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Dual-task performance in seniors with mild cognitive impairment and Alzheimer's disease: a longitudinal study

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HIGHLIGTHS

- Alzheimer's disease has an impact on the ability of carrying out a dual task.
- Dual task performance worsens over time in older adults with Alzheimer's disease.
- Time, steps and cadence worsened with time in older adults with Alzheimer's disease.
- We suggest that walking and using the phone is an effective dual task assessment.

ABBREVIATIONS

AD	Alzheimer`s disease
CDR	Clinical Dementia Rating
CMT	cognitive-motor test
DSM-IV-TR	Diagnostic and Statistical Manual of Mental Disorders
DT	Dual task
MCI	Mild cognitive impairment
MMSE	Mini Mental State Exam
PrC	Preserved cognition
T1	Initial moment
T2	After 32 months
TUGT	Timed up and go test
UFSCar	Universidade Federal de São Carlos

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BACKGROUND: Motor performance in older adults with cognitive impairment is worse under dual task conditions, increasing the risk of falls. However, there is a lack of studies that analyze this performance over time in people with different cognitive profiles.
AIM: This study aimed to compare the performance of an isolated task and a dual task in people with preserved cognition (PrC), with mild cognitive impairment (MCI) and Alzheimer`s disease (AD).
METHOD: Data were collected on two occasions (T1 and T2), thirty-two months apart. Participants (n=51) were separated between groups: PrC (n=22), MCI (n=19) and AD (n=10). They were analyzed in three situations: 1) isolated motor task - Timed up and go test (TUGT); 2) cognitive-motor test (CMT)– dialing on a phone; 3) dual task (DT). To compare the performance of the dual task between the groups, delta was calculated and the ANCOVA test was applied.
RESULTS: Although the cost of the dual task was not significantly different over time in any group, we found increases in the time required to complete the TUGT ($p<0.01$) and TUGT-DT ($p>0.01$) after 32 months in the AD group and a reduction in time in the PrC and MCI groups. A greater number of steps in the TUGT-DT ($p<0.01$) and an increase in cadence in the TUGT ($p = 0.01$) and TUGT-DT ($p<0.01$) were also found in the AD group.
CONCLUSION: We suggest that a more functional task, such as walking while typing on the phone, may be considered a more sensitive way of assessing older adults with AD.

KEYWORDS: Alzheimer's disease | Dual task | Cognitive Impairment | Older adults | Timed Up and Go test

INTRODUCTION

Due to the increase in life expectancy, pathologies inherent to aging, including the possibility of neurodegenerative diseases, such as some types of public health, have become an important public health problem. This is because dementia is considered one of the main causes of disability in adult life, triggering high costs of assistance to the burden of family members and relatives. However, it presents a challenge for research to understand the trajectory of this disease over time,and thus be able to guide health actions through the most effective approaches and interventions [1]. Alzheimer's disease (AD) is a progressive, irreversible condition that exerts a negative impact on cognitive functions and the performance of activities of daily living [2]. Mild cognitive impairment (MCI) is another condition that has been investigated in the aging process and constitutes a transition phase between physiological neuronal loss in the natural aging process and dementia [3].

Older adults with cognitive impairment have a poorer performance in dual tasks compared to those with preserved cognition (PrC) [4]. Cross-sectional studies comparing older adults with PrC to those with some type of cognitive impairment have reported a negative impact on gait during a dual task in the latter group [5,6,7,8]. These changes may be explained by a central interference caused by the increase in brain activity during the simultaneous performance of two tasks and the limitation of attentional resources [9], which may decrease performance in one or both tasks and considerably increase the risk of falls [10].

Although the studies cited have contributed knowledge on dual task performance, as well as motor performance among older adults with MCI and AD, there is a need for longitudinal studies to investigate the dual task performance of older adults in different cognitive status conditions.

Therefore, the aim of the present longitudinal study was to compare the performance on an isolated task and dual task in older adults with PrC, MCI and mild AD. We tested the hypothesis that, over time, older adults with PrC, with MCI and AD would present significant differences when performing the dual task, with worse performance in older adults who had greater cognitive impairment.

METHODS

Participants

The present study is a sub-study of the longitudinal project called the"Brazilian longitudinal study about motor alterations in older people with cognitive disorders (BLSMotorCD)". This study received approval from the human research ethics committee (certificate number: 72774317.7.0000.5504) and all the participants or their caregivers signed a statement of informed consent. At the initial moment (T1), 118 older adults were recruited, who were evaluated and allocated into three groups: PrC, MCI and AD.

