

Functional mobility and executive function in elderly diabetics and non-diabetics*

Mobilidade funcional e função executiva em idosos diabéticos e não diabéticos*

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Abstract

Background: Elderly diabetics tend to show cognitive deficits related to more complex processes such as the executive function, which can lead to a greater risk of falls. **Objectives:** The aims of this study were to compare the functional mobility, the risk of falls and the executive function among elderly with and without type 2 diabetes, and to check the correlation between these variables. **Methods:** Forty community elderly participated in the study and were divided into two groups: G1 elderly with type 2 diabetes and G2 elderly without diabetes, being the variables age, body mass index and gender similar between the groups. The functional mobility and the risk of falls were assessed by the "Timed Up and Go" test (TUG and cognitive TUG) and the executive function was assessed by the Verbal Fluency Test (VFT) (animal category). **Results:** Elderly with diabetes showed worse performance in the verbal fluency test (G1:14.9±4.5; G2:17.7±5.6; p=0.031). A statistically between-group difference was observed regarding the functional mobility; being the G1 presenting worse performance in TUG (G1:10.5±1.8sec; G2:8.9±1.9sec; p=0.01) and cognitive TUG (G1:13.9±3.2sec; G2:10.9±2.3sec; p=0.004) tests. A significant correlation was observed between the cognitive TUG and VFT only in G1 (G1: Spearman's rho = -0.535; p=0.015; G2: Spearman's rho =-0.250; p=0.288). **Conclusions:** Diabetics presented worse performance in the functional mobility and in the verbal fluency test than non-diabetics elderly that suggests a greater risk of falls for the elderly with diabetes. The inclusion of these evaluation parameters for diabetics on the physical therapy clinical practice is crucial in order to maintain the functionality and to prevent falls.

Key words: diabetes Mellitus; accidental falls; cognition; mobility limitation.

Resumo

Contextualização: Idosos diabéticos tendem a ter declínio da funcionalidade motora e a apresentar déficits cognitivos relacionados a processos mais complexos, como a função executiva, o que pode levar a um maior risco de quedas. **Objetivos:** Comparar idosos com e sem diabetes tipo 2 quanto à mobilidade funcional, ao risco de quedas e à função executiva e verificar a correlação entre essas variáveis. **Métodos:** Participaram do estudo 40 idosos da comunidade, divididos em dois grupos: G1, idosos com diabetes tipo 2 e G2, idosos sem diabetes, sendo os grupos semelhantes quanto ao gênero, idade e índice de massa corporal. A mobilidade funcional e o risco de quedas foram avaliados pelo *Timed Up and Go* (TUG e TUG_{cognitivo}), e a função executiva, pelo teste de fluência verbal (categoria animal). **Resultados:** Os diabéticos apresentaram pior desempenho no teste de fluência verbal (G1:14,9±4,5; G2:17,7±5,6; p=0,031). Uma diferença estatisticamente significativa foi observada entre os grupos em relação à mobilidade funcional, sendo que o G1 apresentou pior desempenho no TUG (G1:10,5±1,8s; G2:8,9±1,9s; p=0,01) e noTUG_{cognitivo} (G1:13,9±3,2s; G2:10,9±2,3s; p=0,004). Uma correlação significativa foi observada entre o TUG_{cognitivo} e o teste de fluência verbal apenas no G1 (G1: Spearman's rho = -0,535; p=0,015; G2: Spearman's rho = -0,250; p=0,288). **Conclusões:** Os diabéticos apresentaram um pior desempenho nos testes de mobilidade funcional e de fluência verbal que os idosos sem a doença, sugerindo um maior risco de quedas para idosos diabéticos. A inclusão desses parâmetros de avaliação para diabéticos na prática clínica da fisioterapia é fundamental para preservar a funcionalidade e evitar quedas.

Palavras-chave: diabetes *mellitus*; acidentes por quedas; cognição; limitação da mobilidade.

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Introduction

The growth of the elderly population is a phenomenon observed in most countries including Brazil¹. Ageing is a physiological and dynamic process, where changes in the ability of homeostatic adaptation occur and thereby eliminate some of the stages of postural control, leading to an increased instability. However, ageing associated to a disease such as diabetes *mellitus* progressively leads the individual to further damage^{2,3}. Diabetes *mellitus* is a syndrome of multiple etiologies, resulting from the lack of insulin and/or the inability of this hormone to properly exert its effects, which may lead to the development of associated diseases and complications such as retinopathy, nephropathy, peripheral neuropathy, loss of joint mobility and muscle strength⁴. Moreover, cognitive function also seems to become altered in individuals with diabetes *mellitus*⁵.

