

Time up and Go Classic, Manual and Cognitive: Prediction Analysis of the Risk of Falling Physically Active Elderly

Time up and Go Clássico, Manual e Cognitivo: Análise da Predição do Risco de Queda de Idosas Fisicamente Ativas

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Received in: 08/05/2019

Approved in: 28/08/2019

Abstract

Elderly falls affect public health, which justifies the evaluation of their risk. The present study analyzed gait performance of physically active elderly women by means of the test, predicting the risk of falls in this population, as well as determining the levels of sensitivity and specificity of these tests. A quantitative cross-sectional study was carried out with 191 women (67,30±5,13 years), practicing Pilates and water aerobics, divided into fallers and non-fallers groups. The tests applied were the classic Time Up and Go (TUG), its manual version (TUGm) and cognitive (TUGc). A drop rate of 28.8% was found. Participants from both groups did not indicate performance deficits in the evaluation of TUG, TUGm and TUGc ($p \geq 0,05$). According to the logistic regression analysis, the TUG, TUGm and TUGc tests did not explain the occurrence of falls ($p \geq 0,05$). The ROC curve showed an accuracy of 0.520 for TUG ($p=0,673$), 0.517 for TUGm (0.711) and 0.526 for TUGc ($p=0,570$). The cut-off points suggested to determine the risk of falling for TUG, TUGm and TUGc were $\leq 9,95$ sec., $\geq 10,35$ sec. and $\geq 11,30$ sec., respectively. The TUG, TUGm, and TUGc tests showed predictive capacity and low diagnostic accuracy, thus reduced competence to discriminate fallers from non-fallers among physically active elders. Its application is suggested in association with balance tests, lower limb strength and gerontological scales.

Keywords: Accidental Falls. Aged. Physical Fitness.

Resumo

Quedas de idosos incidem em questão de saúde pública, o que justifica a avaliação do seu risco. O presente estudo analisou o desempenho da marcha de idosas fisicamente ativas por meio do teste, predizendo o risco de queda dessa população, além de determinar os níveis de sensibilidade e especificidade desses testes. Estudo transversal quantitativo desenvolvido com 191 mulheres (67,30±5,13 anos) praticantes de Pilates e hidroginástica, divididas em grupo caidor e não-caidor. Os testes aplicados foram o Time Up and Go (TUG) clássico, sua versão manual (TUGm) e cognitiva (TUGc). Verificou-se taxa de queda de 28,8%. Participantes de ambos os grupos não indicaram déficits de desempenho na avaliação do TUG, TUGm e TUGc ($p \geq 0,05$). Segundo a análise de regressão logística, os testes TUG, TUGm e TUGc não explicaram a ocorrência de quedas ($p \geq 0,05$). A curva ROC apontou acurácia de 0,520 para o TUG ($p=0,673$), 0,517 para o TUGm (0,711) e 0,526 para o TUGc ($p=0,570$). Os pontos de corte sugeridos à determinação do risco de queda para o TUG, TUGm e TUGc foram $\leq 9,95$ seg., $\geq 10,35$ seg. e $\geq 11,30$ seg., respectivamente. Os testes TUG, TUGm e TUGc mostraram capacidade preditiva e acurácia diagnóstica baixa, logo reduzida competência para discriminar caidores de não-caidores entre idosas fisicamente ativas. Sugere-se sua aplicação associada à testes de equilíbrio, força de membros inferiores e escalas gerontológicas.

Palavras-chave: Acidentes por Quedas. Idoso. Aptidão Física.

1 Introduction

Over the years, investigations have detailed the relationship between gait disorders and falls in the elderly^{1,2}. Gait is a complex motor ability, composed by the result of cyclical movements of limbs, necessary for the displacement of the body³. Studies of systematic review and meta-analysis showed that changes in the pattern of gait in elderly increases the risk of falling^{1,4}. However, the issue is not fully clarified^{5,6}.

Elderly people walk more slowly, a compensatory strategy², which reduces the amplitude of the step, by increasing the support phase, generating postural instability and possible fall⁷. It is estimated that approximately 30% of the elderly over 65 years fall once a year⁸, which causes

injuries, hospitalization or even death⁹. Fall is considered a multifactorial event, arising out of intrinsic and/or extrinsic factors¹⁰. Therefore, standardized and trustful instruments are needed that offer appropriate evaluations^{10,11}.