AD and MCI were diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) [11], including assessments of the Clinical Dementia Rating (CDR) [12] and Mini Mental State Examination (MMSE) [13]. The confirmation of the diagnosis was performed at the Department of Medicine at the *Universidade Federal de São Carlos* (UFSCar) by a trained team coordinated by Dr. FACV at the Behavioral Cognitive Neurology Clinic.

After 32 months (T2) [10], one hundred and eighteen older adults were contacted again by the evaluators. Of these, fifty-one individuals participated in T2 (10 with AD, 19 with MCI and 22 with PrC). Reasons for discontinuation during the study period were withdrawal (n = 23), loss of contact (n = 12), death (n = 11) and exclusion (bedridden/restricted to a wheelchair: n = 18; severe behavioral disorder: n = 3).

Procedures

The two evaluators at T1 [5] and T2 were blinded to the allocation of volunteers in the different groups and underwent a reliability analysis. The inter-examiner reliability test was performed on the same day for both evaluators and the intra-examiner was applied with an interval of seven days from the first test. Nineteen randomly selected types of footage of TUGT evaluations were used. Only the time variable was computed for the reliability test. All footage used was from cognitively preserved individuals or diagnosed with MCI. Each examiner evaluated the same videos in the two periods described (intraclass correlation coefficient = 1).

After analyzing the patient history, sociodemographic variables, the Geriatric Depression Scale was applied to determine symptoms of depression [14] and the Minnesota Questionnaire was administered to measure the level of physical activity [15]. Then, the participants performed the following tasks twice, one considered as familiarization and the second for the test:

Timed Up and Go test (TUGT)

The version of the TUGT adapted for older adults with cognitive impairment was used [16]. The following standard commands were given: “Get ready, go. Stand up, walk, go around the cone and sit down” [16]. The timer was started when the individual left the chair and stopped when the subject leaned back again. Cadence was calculated by the number of steps divided by the running time (Figure 1). The course performed in less than 12.47 seconds has less risk of falling, while if the time is longer than 12.47 seconds, it represents a greater risk of falls[17].

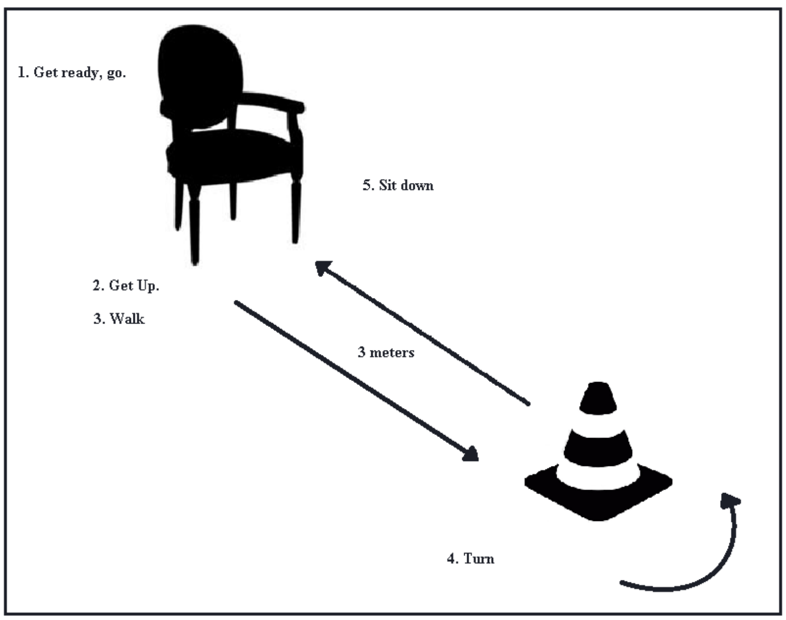

Figure 1. Illustration of commands while applying the TUGT. Source: the author.

Cognitive-motor task (CMT)

For the Cognitive-motor task, the participant was instructed to type a sequence of eight numbers on a cell phone, a common task nowadays that requires preserved cognition functions (such as attention and visuospatial notion, for example), as well as the motor function for typing. A randomly selected card was attached to the screen of the telephone and the participant received the following instructions: “Get ready, go. Pick up the telephone, type the eight numbers on the card and put the phone back on the table” [5]

(Figure 2).The objective of this task was to observe the performance of older adults when performing the task of dialing on the telephone, without walking [18].

