Gait & Posture 39 (2014) 291–296

Contents lists available at ScienceDirect

Gait & Posture

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

Full length article

The effects of a concurrent motor task on walking in Alzheimer's disease

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ARTICLE INFO

Article history:
Received 25 March 2013
Received in revised form 12 June 2013
Accepted 26 July 2013

ABSTRACT

The important relationship between cognition and gait in people with dementia has been explored with dual-task studies using added cognitive tasks. Effects of less commonly studied but also attention-dividing motor dual-tasks are important to assess in this group as they are common in everyday function and may affect gait differently from cognitive dual-tasks. They may also be easier to comprehend allowing their application with more severe cognitive impairment. The aim of this study was to evaluate the effects and feasibility of a motor dual-task (MDT) on gait measures in people with Alzheimer's disease (AD). Thirty people (15 men, mean age ± SD, 80.2 ± 5.8 years) with a diagnosis of probable AD (MMSE range 8–28) walked on an electronic walkway (i) at self-selected comfortable pace and (ii) at self-selected comfortable pace while carrying a tray and glasses. The MDT produced significant decreases in velocity (Baseline = 111.5 ± 26.5 cm/s, MDT = 96.8 ± 25.7 cm/s, $p < 0.001$) and stride length (Baseline = 121.4 ± 21.6 cm, MDT = 108.1 ± 21.0 cm, $p < 0.001$) with medium effect sizes, and increased stride time (Baseline = 1.11 ± 0.11 s, MDT = 1.14 ± 0.12 s, $p = 0.001$) with small effect size. Measures of spatial (Baseline = $3.2 \pm 1.0\%$, MDT = $3.9 \pm 1.5\%$, $p = 0.006$) and temporal (Baseline = $2.4 \pm 0.8\%$, MDT = $2.8 \pm 0.8\%$, $p = 0.008$) variability increased with the motor dual-task, with medium effect sizes. A trend for motor dual-task changes in gait measures to increase with greater disease severity did not reach significance. The tray-carrying task was feasible, even for participants with severe cognitive decline. Further comparison of different types of motor and cognitive dual-tasks may contribute to development of a framework for clinical intervention to improve reduced dual-task walking capacity in people with AD.

Deterioration of walking in people with Alzheimer's disease (AD) begins early in the course of the disease [1] and includes decreased velocity, stride length and cadence together with increased stride to stride variability [2]. Gait decline is associated with increased rates of falling [3].

Gait impairment in AD is thought to be due to decline in cognitive and sensorimotor function related to the disease. It is now recognised that gait control requires cognition, particularly executive functions (e.g. planning, working memory) [4] with the degree of cognitive involvement dependant on the novelty and complexity of the gait task [4]. The progressive deterioration of executive function [4] together with the increased sensorimotor decline demonstrated in people with AD compared to controls [5], may therefore result in the slowed and more variable walking typical in people with AD, even with simple gait tasks. Other likely contributing factors are the increased cognitive load of compensating for sensory decline [4] and the early damage to neural structures known to control motor function [4].

The relationship between cognition and gait has been explored with dual-task studies. In people with AD, dual-task walking highlights the impact on gait of executive function impairment whereby a concurrent task produces greater deficits compared to those elicited in cognitively healthy controls [6]. Changes in gait variability during dual-task walking may predict falling in people with AD [6] and assist with diagnosis of dementia [7]. Dual-task gait studies have mostly used cognitive tasks (e.g. verbal fluency) [8]. Motor dual-tasks are also important to investigate as they are common in everyday function. They are similar to cognitive dual-tasks in that they are attention-demanding and require higher cognitive control, although different cognitive processes are likely to be involved. They may also differ by creating a greater load on sensorimotor systems due to their characteristics. For example, holding an object steady with both arms may constrain upper body and head movement, or carrying something large may alter visual information by obscuring the path ahead. Functional motor

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http://dx.doi.org/10.1016/j.gaitpost.2013.07.126

dual-tasks may be more familiar and easier to comprehend than some commonly used cognitive dual-tasks, allowing their wider application, especially for groups with greater cognitive impairment.

Motor dual-tasks have been investigated in cognitively intact fallers [9] and in fallers and non-fallers with dementia [10] as well as in groups with Parkinson's disease (PD) [11] and stroke [12]. A commonly studied motor task is carrying a tray loaded with glasses [11,12]. Effects of different motor dual-tasks appear to be similar across these groups with the strength of the effect related to the complexity of the added task [13]. Most of these studies have excluded people with cognitive impairment [11]. One previous study using a motor dual-task in people with AD showed that carrying a glass of water when walking resulted in greater dual-task cost for the AD group compared to a group with mild cognitive impairment [1]. The "Timed Up and Go" test was used to evaluate walking and spatiotemporal gait measures were not reported [1]. Reduced velocity and increased spatial variability with a similar glass-carrying task was reported in a recent study of a group with mild to moderate cognitive impairment of varied aetiology [10]. Gait characteristics differ according to dementia type [14] therefore it may be preferable for gait studies to group participants with dementia of a single type. The effects of a motor dual-task on walking in a group with AD, including those with severe impairment, have not been reported.