A test is often used in the examination of functional mobility of the elderly is the *Team Up and Go* (TUG). The test was developed by Mathias et al.¹² with the purpose of investigating balance disorders. Subsequently, Podsiadlo and Richardson¹³, in research with 60 elderly patients in a geriatric hospital, modified and validated TUG, which received the title of “test to sit and raise”. TUG has good levels of reliability and concurrent validity^{14,15}, it is easy to apply and low cost¹⁶.

However, the specialized literature differs on the best value

on the performance in the TUG to identify elderly fallers. A study conducted with 491 elderly women of the community ($n=413$; 73.2 ± 3.2 years) and institutionalized ($n=78$; 79.4 ± 3.7 years), Bischof et al.¹⁷ suggested the scores ≥ 12 seconds to detect the risk of falling. However, when it comes to elderly practitioners of regular physical exercises, these have, in general, the best level of physical fitness than institutionalized elderly. For this reason, the specialized literature questioned the cut-off point of the ideal TUG to detect the risk of fall of physically active elderly practitioners¹⁵. Because depending on the assumed value, this may not be sufficiently sensitive to distinguish non-fallers from fallers¹⁸.

Experimental study¹⁹, systematic review²⁰ and meta-analysis²¹ recommended the examination of gait also on condition of multitasking, because the decline in the cognitive ability influences the pattern of gait^{22,23}. Lundin-Olsson et al.²⁴ investigated the effect of multiple tasks on the balance, mobility and falls in institutionalized elderly, adding to TUG a manual task (TUGm). The authors found that elderly patients with time difference greater than 4.5 seconds between TUGm and the conventional TUG showed, after six months, greater propensity to fall.

Shumway-Cook et al.¹¹ investigated 30 elderly people in the community (65-85 years) with and without a history of falls. The authors found that levels of sensitivity and specificity for the conventional TUG of 80% and 100%, suggesting the cutoff point ≥ 13.5 seconds. In the case of TUGm, the authors found 86% of sensitivity and 93.3% of specificity, as well as a cut-off point of ≥ 14.5 seconds. This study included a third test, the cognitive TUG (TUGc). The value of sensitivity observed for the TUGc was 80%, specificity 93.3% and a cutoff point ≥ 15.0 seconds. As it is realized, the cut-off values suggested to the identification of the risk of falling in the elderly differ from study to study. According to Bohannon²⁵, despite the test TUG to be widely used in the clinical area there is a lack of definitive normative reference values for the different populations of elderly people.

The objective of this study was to analyze the performance of gait in elderly women regular practitioners of physical exercises by tests TUG, TUGm and TUGc, predicting the risk of falls in this population, as well as determining levels of sensitivity and specificity for the tests.

2 Material and Methods

It is a quantitative transversal study. The sample size calculation was performed *a posteriori* by the software G*Power 3, taking as a basis: 1) study design; 2) 191 participants, divided in G1: individuals with a history of falls ($n=55$) and G2: individuals without history of falls ($n=136$); 3) The rate of type I error of 5% ($\alpha=0.05$); 3) moderate effect size (0.50), which resulted in a statistical power of 87% ($1-\beta=0.87$). The studied population was composed by 191 women (67.30 ± 5.13 years), divided into faller group ($n=55$) and non-

faller group ($n=136$). The design of the groups was based on previous studies^{3,7,18}. The participants were recruited from two groups of the Pilates method of an extension program, and (ii) practitioners of the water aerobics. The groups trained twice a week (60 minutes per section). The activities took place at the premises of Federal University of Vale do São Francisco (UNIVASF), located in the city of Petrolina-PE. The exercises were taught by students of the Physical Education course under the supervision of university professors with formation in their respective areas.

As inclusion criterion age between 60-79 years was adopted, minimum time of six months of practice of Pilates/aerobics, having 75% of attendance in the activities, not presenting muscle injury, joint or bone in the evaluation period, in addition to neurological diseases such as Parkinson's disease or stroke. Those that did not complete all the investigation steps did not sign the Informed Consent Form (ICF) were excluded. The study was approved by the Human Research Ethics Committee of Federal University of Vale do São Francisco (CAAE: 72954317.0.0000.5196).