It is estimated that by 2025, the world population of diabetics will double when compared to the existing number of diabetics in 2000 (from 150 million to 300 million)⁶. Elderly with type 2 diabetes *mellitus* are more likely to present some cognitive deficits when compared to those without this disease⁷. Alongside the structural and functional modifications in the central nervous system that occur due to the ageing process, the cortical and sub cortical structures may undergo additional alterations due to changes in metabolism. Evidence suggests that learning and memory deficits in those individuals may be due to a synergist interaction between changes in metabolism related to diabetes, in which changes in the blood glucose levels rapidly affect brain function, and structural and functional changes that occur in the central nervous system due to normal ageing process⁸. Nevertheless, these cognitive deficits are probably limited to more complex processes that are directly related to the frontal lobe as the executive function, which refers to the ability to plan strategies for solving problems and for the implementation of goals^{9,10}.

In many activities of daily living, people need to take more than one task simultaneously, such as walking while communicating with other people. Thus, a cognitive impairment while performing a dual task can be an important indicator of functional status of a patient with diabetes *mellitus*. When two tasks are simultaneously executed, the performance of one or both tasks may be reduced. The dual task often involves simultaneous visual spatial and verbal information that are known as executive function¹¹. Changes in this function are related to a greater risk of falls¹².

As the performance of concurrent tasks is complex, this could lead to a deficit in postural stability and even during the performance of relatively simple cognitive tasks by influencing the balance¹³⁻¹⁵. Thus, the combined assessment of balance and cognition tasks in elderly becomes of great importance,

since most falls in this population occurs during activities in which attention needs to be divided¹⁶. Moreover, the restriction of functional mobility of the elderly can decrease their social interaction and interfere in their self-esteem and in their sense of well-being. To preserve gait and mobility in elderly is a major target of physical therapy intervention. Hence, the objectives of this study were: 1) to compare the mobility, the performance in dual task and the executive function among elderly with and without diabetes; 2) to verify the association between the diabetes diagnosis time, glycemic value and the number of correct mathematical accounts done during the Timed Up and Go test (cognitive TUG) with the time of performance of functional mobility tests and 3) to investigate the correlation between the performance on the verbal fluency and dual task tests.

Methods

This is a cross-sectional, exploratory research design with a convenience sample of community-dwelling elderly with and without diabetes. Ethical approval was obtained from the Centro Universitário de Belo Horizonte (UNIBH) - Belo Horizonte, MG, Brazil Ethics Committee (021/2008).

Volunteers were contacted by telephone, and were informed about proper time and date for data collection. Drawing lots randomly established the order of application of the tests, and no dropouts occurred. All participants were informed about the aims and the procedures of the study and signed an informed consent form prior to the beginning of data collection.

A total of 40 elderly were recruited to the study and divided into two groups: G1, formed by 20 elderly with a medical diagnosis of type 2 diabetes *mellitus* and G2, formed by 20 elderly without clinical diagnosis of diabetes *mellitus*. The following inclusion criteria were used: elderly diabetics clinically classified as type 2, aged greater than or equal to 60 years, diabetes diagnosis time equal or greater than 6 years, independent gait, without gender, social class, color or ethnic group restrictions.

Exclusion criteria were: blood sugar levels higher than or equal to 200 mg/dl at the time of the data collection, presence of neurological diseases (except for diabetic peripheral neuropathy), visual deficits not compatible with correction by lenses, a limp, orthotic or prosthetic devices in lower limbs, lower limb amputation or surgery, active plantar ulcers, active seniors (physical activity three times a week or 150 minutes weekly) and presence of cognitive impairment detectable with the Mini-Mental State Examination¹⁷.

Socio-demographic data and the information on the clinical conditions of the participants were obtained by using a standardized questionnaire that was applied by a previously trained examiner for characterization of the sample.

The executive function was verified by the Verbal Fluency Test – animal category. This method assesses the ability to search and retrieve data based on long-term memory, which requires organization skills, self-regulation and operational memory¹⁸. To perform the test, patients were asked: “You must tell all the names of animals you can think of, as soon as possible. Any type of animal is valid: insets, birds, fishes, wild/jungle animals, and pets. The more you tell, the better. Go ahead”. The score is given by the number of correct answers obtained in one minute, considering a few observations: ox and cow are considered two animals, female and male cat are considered as one. For this semantic category, individuals without impairments, with minimum eight years of schooling, are capable of evoking at least 13 animals, while individuals without impairments, but with less than eight years of schooling, evoke at least 9.