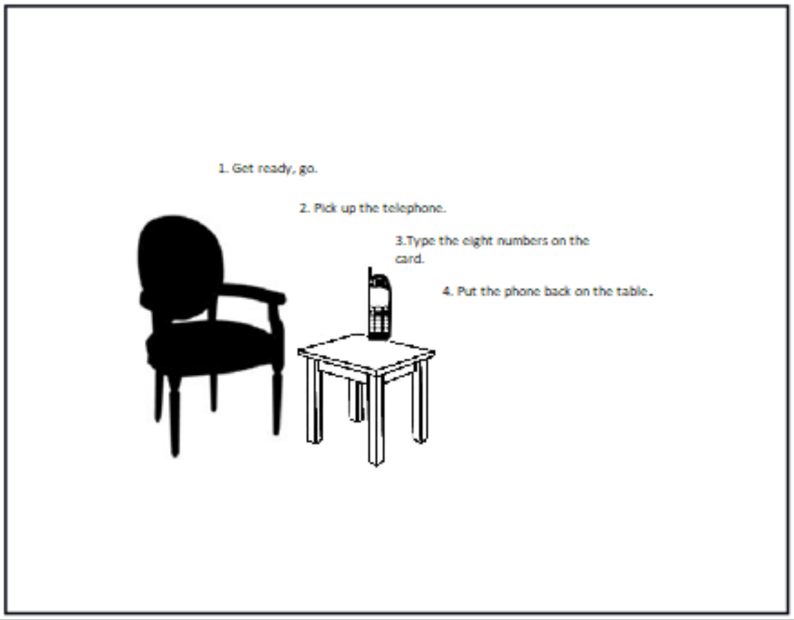

Figure 2. Illustration of commands while applying the CMT. Source: the author.

Timed Up and Go Test with cognitive task (TUGT-DT)

For the dual task, a second randomly selected card was used. The participant received the following instructions: "Get ready, go. Stand up, pick up the telephone, walk while typing the eight numbers on the card, walk around the cone, put the telephone back on the table and sit down" [5] (Figure 3).

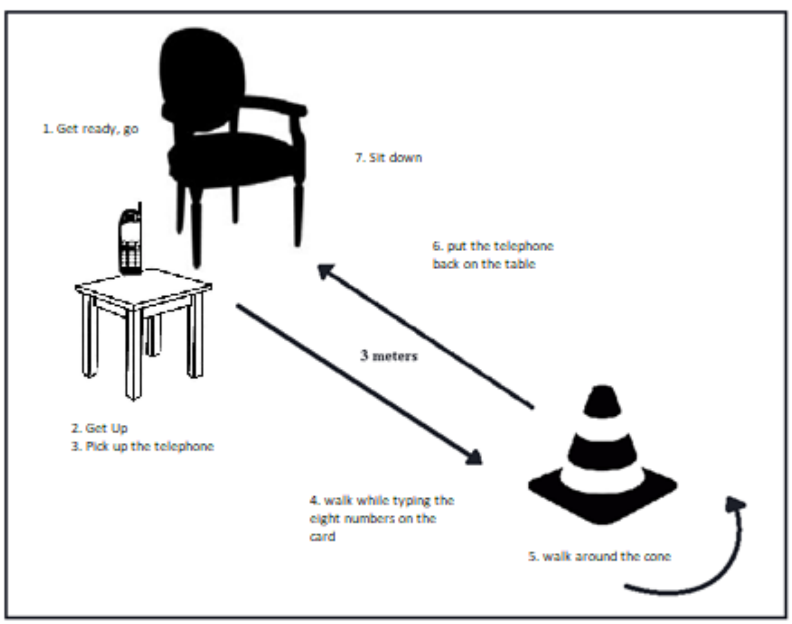

Figure 3. Illustration of commands while applying the TUGT-DT. Source: the author.

Statistical Analysis

Descriptive statistics were first performed. The Shapiro-Wilk test was used to determine the normality of the data. Non-normal data were transformed into Z-scores. Differences between T1 and T2 were calculated to analyze the time, errors and cost of the CMT (ratio of the difference in the ratio of numbers typed per second times the percentile of the correct answers of the cognitive task and the TUGT-DT over the same ratio of the cognitive task) (Figure 4), time, steps and cadence of the TUGT and time, steps, cadence, errors and cost of the dual task (ratio of the difference between the TUGT-DT and the TUGT time over the TUGT time) (Figure 5) in the groups [5]. As a difference among the groups was found for age, which could affect the results, ANCOVA was performed considering age as a confounding variable. The chi-square test was used to compare the categorical variables. The level of significance was set to 5% ($p < 0.05$).

$$\text{CT cognitive-motor} = \frac{\text{tDT - tTUG}}{\text{tTUG}} \text{ x100}$$

Figure 4. Calculation of the cost of the Cognitive-Motor task. t=time, CT=task cost, DT=Dual task, TUG=Timed up and go test.

$$\text{CT cognitiva} = \frac{\text{RRCdt - RRCtc}}{\text{RRCtc}} \text{ x100}$$

Figure 5. Calculation of the cost of the dual task. CT= task cost, RRC=ratio of correct answer (ratio of answer by second x correct percentile), DT=dual task, TC=isolated cognitive-motor task.