2.1 Procedures for collection

Two trained evaluators were responsible for data collection. The procedures occurred between March 2016 and June 2016, in reserved environment, after the participants signed the Informed Consent Form. The procedures applied were the following:

I- Questionnaire: i) the degree of schooling, self-report on falls (last 12 months), comorbidities, daily consumption of types of medicines; ii) the classification of the physical activity level by means of questions about: a) resolution of activities of daily living (ADL), b) time of practice of Pilates or water aerobics;

II- anthropometric data: body mass and height were determined by means of a mechanical balance, up to 300 Kg Welmy (Brazil), with anthropometric ruler of scale up to 2 meters. The Body Mass Index (BMI) was established by the formula: weight (kg)/height(m²). The classification of health status assumed cutoff points of Lipschitz²⁶: low weight (BMI<22 kg/m²), eutrophy (BMI 22 kg/m² 27 kg/m²) and excess weight (BMI>27 kg/m²);

III- Mini Mental State Examination (MMSE): used for the examination of cognitive function and possible cases of dementia. The adopted cut-off point was Brucki et al.²⁷: up to 20 points (illiterate), 25 points (1-4 years of schooling), 26.5 points (5-8 years of schooling), 28 points (9-11 years of schooling) and 29 points (schooling >11 years);

IV- Performance of gait:

Team Up and Go, Classic version (TUG)^{17,28}: the participants were asked to sit and stand up from a chair of 45 cm in height, with support for the arms, then walk 3 meters, make a 180° turn into a cone, return to the chair and sit down. The cut-off point used for the risk of falling was suggested by

Podsiadlo and Richardson¹³: performance ≤ 10 seconds;

b) *Team Up and Go* manual (TUGm)²⁹, the participants performed the same gait task of the conventional TUG, however carrying a tray of paper of 25 cm, with the dominant hand. On the tray there was a glass (8 cm in diameter and 9 cm of height), containing water (1cm below the rim). The procedure for evaluation of the performance was identical to that adopted for the conventional TUG. It is considered as a risk to fall the results ≥ 14.5 seconds.

c) *cognitive Team Up and Go* (TUGc)²⁹, its procedures were identical to the conventional TUG. However, the participants were asked to tell, during the gait, in descending order, starting at number 100, subtracting three numbers, without pause. The evaluation of the performance was equal to the procedures applied to the conventional TUG. The result ≥ 15 seconds was considered as a risk to fall.

2.2 Statistical analysis

The data normality was obtained by Shapiro Wilk test. Data regarding age, weight, height, BMI and MMSE were normal, therefore, the comparison between groups was performed by Student's t test (mean and standard deviation). The data of the tests TUG, TUGm and TUGc did not present normal distribution. Thus, the comparison of performance between the faller group and non-faller was calculated using the Mann-Whitney U test (median, maximum/minimum score and confidence intervals (95% CI). The confrontation of comorbidities was examined by the Chi-square test. The logistic regression, model *forward*, was used to calculate the odds ratio of the occurrence of the event of the fall. With the ROC curve (*Receiver Operating Characteristic*) the level of sensitivity and specificity was assessed of the three tests of gait. The determination of the optimal cut-off point was established by the index of Yunden³⁰. The area under the curve was considered as a reference to the quantification of predictive factor, which allowed the discrimination between individuals with and without risk of falling. Its graphical representation was performed by the software "MedCalc statistical" version 13.0. Other data were processed in SPSS, version 24.0. The level of confidence adopted was $\alpha=5\%$.

3 Results and Discussion

Table 1 shows the main characteristics of the assessed population. It was verified the mean age for the faller group 67.12 \pm 5.39 years and 67.25 \pm 5.05 years for those without history of falls. The non-faller elderly presented high weight ($p \geq 0.05$). According to the self-report on the habits of life and comorbidities, it was observed: average of practice of the method Pilates and water aerobics of 13.35 \pm 0.3 months ($p \geq 0.05$), daily consumption of medicines among 1-2 types ($p \geq 0.05$) and rate of fall of 28.8% in the period of 12 months ($p \geq 0.05$). Significant differences were observed for the set of comorbidities: diabetes mellitus and problems related to

the regulating system of postural control: vision, hearing, and labyrinthitis ($p < 0.05$).

