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Functional Mobility and postural balance in older adults with Alzheimer's disease: comparative study between mild and moderate stages

Mobilidade Funcional e equilíbrio postural de idosos com Doença de Alzheimer: análise comparativa entre as fases leve e moderada

Movilidad Funcional y equilibrio postural de ancianos con enfermedad de Alzheimer: análisis comparativo entre fases leves y moderadas

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Abstract
Objective: This study aimed to compare the functional mobility and postural balance of older adults among smild and moderate stages of Alzheimer's disease using the Timed Up and Go test (TUGT) and the Clinical Test of Sensory Interaction and Balance (CTSIB). *Methodology*: Forty elderly people were divided into two groups according to the mild (CDR1; n = 26) and moderate (CDR2; n = 14) stages of the disease. The Clinical Dementia Rating Scale (CDR) was used for staging the disease, which allows classifying the different degrees of dementia, assessing cognition and behavior. The scale allows classification into CDR 0 (normal or no alteration); 0.5 (questionable or mild cognitive impairment); 1 (mild dementia); 2 (moderate dementia) and 3 (severe dementia). In this study, only subjects classified as CDR 1 or CDR 2 were included. For the assessment of functional mobility, the Timed Up and Go Test (TUGT) was used in the conditions of single task, dual cognitive task and dual motor task, and the Clinical Test of Sensory (CTSIB) to assess postural balance. Data were compared between groups. *Results*: Performance on the TUGT single task, cognitive dual task, and motor dual task was significantly worse in the CDR2 group compared to the CDR1 group ($p < 0.05$). The CTSIB was not significantly different between the groups in the four conditions. *Conclusion*: Functional mobility during tasks involving cognition differs between older adults with mild and moderate dementia, and this commitment is more accentuated in dual-task situations. Postural balance did not differ between the stages of the disease.
Keywords: Posture control; Neurodegenerative disorders; Physical functional performance; Cognitive impairment.

Resumo
Objetivo: Este estudo objetiva comparar o equilíbrio postural de pessoas idosas entre as fases leve e moderada da Doença de Alzheimer utilizando o Timed Up and Go test (TUGT) e o Teste Clínico de Interação Sensorial e Equilíbrio (CTSIB). *Metodologia*: Foram avaliados 40 idosos divididos em dois grupos de acordo com os estágios leve (CDR1; n = 26) e moderado (CDR2; n = 14) da doença. Utilizou-se para estadiamento da doença o Clinical Dementia Rating Scale (CDR), o qual permite classificar os diversos graus de demência, avaliando cognição e comportamento. A escala possibilita a classificação em CDR 0 (normal ou nenhuma alteração); 0,5 (questionável ou comprometimento cognitivo leve); 1 (demência leve); 2 (demência moderada) e 3 (demência grave). Nesse estudo, foram incluídos apenas os sujeitos classificados em CDR 1 ou CDR 2. Para a avaliação da mobilidade funcional usou-se o Timed Up and Go Test (TUGT)

nas condições de tarefa simples, dupla tarefa cognitiva e dupla tarefa motora, e o Teste Clínico de Interação Sensorial e Equilíbrio (CTSIB) para avaliação do equilíbrio postural. Os dados foram comparados entre os grupos. Resultados: O desempenho nas tarefas do TUGT simples, dupla tarefa cognitiva e dupla tarefa motora foi significativamente pior no CDR2 em comparação ao grupo CDR1 ($p < 0,05$). O CTSIB não se apresentou significativamente diferente entre os grupos nas quatro condições. *Conclusão*: A mobilidade funcional durante tarefas que envolvem a cognição difere entre as fases leve e moderada da demência em pessoas idosas, sendo esse comprometimento mais acentuado em situações de dupla tarefa. O equilíbrio postural não apresentou diferença entre as fases da doença.
Palavras-chave: Controle postural; Desordens neurodegenerativas; Desempenho físico funcional; Comprometimento cognitivo.