RESULTS

Table 1 shows the sociodemographic variables of the sample at T1. Significant differences among the groups were found for age, sex, number or medications, level of physical activity and cognition.

Table 1. Sociodemographic and clinical characteristics of sample (n = 51).

Variable (mean ± SD)	PrC n = 22	MCI n = 19	AD n = 10	p
Age	72±6.34	72±4.95	78±4.39	0.021*#
Female sex, n (%)	12 (54.5)	18 (94.7)	4 (40.0)	0.002*@
Schooling (years)	7±4.2	6.26±4.04	6.10±3.66	0.590
Multi/bifocal glasses, n (%)	16 (72.72)	13 (68.42)	5 (50.0)	
Gait-assistance device, n (%)	1 (4.54)	2 (10.53)	1 (10.0)	0.873
Medications (n)	2.68±2.35	5.11±3.33	5.20±2.49	0.043*α
Comorbidities (n)	2.09±1.51	2.74±1.56	3.50±1.35	0.380
BMI (kg/m²)	28.68±5.53	29.80±4.64	28.42±4.24	0.640
Minnesota (points)	2876.42±3609.18	1424.57±1300.59	846.55±1255.85	0.012*β
GDS (points)	2.00±1.74	3.53±2.39	3.10±1.85	0.057

PrC: preserved cognition; MCI: mild cognitive impairment; AD: Alzheimer's disease; n: number of individuals; SD: standard deviation; kg: kilograms; m: meters; BMI: body mass index; GDS: Geriatric Depression Scale; *p <0.05; .#: AD ≠MCI and PrC; @: MCI ≠PrC and AD; α: PrC ≠ AD; β: PrC ≠MCI and AD.

Table 2 shows the data on the performance of the three groups over time. Significant differences were found among the groups (PrC, MCI and AD) for two variables on the TUGT (time and cadence) and three variables on the dual task (time, number of steps and cadence). Significant increases in the time required to complete the TUGT and TUGT-DT were found after 32 months in the AD group ($p < 0.01$ and $p = 0.02$, respectively), whereas a reduction in time was found in the PrC and MCI groups. A greater number of steps on the TUGT-DT ($p < 0.01$) and an increase in cadence on the TUGT and TUGT-DT ($p = 0.01$ and $p < 0.01$, respectively) were also found in the AD group.

Table 2. Performance on isolated and dual tasks of older adults in PrC, MCI and AD groups over time.

Variables: T2-T1=∆ (mand ± SD)	PrC n = 22	MCI n = 19	AD n = 10	P	Effect size	Power
Isolated task						
Time - CMT (s)	-0.20±0.39	-0.06±0.83	0.55±1.84	0.42	0.03	0.19
Errors –CMT	0.24±1.41	-0.24±0.19	-0.65±0.75	0.32	0.05	0.24
Cost - CMT (%)	-17.0±140.0	-2.0±43.0	43.0±60.0	0.45	0.03	0.18
Time - TUGT (s)	-0.27±0.45	-0.30±0.60	1.16±1.60	0.00*#	0.26	0.95
Steps - TUGT	-0.19±0.84	-0.19±1.11	0.78±0.75	0.06	0.11	0.56
Cadence - TUGT (steps/min)	-0.34±1.02	-0.51±0.77	0.84±0.95	0.01*#	0.17	0.79
Dual task						
Time (s)	-0.33±0.26	-0.11±1.07	0.94±1.35	0.02*#	0.15	0.72
Steps	-0.31±0.48	-0.21±0.81	1.09±1.42	0.00*#	0.22	0.89
Cadence (steps/min)	-0.51±0.81	0.15±1.00	0.84±0.76	0.00*#	0.25	0.94
Errors	-0.10±0.19	-0.22±0.82	0.64±1.88	0.13	0.08	0.41
Cost (%)	-16.0±57.0	18.0±127.0	-00.0±120.0	0.53	0.02	0.15

T1: baseline; T2: follow-up; SD: standard deviation; PrC: preserved cognition; MCI: mild cognitive impairment; AD: Alzheimer's disease; n: number of individuals; CMT: cognitive-motor task; TUGT: Timed Up and Go Test; s: seconds; min: minutes; *p <0.05.#: AD ≠ MCI and PrC

DISCUSSION

The main finding of this study was that older adults with AD, over time, had a significant impact on their performance in all variables in both conditions (simple task and DT). A worse performance was found in relation to cadence and time required to complete the isolated task (TUGT) in the AD group, while the older adults in the MCI and PrC groups had similar performances over time. These findings indicate that two years and eight months is enough time to have a significant impact on the motor aspects of individuals with AD, even in the early stages of the disease, while this same period of time does not seem to affect isolated motor tasks in older adults with PrC or mild cognitive impairment.