Table 1 - Main characteristics of the assessed population

Variables	Fallers (n=55)	Non-Fallers (n=136)	p
Age (years)	67.12 \pm 5.39	67.25 \pm 5.05	0.273
60-69 (f)	22%	94%	-----
70-79 (f)	33%	42%	-----
BMI (Kg/m ²)	26.60 \pm 3.62	30.86 \pm 24.14	0.288
Height (cm)	1.53 \pm 0.70	1.53 \pm 0.52	0.917
Mass (kg)	62.65 \pm 1.00	66.15 \pm 11.93	0.542
Schooling (years)	6.14 \pm 2.10	7.18 \pm 2.6	0.442
MEEM	27.45 \pm 1.52	27.82 \pm 2.12	0.321
Falls (12 months)	3.15 \pm 1.24	-----	-----
Types of Medicines (f)	1.88 \pm 1.33	1.69 \pm 1.76	0.424
Practice exercise (months)	12.50 \pm 0.6	14.20 \pm 0.2	0.248
Comorbidities			
Diabetes mellitus			<0.001 [†]
Yes (f)	14.7%	14.2%	
No (f)	86.3%	86.8%	
Hypertension			0.225
Yes (f)	52.8%	55.7%	
No (f)	47.2%	44.1%	
Vision			<0.001 [†]
Yes (f)	75.8%	72.2%	
No (f)	24.2%	27.8%	
Hearing			<0.001 [†]
Yes (f)	29.8%	9.1%	
No (f)	70.2%	90.9%	
Labyrinthitis			<0.001 [†]
Yes (f)	26.0%	23.4%	
No (f)	74.0%	76.6%	

Legend: frequency (f); kg = kilograms; cm= centimeters; BMI = body mass index; kg/m²=kilograms/square meter; MMSE= Mini Mental State Examination; $p \leq 0.05$ = t Student; [†] $p \leq 0.05$ =Chi-Square test.

Source: Research Data.

In Table 2 the performance of participants in the tests of mobility is presented (TUG, TUm and TUGc). Comparatively, it was found that elderly woman individuals without history of falls were faster than fallers. In addition, there were no significant differences between the groups for the gear on the condition of simple task - TUG ($Z = -1.000$; $p > 0.05$), manual task - TUGm ($Z = -1.034$; $p > 0.05$) and cognitive task - TUGc ($Z = -0.731$; $p > 0.05$).

Table 2 - average results of performance tests of gear for the faller group and non-faller group

Variable	Median (95% CI)	V. min-V. max	Z	p
TUG (sec).			-1.000	0.920
G1 (n=55)	9.77 (9.47-10.43)	6.31 – 16.20		
G2 (n=136)	9.21 (9.16-9.79)	5.83 – 16.62		
TUGm (sec).			-1.034	0.301

G1 (n=55)	9.91 (9.81-10.89)	7.00 – 15.73		
G2 (n=136)	9.65 (9.71-10.37)	6.62 – 17.44		
TUGm (sec.)			-.731	0.465
G1 (n=55)	10.49 (10.46-12.15)	7.59 – 19.83		
G2 (n=136)	10.60 (10.49-11.52)	6.28 – 18.32		

Legend: TUG: *Time Up and Go* (classic); TUGm: *Time Up and Go* (manual); TUGc: *Team Up and Go* (cognitive); Sec: seconds; CI 95%: Confidence interval; V. min.: Minimum value; V. Max.: Maximum value; Z: The Z-score (*Mann Whitney test*); p< 0.05.

Source: Research Data.

Table 3 presents the results of the binary logistic regression, used to estimate the risk of falling. A statistically significant model was obtained, showing there is an association between falls and the performance of gait [$X^2(3)= 3.618$; $p>0.05$, $R^2= 0.027$]. On the other hand, when it was proceeded with the analysis of the tests TUG, TUGm and TUGc the confrontation between fallers and non-fallers, statistically significant results were not verified ($p \geq 0.05$).

