variable was a measure of cognitive function. All statistical analyses were performed using the IBM SPSS Statistics version 24.0 (IBM Corporation, Armonk, NY). [23].