According to Ansai [5], dual task measures are more associated with cognitive domains when compared to single-task measures. Therefore, we expected to find greater differences in the cost of dual tasking over time.

However, the cost of the DT did not change significantly in any of the groups analyzed, and significant differences were found in relation to the time required to perform the tasks, number of steps and cadence for both the isolated tasks and the pairs in the AD group. Similar findings are described by Cedervall [10] who analyzed gait performance in older adults with mild AD over a period of two years and found no significant difference in the cost of DT, while gait speed and step length were decreased.

Nevertheless, we can interpret that, during the period of this study, the motor impairment in the older adults with AD declined considerably to the point that even when evaluated separately, there was a difference in this group. In our case, older adults with AD, at T1, performed the test in 14.3s and, in T2, in 19.63s. We can see a significant decline in this time, but it is worth noting that in both moments, the values are above the predictive value for risk of falls in Brazilian older adults - 12.47 seconds [17].

However, studies suggest that the dual task assessment can identify MCI and AD [6,19] and can predict an increased risk of falls in older adults with some degree of cognitive impairment [20]. By strengthening these hypotheses, we suggest that a functional task such as walking and typing on the common telephone today and which requires preserved cognitive functions (such as attention and visuospatial notion, for example), as well as the motor function for typing, can become more challenging and should be considered in the evaluation of older adults with cognitive impairment.

Changes in the dual task performance can be explained by central interference caused by increased brain activity and limited attentional resources when performing two tasks simultaneously [9]. Gait requires processing by the motor cortex, basal ganglia, and cerebellum, as well as the interaction of attention, executive functions, and visuospatial skills. In other words, it requires brain activation and preserved cognition domains. This occurs more markedly in older adults with cognitive deficits [6].

In fact, studies report a strong association between cognitive functions (especially frontal cognitive functions) and motor aspects in older adults with cognitive impairment [4]. The task of walking and typing a number on the phone requires frontal cognitive skills of attention and executive functions, as well as the preservation of motor skills to ensure good performance [5]. Thus, the reduction in cognitive capacity that occurs in older adults can explain the changes in gait, which, in turn, can affect postural stability and increase the risk of falls [10,20,21].

The hypothesis of this study was confirmed, as older adults diagnosed with Alzheimer's Disease, even in the early stages, showed worse performance in the dual task over time. There appears to be no difference in dual task performance between individuals with mild cognitive impairment over time compared with older adults with PrC. This suggests that the brain regions altered by the physiological process of aging and in cases of MCI do not seem to suffer significant interference to trigger a deficit in the performance of the dual task in this period of time, unlike the condition of older adults with AD. These findings are similar to studies that evaluated older adults with and without cognitive impairment in a longitudinal perspective [9,10,22].

However, more research is needed to investigate these situations in the MCI, as previous studies have reported that older adults with cognitive deficits have a higher risk of falls than those with preserved cognition [20].

This study has limitations that should be considered, such as the small sample size (n = 51) and the different numbers of participants in each group (PrC = 22, MCI = 19 and AD = 10). The strengths of this study were the confirmation of the diagnosis by a specialized medical team, the use of a clinical measure of mobility widely used by health professionals (Timed Up and Go Test), the reliability of the evaluators (ICC = 1) and using a more functional dual task that can be reproduced by other health professionals.

Future studies should analyze the changes over time in different cognitive domains in dual tasks among older adults with MCI, AD and PrC. Such studies could help explain the association between cognitive changes and motor aspects in these three groups. Moreover, measures of dual task performance should be included in the evaluation of older adults with cognitive impairment, which could help establish prevention measures and rehabilitation processes for older adults with cognitive impairment, especially those with Alzheimer's disease.

CONCLUSION

Alzheimer's Disease, even in the mild phase, has a significant impact on the motor performance of older adults over time. While the cost of the dual task did not undergo significant changes in any of the three groups analyzed, the individuals with AD had a poorer performance on dual tasks in terms of the time required to complete the tasks, number of steps and cadence compared to the older adults with MCI and preserved cognition. These changes in older adults with AD during the performance of a more functional dual task, such as walking and talking on the telephone, can be considered an effective way to evaluate this population.

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