Risk of falls was assessed by two tests with reliability recognized by the literature named TUG (ICC=0.98) and cognitive TUG, which is associated to a cognitive task (ICC=0.99)¹⁸. TUG is a balance test commonly used to examine functional mobility in elderly. The time taken to complete the test is strongly associated to the level of functional ability. Independent elderly with no changes in balance perform the test within 10 seconds. Elderly who are independent in transfers take 20 seconds or less to complete it. Those who take more than 20 seconds to perform the test are dependent for mobility and for many activities of daily living. This latter value indicates the need for proper intervention. A time superior to 14 seconds indicates high risk of falls¹⁹.

For TUG performance, we used an armchair, with seat height on average of 46 cm, a stopwatch and cards for writing the results. We also asked participants to wear their regular footwear²⁰. Before starting the test, participants received information about test execution, which started after the verbal instruction “Go” was given. In the early timing, participant was sitting in the chair with their back supported on its back and their feet in parallel to the ground. Later, participant stood up from the chair, walked a 3 meters distance away from it and walked back to the chair in the shortest time possible. Participants were allowed to perform the test twice, being the first attempt meant only for learning purposes (help from another person was not allowed during the test).

The cognitive TUG was performed using the same parameters as the TUG. However the participant was required to answer a mathematical operation of subtraction, performed by the examiner, from numbers 100 up to 20, always subtracting three, in a random manner¹⁹. Participants were not reported whether their answers were correct or not during the test.

A secondary task has a negative effect on mobility, thus the influence of the attention demands on elderly mobility can be

determined. Time for completion of cognitive TUG increases from 22 to 25% of the TUG time, considering the cut-off time of 15 seconds, with 93% specificity. It is noted that TUG and cognitive TUG tests are equally sensitive in assessing the risk of falls¹⁹.

Descriptive statistical analysis was used for all clinical and demographic variables. The Mann-Whitney test was used to compare the following variables between G1 and G2: age, body mass index (BMI) performance on TUG and cognitive TUG, and the number of correct accounts obtained during the cognitive TUG. The proportion of genders between groups was compared by means of the Fisher’s exact test for equality of two proportions.

The possible influence of the variables diabetes *mellitus* diagnosis time, capillary glycemia and number of correct accounts obtained during the cognitive TUG on the variable time of the mobility tests performance was verified by simple regression analysis. The non-parametric Spearman Rank Correlation test was undertaken in order to verify the presence of correlation between the elderly performance on VFT and cognitive TUG. Statistical analyses were performed using Minitab software (version 15, 2007), and alpha level was set at 0.05.

Results : : : .

Demographic, social and clinical characteristics of the 20 elderly diabetics (G1) and the 20 elderly non-diabetics (G2) are shown on Table 1. There were no between-group differences for age, BMI and gender.

The participant’s performance for both TUG and cognitive TUG tests is shown on Table 2. Statistically significant between-group differences were observed for both TUG ($p=0.0186$) and cognitive TUG ($p=0.0043$) performance. Elderly with diabetes *mellitus* showed a worse performance in both tests compared with elderly without diabetes, i.e., they required more time to accomplish the tests.

The variables diabetes diagnosis time and glycemic value did not influence the outcomes of TUG and cognitive TUG ($p>0.05$) for G1. The number of correct accounts obtained during the course of cognitive TUG did not affect the time of mobility tests performance in either G1 or G2.

A statistically significant between-group difference was observed for the VFT performance ($p=0.031$). Elderly with diabetes *mellitus* demonstrated a smaller number of correct evocations (14 ± 4.4997 animals) in comparison to elderly without diabetes (17.7 ± 5.6948 animals).

A moderate and negative correlation was found between cognitive TUG and VFT tests for G1 (Spearman’s rho = -0.535;

p=0.015), but not for G2 (Spearman's rho = -0.250; p=0.288). The comparison of elderly participants' performance among the three tests is represented on Figure 1.

Discussion

The type 2 diabetes *mellitus* is related to significant reductions in psychomotor efficiency of the individual, with a decrease of postural balance, leading to a slower and unstable gait^{13,21}. Evidence also suggests a strong association between psychomotor deficits and cognitive impairment in diabetics, particularly in people aged over 65 years^{13,21}.

