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ORIGINAL RESEARCH

Can the timed up and go test be used as a predictor of muscle strength in older adults?

O timed up and go test *pode ser utilizado como preditor da força muscular em idosos?*

¿Se puede utilizar la prueba de levantarse y andar como predictora de la fuerza muscular en personas mayores?

Letícia Lopes de Queiroz[1], Leonardo Gomes de Oliveira da Silva[2], Hudson Azevedo Pinheiro[3]

ABSTRACT | This study analyzed the timed up and go test (TUG) as a tool to evaluate muscle strength in community-dwelling older people. As a methodology, an observational, cross-sectional and analytical study was conducted. Data from 442 older people were analyzed, both women (71.7%) and men (28.3%). Ages ranged from 62– 104 years, with a mean of 80.85 (±8.047) years. TUG was used as a tool to evaluate muscle strength. Comparison and correlation analyses were performed to compare performance between the TUG and the chair stand test (CST) and between TUG and handgrip strength (HGS). Analysis of agreement between the diagnosis of low physical performance on TUG and the diagnosis of muscle weakness on CST and HGS was also performed. The predictive values were estimated using the receiver operating characteristic curve. The analyses showed a moderate direct proportional correlation between TUG and CST performance and low inversely proportional correlations between TUG and HGS performance and between CST and HGS (p<0.001). In the accuracy analyses, it was observed that TUG test could predict muscle strength in CST (S 34.4%; PPV 91.5%; NPV 26.1%; AUC=0.779; 95%CI 0.724–0.835; p<0.001) and handgrip dynamometry (S 44.2%; PPV 77.4%; NPV 67.2%; AUC=0.652; 95%CI 0.599–0.705; p<0.001). The Timed Up and Go test was able to satisfactorily indicate individuals with normal muscle strength in CST.

Keywords | Muscle Strength; Aged; Geriatric Assessment; Physical Functional Performance.

RESUMO | Este estudo analisou o uso do *timed up and go test* (TUG) como ferramenta de avaliação da força muscular em idosos da comunidade. Como metodologia, foi realizado um estudo observacional, transversal e analítico. Foram analisados dados de 442 idosos, do sexo feminino (71,7%) e do masculino (28,3%), com idades entre 62 e 104 anos, e média de 80,85 (±8,047) anos. O TUG foi utilizado como instrumento de avaliação da força muscular. Foram realizadas análises de comparação e correlação entre o desempenho no TUG e no teste de sentar e levantar (TSL), e entre o TUG e a força de preensão manual. Também foram realizadas análises de concordância entre diagnóstico de baixo desempenho físico no TUG e diagnóstico de fraqueza muscular no TSL e na força de preensão manual. Os valores preditivos foram traçados por meio da curva *receiver operating characteristic* (ROC). As análises mostraram correlação diretamente proporcional moderada entre o desempenho no TUG e no TSL e correlações inversamente proporcionais baixas entre o desempenho no TUG e a força de preensão manual e entre o TSL e a força de preensão manual (p<0,001). Nas análises de acurácia, observou-se que o TUG apresentou capacidade de prever a força muscular no TSL (S 34,4%; VPP 91,5%; VPN 26,1%; AUC=0,779; 95% IC 0,724-0,835; p<0,001) e na dinamometria de preensão palmar (S 44,2%; VPP 77,4%; VPN 67,2%; AUC=0,652; 95% IC 0,599-0,705; p<0,001). Conclui-se que o TUG apresentou capacidade de indicar de forma satisfatória os indivíduos com força muscular normal no TSL.

Descritores | Força Muscular; Idoso; Avaliação Geriátrica; Desempenho Físico Funcional.

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[1]Secretaria de Saúde do Distrito Federal (SES-DF) – Brasília (DF), Brazil. E-mail: leticialopesqueiroz24@gmail.com. ORCID-0000-0001-9570-0533
[2]Tribunal de Contas do Distrito Federal (TCDF) – Brasília (DF), Brazil. E-mail: leorivals212@gmail.com. ORCID-0000-0002-2062-2347
[3]Secretaria de Saúde do Distrito Federal (SES-DF) – Brasília (DF), Brazil. E-mail: hudsonap@gmail.com. ORCID-0000-0003-1081-4174

Corresponding address: Letícia Lopes de Queiroz – Condomínio Borges Landeiro, Qno 12 Área Especial C, via 04, Bloco E, Apto 1104 – Brasília (DF), Brazil – ZIP Code: 72255-203 – E-mail: leticialopesqueiroz24@gmail.com – Financing source: nothing to declare – Conflict of interests: nothing to declare – Presentation: Nov. 2nd, 2022 – Accepted for publication: Jan. 6th, 2023 – Approved by the Research Ethics Committee: Opinion No. 4,606,038.