Table 3 - Results for logistic regression analysis of the population assessed

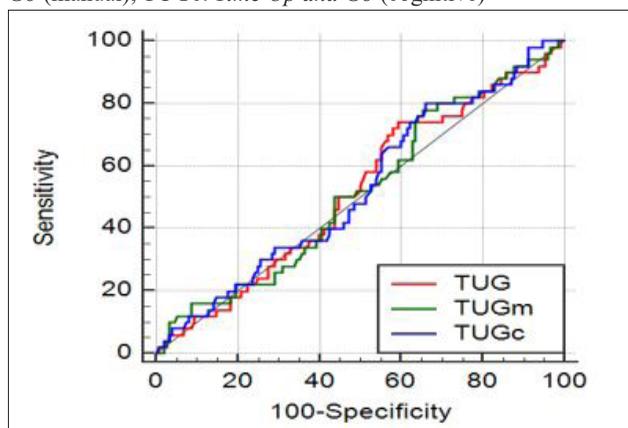
Variable	Cut-off point	B	OR	IC95%	p
TUG (sec.)	9.95	0.800	2.226	0.867-5.714	0.096
TUGm (sec.)	10.35	0.493	0.611	0.237-1.573	0.307
TUGc (sec.)	11.30	0.119	1.127	0.495-2.565	0.777

Legend: TUG: *Time Up and Go* (classic); TUGm: *Time Up and Go* (manual); TUGc: *Time Up and Go* (manual); B: Logistic coefficient; OR: *Odds Ratio* for falls; CI 95%: Confidence interval (*Hazard Ratio*); p=0.05.

Source: Research Data.

The ROC curve determined the level of accuracy of the tests TUG, TUGm and TUGc to predict the risk of falling in the elderly practitioners of regular physical exercises (Figure 1).

Figure 1 - ROC curve, results of the comparison of the performance of the population evaluated, according to the levels of sensitivity and specificity to the determination of the risk of fall (95% CI). TUG: *Time Up and Go* (classic); TUGm: *Time Up and Go* (manual); TUGc: *Time Up and Go* (cognitive)



Source: Research Data.

The area presented to TUG below the curve was 0.520

(IC 95%: 0.448-0.591; $p=0.673$), followed by the level of sensitivity of 74% and specificity of 40.05%. The cut-off point suggested to the determination of the risk of fall was ≤ 9.95 seconds. The examination of TUGm indicated accuracy below 0.517 (CI 95%: 0.445-0.585; $p=0.711$), with 78% sensitivity and 34.5% of specificity. The score point recommended to the identification of fallers was ≥ 10.35 seconds. The TUGc analysis presented area below the ROC curve of 0.526 (IC 95%: 0.454-0.598; $p=0.570$), sensitivity of 80% and 33.8% of specificity. The cut-off point suggested to fallers was performance ≥ 11.30 seconds.

The specialized literature describes that the rate of fallers elderly of the community is approximately 30%⁸. In the present study, 28.8% of the participants showed falls in the last 12 months. The finding is representative, because it corroborates with the international literature. On the other hand, the rate of 28.8% found in the city of Petrolina-PE was higher than the value of 22.2% recorded in Santa Catarina among 230 elderly practitioners of Gymnastics (69.08±6.10 years)³¹.

Furthermore, the rate of falls observed corroborated with the systematic review of Curry et al.³¹, which included 17 studies (period of 2000 and 2011, totaling 114,911 septuagenarian individuals of the community with different levels of physical activity, from seven countries (Brazil, Italy, Spain, China, the United States, Turkey and Nigeria). These authors found 28.50% of prevalence of fall. The findings of the present study pointed to the importance of the development of measures for the prevention of falls by the elderly population of the city of Petrolina-PE.

According to the norms of the three tests TUG, risk of falls was not observed among the participants of both groups ($p \geq 0.05$)^{11,13}. However, comparatively, elderly female individuals without history of falls showed better performance indices. This result confirmed previous investigations, that described the fall as a multifactorial event^{1,8}, thus, the fact cannot be predicted solely by a single variable (gear) or even identified by a single test or instrument¹⁹⁻²¹. This means that extrinsic factors such as lighting, the paving of environments, the postural control, the fear of falling and confidence in balance may have contributed to previous falls among the population assessed.

Other potentiating factor of the fall of the elderly are the comorbidities. In this study, the population assessed showed statistically significant differences ($p < 0.05$) for vision, hearing, and labyrinthitis. Deficits in these capabilities may change considerably the sensory exceptory and interoceptive regulation of static and dynamic balance¹¹. Based on the results of the MMSE, it was found that both groups showed preserved cognitive performance ($p \geq 0.05$). This result attested to the fact that there are biases in relation to cognitive capacity of the participants.