Resumen

Objetivo: Este estudio tiene como objetivo comparar la movilidad funcional y el equilibrio postural de personas mayores entre estadios leves y moderados de la enfermedad de Alzheimer utilizando la prueba Timed Up and Go (TUGT) y la Prueba Clínica de Interacción Sensorial y Equilibrio (CTSIB). Metodología: Cuarenta ancianos fueron divididos en dos grupos según el estadio leve (CDR1; n = 26) y moderado (CDR2; n = 14) de la enfermedad. Para la estadificación de la enfermedad se utilizó la Clinical Dementia Rating Scale (CDR), que permite clasificar los diferentes grados de demencia, valorando la cognición y la conducta. La escala permite clasificar en CDR 0 (normal o sin alteración); 0,5 (deterioro cognitivo dudoso o leve); 1 (demencia leve); 2 (demencia moderada) y 3 (demencia grave). En este estudio solo se incluyeron sujetos clasificados como CDR 1 o CDR 2. Para la evaluación de la movilidad funcional se utilizó el Timed Up and Go Test (TUGT) en las condiciones de tarea simple, tarea cognitiva dual y tarea dual motora, y la Prueba Clínica de Interacción Sensorial y Equilibrio (CTSIB) para evaluar el equilibrio postural. Los datos se compararon entre los grupos. Resultados: El rendimiento en la tarea simple TUGT, la tarea dual cognitiva y la tarea motora dual fue significativamente peor en el grupo CDR2 en comparación con el grupo CDR1 ($p < 0,05$). El CTSIB no fue significativamente diferente entre los grupos en las cuatro condiciones. Conclusión: La movilidad funcional durante las tareas que implican la cognición difiere entre las etapas leve y moderada de la demencia en las personas mayores, siendo este deterioro más pronunciado en situaciones de doble tarea. El equilibrio postural no difirió entre las etapas de la enfermedad.
Palabras clave: Control de la postura; Trastornos neurodegenerativos; Desempeño funcional físico; Deterioro cognitivo.

1. Introduction

The prevalence of chronic degenerative diseases (e.g., Alzheimer's disease [AD]) increased with population aging; such diseases can compromise autonomy, postural balance, and gait (Barreto, et al., 2015; Fujisawa, et al., 2017; Haskel, et al., 2017). AD is characterized by a progressive cognitive decline affecting the frontal cortex and impairing memory, language, and executive functions (Nietzsche, et al., 2015; Silva, et al., 2018).

Executive function is the cognitive capacity to plan, initiate, maintain, and inhibit behaviors (Cristofori, et al., 2019). Its impairment (i.e., executive dysfunction) due to AD may justify motor changes in gait and postural balance. Complex tasks (e.g., dual tasks) demanding greater prefrontal cortex function also require planning, attention, and cortical organization (Allali & Verghese, 2020; Ansai, Andrade & Rossi, et al., 2017; Bortoli, et al., 2015; Siqueira, et al., 2019).

Allali and Verghese (2020) reported executive dysfunction as the initial characteristic of impaired gait and postural balance in older adults with AD, mainly due to poor attention functionality. This impairment leads to postural instability, postural balance deficits, and mobility limitation, justifying the fall risk (Allali & Verghese, 2020; Borges, et al., 2016; Bortoli, et al., 2015; Siqueira, et al., 2019).

The cognitive decline in older adults predisposes altered motor function, gait, and postural balance (Allali & Verghese, 2020; Bortoli, et al., 2015; Cruz, et al., 2015; Siqueira, et al., 2019). Dyer et al. (2020) showed associations between cognitive decline and falls and gait speed in older adults. Also, the performance of divided attention tasks (dual tasks) is poor in older adults, especially during gait (Borges, et al., 2015; de Melo, et al., 2019).

Studies showed that cognitive decline was associated with postural balance deficits and prevalence of falls, with greater impairment in older adults with AD than in those without it (Bortoli, et al., 2015; Cruz, et al., 2015). In addition, the fall risk was higher in older adults with executive dysfunction than in cognitively healthy older adults (Allali & Verghese, 2020; Allali, et al., 2017). In this context, understanding changes in functional mobility and postural balance among different AD stages allows

health professionals to identify triggers for altered motor function and develop early interventions. Therefore, the present study aimed to compare functional mobility and postural balance of older adults among different AD stages using the Timed Up and Go test (TUGT) and Clinical Sensory of Test Interaction and Balance (CTSIB).

2. Methodology

This cross-sectional study was approved by the research ethics committee of the Federal University of Rio Grande do Norte (number 2.772.429) and conducted at the Clinical Center Dr. José Carlos Passos (Natal, Brazil) according to the Declaration of Helsinki. We selected patients of both sexes diagnosed with AD (Frota et al., 2011), over 60 years old, and presenting mild (CDR1) or moderate (CDR2) dementia according to the Clinical Dementia Rating scale (CDR). All volunteers and caregivers signed an informed consent form.