RESUMEN | Este estudio analizó el uso de la prueba de levantarse y andar (TUG) como una herramienta para evaluar la fuerza muscular en adultos mayores residentes en la comunidad. Como metodología, se trata de un estudio observacional, transversal y analítico. Se analizaron datos de 442 ancianos, del sexo femenino (71,7%) y masculino (28,3%), de edad de entre 62 y 104 años, y edad media de 80,85 (±8,047) años. El instrumento TUG se utilizó para evaluar la fuerza muscular. Se realizaron análisis de comparación y correlación entre el rendimiento en TUG y en la prueba de sentarse y levantarse (SL), y entre TUG y la fuerza de agarre. También se realizaron análisis de concordancia entre el diagnóstico de bajo rendimiento físico en TUG y el diagnóstico de debilidad muscular en SL y fuerza de agarre. Los valores predictivos se trazaron utilizando la curva *receiver operating characteristic* (ROC). Hubo una correlación directamente proporcional moderada entre el rendimiento de TUG y de SL, y se encontraron correlaciones inversamente proporcionales bajas entre el rendimiento de TUG y la fuerza de agarre, así como entre SL y la fuerza de agarre (p<0,001). En los análisis de precisión se observó que TUG fue capaz de predecir la fuerza muscular en SL (S 34,4%; VPP 91,5%; VPN 26,1%; AUC=0,779; IC 95% 0,724-0,835; p<0,001) y en la dinamometría de agarre (S 44,2%; VPP 77,4%; VPN 67,2%; AUC=0,652; IC 95% 0,599-0,705; p<0,001). Se concluye que TUG fue capaz de indicar satisfactoriamente a los individuos con fuerza muscular normal en SL.
Palabras clave | Fuerza Muscular; Anciano; Evaluación Geriátrica; Rendimiento Físico Funcional.

INTRODUCTION

It is estimated that muscle strength progressively decreases 10%–15% from the fifth to the seventh decades of life[1,2]. This reduction in muscle strength and mass can influence loss of autonomy[3], risk of frailty[4], and sarcopenia[5]. Furthermore, it is known that reductions in muscle strength are more accurate predictors of mortality than changes in muscle mass[6].

With the reduction of muscle strength resulting from aging, the identification of clinical tools to track muscle strength deficits becomes essential for adequate decision-making in health, which aims to prevent disabling injuries that affect the quality of life of older people and the quality of care in health systems[7,8] due to complications that can lead to consequences such as falls, functional limitations[9], hospitalizations, and mortality[6]. Furthermore, this identification allows for diagnostic evaluation[3], detection of specific early clinical interventions[6], and reduction of the costs of health services[3].

In this context, the timed up and go test (TUG) is a reliable tool for evaluating functional mobility, also presenting a significant correlation with the risk of falls, fear of falling, and functional performance[6,10]. However, it is also a possible screening tool for sarcopenia, due to the possibility of evaluating muscle strength and speed in a single test. This use of TUG was analyzed by the study by Filippin et al.[3], in which they reported that the test presented adequate sensitivity (88.9%) to predict sarcopenia in older adults, as well as negative predictive value (93.2%) and a 0.66 area under the receiver operating characteristic (ROC) curve, and can be used as a screening tool.

Corroborating these results, Martinez et al.[6] observed that TUG presented 66.7% sensitivity, 88.7% specificity, and moderate accuracy (0.80; CI=0.66–0.94; p=0.001) for prediction of sarcopenia in older adults. Clegg et al.[11] used TUG as an indirect tool to evaluate muscle strength to stratify volume and training levels in an exercise protocol. Thus, such applications allow for expanding the use of TUG to evaluate muscle strength in older adults.

Therefore, this study aimed to analyze the use of TUG as a tool for assessing muscle strength in community-dwelling older adults, with the hypothesis that TUG would present discriminatory power to evaluate muscle strength.

METHODOLOGY

This is an observational, descriptive, cross-sectional, and analytical study. The data were obtained by the retrospective analysis of the medical records of older adults of a Geriatrics and Gerontology center of the Brazilian Federal District Health Department (SES-DF).

The sample consisted of a database of older adults. Medical records were collected from November 2021 to February 2022. Individuals were older adults (aged ≥60), of both sexes, who could walk independently for at least 10 meters, followed simple verbal commands, and responded to the collection tools, evaluated by the mini-mental state examination (MMSE)[12]. Older adults with severe sequelae of stroke, neurological diseases that prevented testing, needed a wheelchair or were bedridden, as well as those with severe cognitive impairment, evaluated by the clock drawing and verbal fluency tests[13], were excluded.