An interesting finding was the significance indicated by binary regression model ($p < 0.05$), which showed that there is

an association between the performance of the gait and falls. This finding corroborated with the specialized literature^{2,11,18}, which associates the slowness of elderly patients with increased risk of falling. On the other hand, the individual analysis of the tests TUG, TUGm and TUGc showed no significant difference ($p \geq 0.05$), which attested to the low degree of sensitivity of tests to detect the risk of fall among the population assessed. The findings confirmed the outcome of the investigation of Virtuoso et al.¹⁸, carried out with 82 physically active elderly, with 19.5% of incidence of falls. According to the authors, there was no association between the occurrence of falls and the results presented by the participants in the examination of the tests TUG and TUGc. For this reason, in the case of physically active elderly, it was suggested the inclusion of other tests and instruments in order to expand and qualify the prediction of the risk of falling.

Following the order of the results, the ROC curve showed levels of accuracy for the tests TUG, TUGm and TUGc, between 51% and 52% (Figure 1). According to specialized literature, so that a test be deemed competent it must present discriminatory value above 75%^{33,34}. This means that values between ≥ 0.5 and ≤ 0.7 indicate marginal accuracy for a tool. Thus, it was concluded that the tests TUG, TUGm and TUGc showed no discriminative capacity to detect the risk of falls among the elderly regular practitioners of physical exercises. The findings corroborate with the outcome of Virtuoso et al.¹⁸, who observed in elderly practitioners of regular exercises accuracy of 65.3% ($p \geq 0.05$) for the classic tug and 58.1% for the TUGc ($p \geq 0.05$). In terms of levels of sensitivity, it was found that for the three tests values between 74-80%, which shows good ability to identify faller individuals, among those considered as such. However, considerably lower levels of specificity, between 33.8 to 40.5%. The interpretation of these values indicates that all three tests showed no scope for discriminating non-faller elderly women individuals, thus increasing the rate of false-positive individuals.

The outcomes presented to the tests TUG, TUGm and TUGc by logistic regression analysis corroborated with the systematic review of Barry et al.³⁵. According to the authors, TUG has the ability to detect the risk of falling, however it was suggested its use in association with tests of balance and strength. The levels of sensitivity and specificity observed in this study for the TUG differed from the outcome of Barry et al.³⁵, who showed low sensitivity value 0.31 (95% CI 0.13-0.57), followed by a high degree of specificity of 0.74 (95% CI 0.52-0.88). Therefore, it was assigned to TUG greater utility to exclude and not to identify the risk of falling. In relation to the cut-off points, the score suggested by statistical analysis to identify fallers was a performance ≥ 9.5 seconds. This result differs from that proposed by Barry et al.³⁵ (>13.5 seconds), however, it should be noted that the population included differs from the population of the present research (physically active elderly).

The ROC curve suggested three new cut-off points to identify the risk of falling. For the classic TUG the proposed value was 10.05 seconds, which is lower than the score adopted initially¹³. For TUGm and TUGc were suggested, respectively, values 3.15 seconds and 3.20 seconds faster than those initially adopted¹¹. Lundin-Olssone et al.²⁴ identified in a sample of frail elderly, that individuals with result ≥ 4.5 seconds in the subtraction between the result of TUG-TUGm tests showed greater susceptibility to fall after 6 months (OR = 4.7, 95% CI 1.5-14.2). The fact was not observed in the present study, given that the difference between the resolution time of the tests TUG and TUGm and TUGc tests was lower than 1.0 second.

3.1 Limitations

The present study has some limitations. First, the participants were not grouped according to the frequency of the events of falls. An explanation for the fact consists of the difficulty presented by the elderly women for dating with accuracy the event of the fall, as well as to classify the type and severity of the event. Given the above, it was decided by the ranking with and without a history of falls. Secondly, the number of faller and non-faller individuals included in the study was not homogeneous, 28.8% and 71.2%, respectively. This may have generated biases in statistical procedures, making it difficult to generalize the results to representative samples.

4 Conclusion

The findings suggested that the tests TUG, TUGm and TUGc have predictive capacity and low diagnostic accuracy to discriminate fallers from non-fallers along the healthy elderly women and regular practitioners of physical exercises. Thus, it is suggested to professionals in the clinical area that if they use all three tests in the examination of the risk of falling to not only pay attention to the choice of the cutting points to be applied, but also to adopt the multifactorial assessment for the examination of the risk of falls. Moreover, further studies are advised that compare the discriminative validity and diagnostic accuracy of the tests TUG, TUGm and TUGc with the physically active elderly population.

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