The main conclusions of this cross-sectional study are that elderly with diabetes presented worse performance in both functional mobility and dual task (functional mobility associated with executive function) tests than non-diabetic elderly when age, gender and BMI were matched, suggesting a greater risk of falls for elderly diabetic patients.

Findings of the present study showed that the elderly diabetic group demonstrated an inferior performance in the TUG, showing a reduction of mobility and an increased risk of falls compared to the group of elderly without diabetes. Similar results were found regarding the execution of cognitive TUG and VFT, indicating deficits on performance of dual task and executive function in elderly with diabetes. These results endorse the relationship

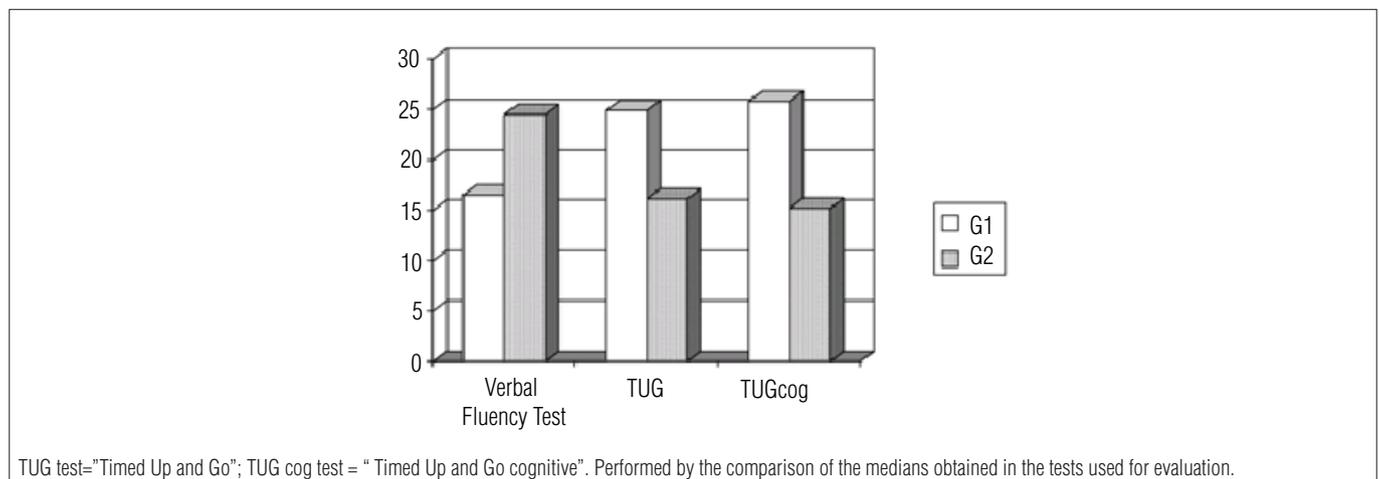
Table 1. Socio-demographic and clinical characteristics.

Variable	Group 1 n=20	Group 2 n=20	p-value
Age (yr), mean (SD)	71.0 (7.6)	68.4 (7.4)	0.31
Feminine, number (%)			
Masculine, number (%)	17 (85)	16 (80)	0.67
BMI (kg/m ²), mean (SD)	3 (15)	4 (20)	0.67
Pre - existing diseases, mean (SD)	26.35 (5.018)	26.85 (5.896)	0.80
Capillary glycemia (mg/dl), mean (SD)	0.80 (0.410)	0.80 (0.882)	
Diagnosis time (yr)	151.75 (58.019)		
Schooling or school years (yr)	9.53 (4.587)		
Leisure activities	4 a 14	4 a 15	
2 to 4 times a month (%)	95	75	

Nas variáveis categóricas (gênero e atividades de lazer) – percentagem; nas variáveis contínuas (idade, doenças prévias, glicemia, tempo de diagnóstico e IMC) – média e desvio-padrão; tempo de escolaridade: mínimo e máximo. IMC=índice de massa corpórea; Variáveis idade e IMC = teste Mann-Whitney; variável gênero = teste z para duas proporções.

Table 2. Performance on TUG and cognitive TUG.