Sample estimation was performed using the G*Power 3.1 program and indicated the need for a sample of 381 older adults.

Sample characterization was performed based on the following covariates: age, sex, schooling level, marital status, family income, body mass index (BMI), presence of comorbidities, and self-report of falls in the previous six months. TUG was the dependent variable. Handgrip strength (HGS) and the chair stand test (CST) were the independent variables.

TUG was used as a tool to evaluate muscle strength. This test quantifies functional mobility in seconds by standing up from a standardized chair, walking a linear course of three meters, turning, and returning to the chair, sitting down again[3]. The reference points for low physical performance adopted were values ≥20 seconds[14].

HGS was evaluated using the Saehan® dynamometer in the dominant hand of each participant, following the recommendations of the European Consensus on Sarcopenia[15,16], which defines muscle weakness scores <27kg/F for men and <16kg/F for women[14].

CST is used in clinical practice to evaluate strength and resistance of lower limbs as a substitute for leg muscle strength, using the time required for a patient to stand up five times from a sitting position without their arms[14]. In this test, the score for muscle weakness is ≥15 seconds[14].

Statistical analysis

Distribution of numerical data was tested by the Kolmogorov-Smirnov test. The comparisons between older adults with normal and low TUG results were performed using the Mann-Whitney U-test. The associations between the physical performance data in TUG and muscle strength in CST and HGS were analyzed by Spearman's correlation test and interpreted as follows: 0.26–0.49: low correlation; 0.50–0.69: moderate correlation; 0.79–0.89: high correlation; and finally, 0.90–1.00: very high correlation[17].

The agreements between the diagnosis of low physical performance in TUG and muscle weakness in CST and HGS were evaluated using the Kappa statistic. Values ≥80% were considered as excellent agreement; values from 40%–60% were considered as moderate agreement; and values <40% were considered as weak agreement[18]. The number of weak and strong older adults with normal or low physical performance in TUG was obtained for each evaluation tool (CST and HGS). To analyze the accuracy of the tool studied (TUG), sensitivity (S), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV) were estimated. ROC curves were built to verify the capacity of TUG measurements to discriminate strong and weak older adults in CST and HGS and the area below the ROC curve (area under the curve – AUC). Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) program version 22.0 (Franz Faul, Universität Kiel, Germany).

RESULTS

Data from 442 participants were analyzed. Participants had a mean age of 80.85 (±8.047) years, with the majority having a low schooling level – incomplete elementary school (55.4%) – and low income – up to three minimum wages (89.8%). Table 1 shows other sociodemographic and clinical characteristics and the participants' performance with the tools.

Table 1. Sociodemographic and clinical characteristics and test performance

Characteristic	Valid data	Values
Gender, n (%)	442	
Women		317 (71.7)
Men		125 (28.3)
Age (years), mean (SD)	442	80.85 (8.047)
Schooling level	442	
Illiterate		80 (18.1)
Low schooling level		245 (55.4)
Elementary school		47 (10.6)
High school		50 (11.3)
Higher education		20 (4.5)
Income	441	
No income		4 (0.9)
Up to 1 minimum wage		177 (40.1)
2-3 minimum wages		215 (48.8)
4-5 minimum wages		34 (7.7)
≥6 minimum wages		11 (2.5)
BMI (kg/m^2), mean (SD)	427	26.21 (4.95)
History of falls (yes), n (%)	433	167 (38.6)
Marital status	441	
Single		37 (8.4)
Married		178 (40.4)
Divorced		49 (11.1)
Widow/widower		177 (40.1)

(continues)

Table 1. Continuation

Characteristic	Valid data	Values
Comorbidities (presence), n (%)	442	
SAH		362 (81.9)
Cardiopathy		100 (22.6)
Diabetes mellitus		173 (39.1)
Osteoporosis		169 (38.2)
Joint problems		274 (62.0)
Depression		199 (45.0)
Hypothyroidism		66 (14.9)
Cognitive disorder		80 (18.1)
Prostatic hyperplasia		29 (6.6)
Vision problems		58 (13.1)
Femur fracture		8 (1.8)
Respiratory problems		37 (8.4)
Medicines (quantity), median [P25; P75]	442	5 [3; 7]
TUG[a] (low physical performance), n (%)	431	135 (31.3)
median (P25-P75)		15 [12; 21.62]
CST[a] (muscle weakness), n (%)	414	330 (79.7)
median (P25-P75)		20.04 [16; 26]
Handgrip dynamometry[b] (muscle weakness), n (%)	439	179 (40.8)
median (P25-P75)		20 [15; 23]

[a]time in seconds; [b]measurement in Kgf; SD: standard deviation; SAH: systemic arterial hypertension; TUG: timed up and go test; CST: chair stand test; P25: 25 percentile; P75: 75 percentile.