The CDR classifies dementia severity according to cognition, behavior, and influence of cognitive decline on daily activities. It is divided into six cognitive-behavioral categories (memory, orientation, judgment and problem solving, community relations, home or leisure activities, and personal care) (Montaño & Ramos, 2005; Morris, 1993; Hughes, et al., 1982) and classifies dementia in a five-point scale: 0 (no cognitive impairment), 0.5 (questionable or very mild dementia), 1 (mild), 2 (moderate), and 3 (severe) (Morris, 1993). Cognition was also assessed using the Mini-Mental State Examination (MMSE) (Almeida, 1998; Folstein, 1975).

Patients without associated neurological diseases (e.g., dementia of other etiology, Parkinson's disease, and previous brain stroke), complaints, vertigo signs, or vestibular syndrome were included in the study. Patients were excluded if they showed physical and cognitive limitations during the tests, practiced regular physical activity, performed physical therapy for balance in the last six months, refused to perform the tests, or had MMSE score lower than nine or CDR different than 1 or 2. Limitations considered for exclusion were severely diminished visual and auditory acuity not improved with corrective devices and inability to reproduce movements or understand and respond to verbal commands.

Variables collected were classified in sociodemographic and clinical data (sex, age, monthly income, educational level, body mass index, number of diseases, number of medications, and AD diagnosis time) and postural balance (falls in the last six months, fear of falling, use of a walking aid device, dizziness).

Functional mobility was assessed using TUGT and the postural balance using CTSIB, and rest intervals were given to patients during and between tests according to their needs. The TUGT is a reliable and comprehensive test to assess functional mobility, including dynamic postural balance. It consists of getting up from a chair, walking three meters, turning around a cone, walking back to the chair, and sitting down (Podsiadlo & Richardson, 1991). The TUGT single-task was performed first, followed by dual-cognitive (animal names were dictated during the test) and dual-motor tasks (patients had to hold a glass of water with the dominant limb during the test) (Fatori, et al., 2015). The time to complete the test, number of steps, and cadence (steps/minute) were registered.

Postural balance was assessed using a modified CTSIB and four sensory conditions: (1) open eyes and firm surface, (2) blindfold and firm surface, (3) open eyes and foam surface, and (4) blindfold and foam surface (Shumway-Cook & Horak, 1986). The test identified which sensory system (visual, somatosensorial, or vestibular) affected postural control. Patients were instructed to remain for 30 seconds in each sensory condition without taking steps to compensate for instability or moving upper limbs, heels, and feet; they wore a blindfold for visual occlusion. We reduced the support by requesting older adults to stand with feet together (Romberg position). One trial was performed for each CTSIB condition. The time (seconds) during each condition was included for analysis, and the test was categorized as "normal" or "abnormal" (i.e., the patient could not maintain stability).

Data were expressed as absolute and relative frequency, mean ± standard deviation, median, minimum and maximum values, and 95% confidence intervals. The Kolmogorov-Smirnov test verified data normality. Time and number of steps to complete the TUGT and time in the CTSIB were compared between patients with CDR1 and CDR2 (groups) using the Mann-Whitney test; the paired t-test compared cadence during TUGT. Inferential analysis was performed using SPSS (IBM Corp.®, USA; version 17.0), and significance was set at $p < 0.05$ (two-tailed).

3. Results

The study included 26 older adults with CDR1 and 14 with CDR2; the mean age was 80.67 ± 6.40 years (CDR1 = 82.00 ± 4.94; CDR2 = 79.96 ± 7.03), and mean AD diagnosis time was 4.19 ± 3.66 years (CDR1 = 3.00 ± 2.84; CDR2 = 6.42 ± 4.05). Most patients were female (75%) with mean educational level of 4.16 ± 5.24 years and illiterate or with incomplete elementary school. The MMSE showed predominant mild and moderate cognitive impairment (total sample = 14.32 ± 3.68 points; CDR1 = 15.50 ± 3.58; CDR2 = 12.06 ± 2.86). Sex and age was not different between groups (Table 1).

Table 1 - Sociodemographic, anthropometric, and clinical data of older adults with Alzheimer's disease (AD) according to CDR (n = 40).