Therefore the primary aim of this study was to evaluate the effects on spatiotemporal gait measures and variability of a motor dual-task in people with AD, including the influence of disease severity. A secondary aim was to investigate the feasibility of motor dual-tasking in people with moderate to severe AD.

1. Methods

1.1. Participants

Participants in this study were drawn from a cohort of people with probable AD from a previous study [15]. Twenty-nine of the previous thirty participants met current study inclusion criteria of diagnosis according to published consensus guidelines (including neuropsychological and neuroimaging evaluation) [16], aged $\geq$65 years, able to walk >100 m without a gait aid and availability of at least 12 strides for analysis [17] under single and dual-task walking conditions. Exclusion criteria were uncorrected visual disorders or significant musculoskeletal and neurological disorders (other than AD) which would affect walking, including pain. One further participant was recruited using the same source and inclusion criteria as for the previous cohort. The university ethics committee approved the study and informed consent was obtained for all participants.

1.2. Apparatus

Gait spatiotemporal data were collected using a GAITRite electronic walkway (830 cm long and 89 cm wide with an active sensor area of 732 cm long and 61 cm wide). The system samples data at 80 Hz and has high test–retest reliability for gait measures of people with AD [18].

The motor dual-task was carrying a tray with two empty glasses using both hands. A rectangular opaque plastic tray (width = 38 cm, depth = 28 cm, weight = 390 g) with cut-out handles on each side and a raised lip (4 cm) around the edge was used. Two long-stemmed, clear plastic glasses were used (height = 18.5 cm, base diameter = 7 cm, weight = 57 g). Two circles, one corresponding to the base of each glass, were drawn on the tray to indicate their starting position for each walk. The circles were positioned along the midline of the tray depth, dividing the tray width into thirds.

1.3. Procedure

Participants attended the university movement laboratory on one occasion. Relevant medical history, body measurements and current medications were recorded. The revised Addenbrooke's Cognitive Examination (ACE-R) which includes the MMSE was used to assess cognitive function [19]. Participants then walked under two conditions: (1) self-selected "comfortable" speed (baseline); and (2) walking carrying a tray with glasses (dual-task). At baseline, participants completed two familiarisation walks followed by up to 4 test walks. Instructions were to "walk at your normal, comfortable speed as if you were walking to the shops". Participants then completed one dual-task familiarisation walk to ensure they understood the tray-carrying task while minimising learning effects [6] and up to 4 test walks. The aim was to have at least 2 usable test walks under each condition for analysis. Instructions were to give equal priority to walking and preventing glass movement on the tray. A researcher demonstrated the task. Walks were started and finished two metres beyond each end of the electronic walkway to ensure constant speed walking was recorded. For both conditions, instructions were repeated prior to each walk and short rests of 1–2 min were taken as required. At the completion of each dual-task walk, movement of each glass was measured (i.e. the maximum distance moved by the glass base from the starting position).

1.4. Data analysis

Gait measures are reported from four previously identified domains of walking (i.e. Pace – velocity and stride length; Rhythm – stride time and cadence; Base of support – stride width; Variability – stride length (spatial) and stride time (temporal) variability) [20]. Variability was calculated using coefficient of variation (CV) which expresses the ratio of the standard deviation of scores to the mean as a percentage. Raw step data were extracted from individual walks and combined for each condition for each participant. Walks were removed if the participant had talked or become obviously distracted, to minimise addition of further competing tasks. This resulted in removal of 17 walks (8.8%) from a total of 193 test walks from both conditions.

Walks were combined for analysis as previously described [15]. Briefly, for each participant, mean velocity of walks under each condition was compared and if minimum and maximum values were >10 cm/s different from each other, the walk most distant in value from the median speed for the group of walks of that individual was discarded. A further nine walks (4.7%) were therefore removed from the total number of test walks leaving 167 included walks. The resultant mean difference between fastest and slowest walks for all participants under both conditions was 4.6 ± 3 cm/s. Total stride numbers per condition (baseline, dual-task) were then compared for each participant and strides removed in order to match numbers under both conditions for each participant (Mean stride numbers 23 ± 7, range 12–37).

Baseline and dual-task measures for the whole group were compared using paired samples *t*-tests. Effect sizes were calculated using Hedge's *g*. Percentage change scores were calculated to permit a comparison of proportional change or the dual-task cost (the difference between single and dual-task measures expressed as a percentage of the single task value) of the motor dual-task. To determine whether dual-task costs were different between subgroups with different dementia severity, dual-task cost values for each gait measure were compared between mild and moderate-severe subgroups using Mann–Whitney U tests, as data were not normally distributed. Effect sizes were reported with r, estimated using the formula $r = z/\sqrt{N}$ where N is the total number of cases [21]. In order to investigate whether there is a relationship