When comparing the performance of HGS and CST, it was observed that older adults with normal TUG presented significantly higher HGS and were faster in CST when compared with those with lower TUG performance (p<0.001). Table 2 shows these data.

Table 2. Comparison of handgrip strength performance and chair stand test among groups of older adults with normal scores and low timed up and go test performance

Characteristic	Older adults with normal TUG	Older adults with poor TUG	p-value
HGS, median (P25; P75%)	20 [16.0; 25.0]	16 [13.2; 20.0]	<0.001*
CST, median (P25; P75%)	18.24 [15.0; 22.0]	27.0 [21.1; 36.0]	<0.001*

Mann-Whitney U-test. *p<0.05. TUG: timed up and go test; CST: chair stand test; HGS: handgrip strength; P25: 25 percentile; P75: 75 percentile.

Correlation analyses showed a moderate directly proportional correlation (r=0.606, p<0.001) between TUG and HGS performance and inversely proportional low correlations between TUG and HGS performance (r=−0.353, p<0.001) and between CST and HGS performance (r=−0.289, p<0.001).

The agreement analysis of the diagnoses of muscle strength of CST and HGS was not statistically significant (p=0.077). Table 3 shows the distribution of participants.

Table 3. Distribution of participants with normal strength and muscle weakness in the chair stand and handgrip strength tests among those with normal and low timed up and go test scores

	CST		
	Normal strength	Muscle weakness	Kappa (p-value)
TUG – normal	91.6% (76)	65.5% (215)	0.134 (<0.001)
TUG – poor performance	8.4% (7)	34.5% (113)	
	HGS		
TUG – normal	77.4% (199)	55.7% (97)	0.225 (<0.001)
TUG – poor performance	22.6% (58)	44.3% (77)	

CST: chair stand test; TUG: timed up and go test; HGS: handgrip strength.

Table 4 and Figure 1 show TUG validity estimates.

Table 4. Timed up and go test validity estimates to discriminate muscle strength in the chair stand and handgrip strength tests and area under the receiver operating characteristic curve

Test	Cut-off point	S(%)	Sp(%)	PPV(%)	NPV(%)	AUC [95%CI]
CST	TUG≥20s	34.4	91.5	94.1	26.1	0.779 [0.724–0.835]*
HGS	TUG≥20s	44.2	77.4	57.0	67.2	0.652 [0.599–0.705]*

S: sensitivity; Sp: specificity; PPV: positive predictive value; NPV: negative predictive value; AUC: area under the curve; ROC: receiver operating characteristic; TUG: timed up and go test; CST: chair stand test; HGS: handgrip strength. *p<0.001.

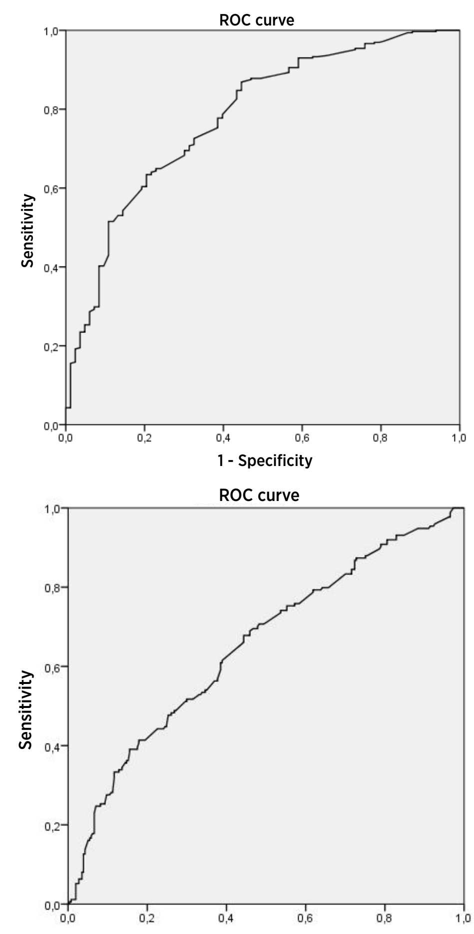

Figure 1. Receiver operating characteristic curves with significant measurements of the timed up and go test to discriminate muscle strength in the chair stand and handgrip strength tests

DISCUSSION

This study aimed to analyze the use of TUG as a tool to assess muscle strength in community-dwelling older adults. TUG satisfactorily discriminated individuals with normal muscle strength, presenting high specificity regarding CST. Its use in clinical practice implies differentiating and dispensing from health services those who do not need interventions with greater safety.