Variables	Categories	Alzheimer's Disease	
		CDR1 N = 26 (65%)	CDR2 N = 14 (35%)
Sex	Female	19 (73.1%)	11 (78.5%)
	Male	7 (26.9%)	3 (21.5%)
Age	60 to 79 years old	12 (46.2%)	5 (35.7%)
	> 80 years old	14 (53.8%)	9 (64.3%)
Monthly income	≤ 2 minimum wages	19 (73.1%)	13 (92.9%)
	≥ 3 minimum wages	7 (26.9%)	1 (7.1%)
Educational level	Illiterate / incomplete elementary school	17 (65.4%)	10 (71.5%)
	Complete elementary school / Post elementary school	9 (34.6%)	4 (28.5%)
BMI	Underweight or normal	14 (53.8%)	10 (71.4%)
	Overweight	12 (46.2%)	4 (28.6%)
Number of diseases	1 to 4	17 (65.4%)	9 (64.3%)
	≥ 5	9 (34.6%)	5 (35.7%)
Number of medications	0 to 4	10 (38.5%)	6 (42.9%)
	≥ 5	16 (63.5%)	8 (57.1%)
AD diagnosis time	0 to 4 years	22 (84.6%)	4 (28.6%)
	≥ 5 years	4 (15.4%)	10 (71.4%)
Falls in the last six months	No	17 (65.4%)	7 (50.0%)
	Yes	9 (34.6%)	7 (50.0%)
Fear of falling	Yes	19 (73.1%)	10 (71.5%)
	No	7 (26.9%)	4 (28.5%)
Use of walking aid device	Yes	4 (15.4%)	1 (7.1%)
	No	22 (84.6%)	13 (92.9%)
Dizziness	Yes	14 (53.8%)	10 (71.5%)
	No	12 (46.2%)	4 (28.5%)

CDR – Clinical Dementia Rating scale; CDR1 – mild clinical dementia; CDR2 – moderate clinical dementia; BMI – Body Mass Index; Brazil national minimun wage in 2019 (R$ 998,00). Source: Authors.

The number of steps (p = 0.039) and time to complete TUGT single- (p = 0.008), dual-cognitive (p = 0.005), and dual-motor (p = 0.019) tasks were higher in CDR2 than in CDR1. Cadence during the TUGT dual-cognitive task was also significantly higher (p = 0.031) in CDR2 than in CDR1 (Table 2).

Table 2 - Timed Up and Go Test between patients with mild (CDR1) and moderate (CDR2) dementia. (n = 40).

		Alzheimer's Disease		
		CDR1 (n = 26)	CDR2 (n = 14)	**p-value**
TUGT		**Mean ± SD (95% CI) or median (minimum - maximum)**		
Single-task	Time (s)	15.06 (9.45 - 55.58)	22.26 (14.45 - 58.19)	**0.008***
	Steps (n)	19.00 (13.00 - 33.00)	24.50 (14.00 - 45.00)	**0.039***
	Cadence (steps/min)	68.49 ± 17.05 (61.61 - 75.38)	59.51 ± 10.85 (53.24 - 65.78)	0.083**
Dual-cognitive task	Time (s)	21.35 (14.20 – 75.93)	28.54 (18.87 - 92.00)	**0.005***
	Steps (n)	21.50 (15.00 – 35.00)	26.00 (17.00 – 63.00)	0.063*
	Cadence (steps/min)	58.19 ± 14.72 (52.24 - 64.13)	48.17 ± 10.62 (42.04 - 54.31)	**0.031****
Dual-motor task	Time (s)	18.04 (11.48 - 56.69)	21.30 (15.55 – 80.00)	**0.019***
	Steps (n)	20.00 (13.00 - 30.00)	23.50 (17.00 – 68.00)	0.131*
	Cadence (steps/min)	67.83 ± 14.07 (62.14 - 73.51)	60.73 ± 10.54 (54.64 - 66.82)	0.107**

CDR – Clinical Dementia Rating scale; CI – confidence interval; SD – standard deviation; TUGT - Timed Up and Go Test; *p-value - Mann-Whitney test; **p-value – Student-t test; s – seconds; n – number; steps/min – steps per minute. Source: Authors.

CTSIB was not different between groups in the four conditions (Table 3).

Table 3 - Conditions of the modified CTSIB between patients with mild (CDR1) and moderate (CDR2) dementia (n = 40).

	Alzheimer's Disease		
	CDR1 (n = 26)	CDR2 (n = 14)	**p-value**
	Median (minimum - maximum)		
Modified CTSIB (seconds)			
Condition 1: Open eyes and firm surface	30.00 (19.12 – 30.00)	30.00 (7.50 - 30.00)	0.077
Condition 2: Blindfold and firm surface	30.00 (4.54 – 30.00)	30.00 (4.11 - 30.00)	0.145
Condition 3: Open eyes and foam surface	30.00 (0.60 – 30.00)	30.00 (0.00 - 30.00)	0.852
Condition 4: Blindfold and foam surface	8.83 (0.10 - 30.00)	16.71 (0.00 - 30.00)	0.710

CDR - Clinical Dementia Rating scale; CTSIB – Clinical Test of Sensory Interaction and Balance. p-value - Mann-Whitney test. Source: Authors.