Elderly group	Tests of Mobility					
	TUG			Cognitive TUG		
	Mean (SD)	<10 sec	>20 sec	Mean (SD)	<10 sec	>20 sec
Grupo 1	10.46 s	13 (65%)	7 (35%)	13.97 s	13 (65%)	19 (95%)
Grupo 2	8.95 s	17 (85%)	3 (15%)	10.95 s	7 (35%)	1 (5%)
		(p=0.0186)			(p=0.0043)	



TUG test="Timed Up and Go"; TUG cog test = " Timed Up and Go cognitive". Performed by the comparison of the medians obtained in the tests used for evaluation.

Figure 1. Comparison of the elderly subjects' performance in all three tests used for evaluation by Mann-Whitney test.

between alterations in executive function, mobility and increased risk of falls in this group of patients^{13,15,21,22}.

Asimakopoulou and Hampson²² showed that elderly with diabetes *mellitus* demonstrated a significant loss in performing more complex tasks, such as the dual task, as assessed by Munshi et al.¹⁰. This may occur because the full attention capacity is exceeded, with a reduction on the neural input leading to longer response time. However, these findings contrast with other investigations that did not verify significant changes during the execution of the tests by elderly diabetics, including the dual task^{23,24}.

Elderly without diabetes *mellitus* demonstrated a better performance on the verbal fluency test than those with diabetes. The verbal fluency test is directly related to executive function, which is linked to the frontal lobe. According to a few studies, this is the most affected area by diabetes *mellitus*, where a cortical atrophy may occur²¹, strongly predisposing patients to falls²⁵.

Moreover, Ble et al.²⁶ state that there is an association between glycemic control and cognitive function. Neuroimaging studies demonstrated alterations in the brain stem, suggesting that a chronic hyperglycemia may contribute to the development of organic brain dysfunction, manifested as an overall reduction in mental efficiency²⁷. The chronic hyperglycemia in type 2 diabetes *mellitus* patients significantly damages the velocity of information processing such as working memory and some aspects of attention²⁸. Alterations in the information processing also occur during acute hyperglycemia, as well as increases sadness and anxiety, which may affect the executive function of the individual. However, the mean capillary glycemia was 151.75 mg/dl for the diabetic elderly group, remaining below the value considered as acute (superior to 200 mg/dl)²⁹.

Another important finding was the correlation between cognitive TUG and VFT tests in elderly with diabetes *mellitus* demonstrated that alterations in the executive function can affect mobility, influencing the risk of falls. Thus, including assessment tools such as the dual task is important, as it allows the investigation of other issues related to information processing, attention and mobility being useful in predicting the risk of falls and/or the evaluation of possible interventions³⁰.

Both groups were similar with regards to age, gender and BMI. Although these variables may affect performance in physical

mobility tests, the influence of these factors can be excluded from the alterations observed in the present study. Rosa et al.³¹ observed an association between risk of falls and socio-demographic aspects such as schooling and leisure activities. The schooling levels and leisure activities were also similar in both groups.

Despite of the important findings observed in this study some limitations of the present study must be acknowledged. Firstly, the use of a convenience sample limits the study external validity, preventing the results to be generalized. Secondly, the cross-sectional design does not permit casual inferences about the relationship between researched variables. Another point to be considered is that the occurrence of chronic hyperglycemia, which is an important factor that influences the executive function, was not investigated because it requires more complex laboratory exams, has larger costs and also required monitor participants for a period of time. Therefore, future studies that investigate chronic hyperglycemia are important for a better understanding of its effects on the functionality of elderly with diabetes.

This research demonstrated that elderly with diabetes had poorer performance in mobility, dual task and cognitive function, suggesting a greater risk of falls for these individuals compared to elderly without diabetes. The observed correlation between VFT and dual task performance (cognitive task) indicates that mobility can be affected by changes in executive function. These results along with findings of previous studies, justify the need to include in the assessment of elderly diabetic tests as the dual task test, since they point out to some important aspects related to information processing, attention and functionality.

Besides taking more time to complete both functional mobility and dual task tests and demonstrating poorer performance on the VFT, elderly with diabetes also are more vulnerable to falls. This study also demonstrated that, for alterations in the executive function were associated with performance on both mobility tests (TUG and cognitive TUG). Therefore, analyzing factors that lead elderly with diabetes *mellitus* to a higher risk of falls is of large importance to clinical practice. Including cognitive TUG in assessment can be of great value to raise a trustworthy physical therapy practice in aged care, which seeks mainly to preserve mobility in the elderly, maintain executive function and functionality and reduce the occurrence of falls.

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