Older adults with normal TUG present higher HGS and were faster in CST when compared with older adults with low TUG performance. Similar to the results found by Benavent-Caballer et al.[19], in which TUG performance was highly correlated with knee extension strength. Standing up from a chair is a motor task that requires a relevant effort of the lower limbs muscles, close to the maximum voluntary isometric contraction. Thus, it is expected that individuals with higher handgrip strength also have shorter times in the execution of CST[20].

We also found a moderate positive correlation between TUG and CST performance. We can infer that this result was obtained due to the relationship of both tests with the mobility and the muscle strength of the lower limbs. TUG is used to evaluate the performance related to the task[5] and the low physical performance, besides predicting adverse outcomes, is also used to categorize the severity of sarcopenia[14]. CST requires strength and endurance, mainly used as an alternative to measure the strength of leg muscles[14].

However, the study showed inversely proportional low correlations between TUG performance and handgrip strength. These findings may be related to the inconsistency among studies on the evaluation of global muscle strength[21-25]. Studies[5,14,16,26] state that body measurements can be correlated, and grip strength may be related to lower limbs strength. However, muscles evaluated by handgrip dynamometers are not recruited in daily activities since static contractions are rarely used. Furthermore, other factors may influence HGS, including footprint size, genetic factors, and anthropometric variables[27].

Chan et al.[28] observed a weak correlation between quadriceps strength and HGS in an older population, similar to our sample, whose mean age is 80.85 years. This occurs because older adults have more physical disabilities, which can distort correlation between limbs.

The results showed weak agreements among all tests, and the agreement between muscle strength in CST and handgrip dynamometry was not statistically significant. This finding may be a result of the sample size, considered relatively small for this type of analysis.

In this study, we observed that TUG has a satisfactory discriminatory capacity of muscle strength compared to CST due to the high specificity (91.5%) and high value of PPV (94.1%), that is, greater security to affirm that an individual with TUG≥20s presents muscle weakness. Martinez et al.[6] observed using the ROC curve analysis that TUG presented a high sensitivity of 66.7% and specificity of 88.7% in the prediction of sarcopenia in hospitalized older adults. Since it has higher specificity than sensitivity, it can be used as a confirmatory test, as it can reliably detect those without sarcopenia.

Unlike our study, using TUG in the discrimination of sarcopenia, Filippin et al.[3] found sensitivity of 88.9% and specificity of 31.4% using the ROC curve. Sensitive tests for early diagnosis are essential because they allow selecting patients who would benefit from specific early diagnosis and intervention. Thus, this test is a clinical tool for screening for sarcopenia[3].

The findings presented in Table 4 show that for TUG validation, CST and HGS presented low accuracy regarding sensitivity. Thus, TUG is not suitable for screening individuals with muscle weakness, requiring better investigation with more sensitive tests for such use.

Furthermore, another interesting aspect about these results is that CST (TUG≥20s) presented PPV=94.1 and NPV=26.1, whereas HGS (TUG≥20s) presented PPV=57.0 and NPV=67.2. We believe that compatibility is related to CST presenting higher values of specificity and because HGS is a gold standard test for muscle strength evaluation, presenting higher sensitivity values.

The study has some limitations that may affect results interpretation. This is a retrospective study, using a database. Thus, we do not have some sample characterization variables, such as the score in the participants' MMSE and information on physical activity practice. Moreover, the lack of description of the amount of data excluded and the small sample size for the type of analysis of agreement between the tests are also limitations.

We recognize the limitations of the study, however, the findings reinforce that the use of the TUG test can facilitate discrimination between individuals who have normal muscle strength of those with muscle weakness and, thus, treat only those who require intervention, reducing costs in public health. Also, when using TUG for this purpose, the time while performing other tests is reduced, which is very beneficial considering this population's high demand for health professionals. Therefore, it is possible to help clinicians find and implement interventions focused on muscle strength gain for older adults.

CONCLUSION

In conclusion, the timed up and go test (TUG) showed a moderate correlation compared to CST and satisfactorily indicated individuals with normal muscle strength in HGS. Thus, it can be used in clinical practice to exempt individuals from health services with greater safety when they do not require intervention.

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