4. Discussion

Functional mobility was more affected during cognitive-motor tasks and worse in CDR2 than in CDR1. Fujisawa et al. (2017) observed that patients with moderate AD spent more time to complete the TUGT single-task than patients with normal cognition, mild cognitive decline, and mild AD. We also observed differences between groups in time to complete the test and number of steps in the TUGT single-task. Older adults with AD have a high fall risk, which can be reliably screened using TUGT (Allali & Verghese, 2020; Allali, et al., 2017; Ansai, Andrade & Rossi, et al., 2017; Borges, et al., 2015; Cruz, et al., 2015; Dyer, et al., 2020; Kato-Narita & Radanovic, 2009). We found a higher time to complete the test than previous studies (Alexandre, et al., 2012; Ansai, et al., 2019). Alexandre et al. (2012) and Ansai et al. (2019) presented a TUGT cutoff point of 12.47 and 17.56 seconds, respectively, for Brazilian older adults with AD. Patients with CDR2 completed the TUGT with median times above these cutoff points (Ansai, et al., 2019; Bortoli, et al., 2015; Podsiadlo & Richardson, 1991).

Dual tasks require more planning, increasing the cognitive demand in different brain areas. A systematic review (Muir-Hunter & Wittwer, 2016) showed strong associations between gait in dual tasks and fall risk in older adults, although prospective studies did not observe this association. Data on dual tasks corroborate literature (Montero-Odasso, et al., 2012) and demonstrate how they may influence gait speed and cadence of older adults. Our data also indicated different functional mobility among CDR stages due to the influence of cognition on motor processes. Ansai et al. (2017) observed that patients with AD performed more stops and mistakes during dual-task TUGT and had a shorter cadence and poorer motor and cognitive performance than other groups. Other studies found that dual tasks predict falls in older adults with mild cognitive decline but not with mild AD (Ansai, Andrade & Masse, et al., 2017; Gonçalves, et al., 2018).

Using the Berg Balance Scale, Kato-Narita et al. (2011) identified a worse postural balance in older adults with moderate AD than in control groups. This corroborated our findings since the loss of functional capacity was associated with deficits in postural balance and falls. Unlike Kato-Narita et al. (2011), we assessed postural balance using the CTSIB, which required less cognitive demands. However, it failed to distinguish postural balance deficits between groups, probably due to the similar motor dysfunction among AD stages. Differences in TUGT may be related to the required cognitive demand since it is reduced in patients with AD (Nietzsche, et al., 2015). To our knowledge, no prospective studies analyzed postural balance in this population using CTSIB, which may be less influenced by cognitive biases than the Berg Balance Scale.

The primary motor cortex and mesencephalic locomotor regions contribute to gait and postural control (Demain, et al., 2013); thus, cognitive processes are involved in the control of static and dynamic postural balance and functional mobility (Maki & Mclroy, 2007). Also, the neurodegenerative process of AD and advanced age may slow postural correction, which is needed to maintain the stability during dynamic tasks and anticipate postural adjustments after changes in surfaces (Borel & Alescio-Lautier, 2014; Maki & Mclroy, 2000). In addition, the division of attention needed during dual tasks generates greater impairment than in static postural balance.

Cadence refers to the number and regularity of steps per minute. De Melo et al. (2019) observed significant differences in cadence between older adults with AD and mild cognitive decline, suggesting the interference of executive functions and cognition in gait performance and mobility. Dyer et al. (2020) found that slow gait speed was associated with cognitive decline and increased fall risk. Their results confirmed the reduced cadence found in CDR2 and reinforced the importance of gait analysis to predict falls in patients with AD.

This study is not free of limitations. The relatively small number of patients and the study design hampered analyzing whether functional mobility deficit was the main contributor to TUGT performance, which involves cognition (e.g., executive functions) and requires patients to process instructions associated with the tasks. Nevertheless, this is the first study comparing functional mobility and postural balance between patients with mild and moderate AD using dynamic and static postural balance

tests. Longitudinal studies are recommended to understand the influence of balance postural and functional mobility on TUGT performance.

5. Conclusion

Functional mobility differed between older adults with mild and moderate dementia; the difference was more evident during dual tasks, probably due to high cognitive demand. Thus, major cognitive decline (i.e., CDR2) may affect gait and functional mobility due to executive dysfunction.

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