

Comparison of predicted and covered distances in the incremental shuttle walking test in older adults

Comparação das distâncias previstas e percorridas no incremental shuttle walking test em idosos comunitários

Comparación de las distancias predichas y recorridas en la incremental shuttle walking test en ancianos comunitarios

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ABSTRACT | Our study aimed to evaluate the external validity of three reference equations for estimating the distance to be covered in the incremental shuttle walking test (ISWT) by older adults and to identify which equation best predicts the distance for this age group. In total, 84 older adults registered in the Health Centers of Diamantina, state of Minas Gerais, Brazil, were selected. The volunteers were subjected to the ISWT and the distance covered, in meters, until the interruption of the test was recorded and compared with the prediction equations. The volunteers had a mean age of 73.15±5.89 years and some health problems common to this age group, were mostly women, and physically active. Statistical analysis showed an interaction between the factors, that is, a difference between the distances covered the ISWT and the distances obtained by the equations. The analysis showed a difference between the men and women ($p<0.05$) and Equation 1 showed a greater correlation strength ($p<0.0001$; $r=0.414$) with the distance covered compared to the other equations. Therefore, our study showed a difference in the comparison of the distances covered and those estimated by three ISWT prediction equations, suggesting that the equations used may overestimate the distance covered by older adults, and

that, Equation 1 showed a prediction closer to the distance covered by the older adults of the sample.

Keywords | Aged; Forecast; Walk Test; ISWT.

RESUMO | O objetivo deste estudo foi avaliar a validade externa de três equações de referência para o cálculo da distância a ser percorrida no *incremental shuttle walking test* (ISWT) por idosos comunitários, e, por fim, identificar qual equação prediz melhor a distância nessa faixa etária. Foram selecionados 84 idosos cadastrados nas Unidades Básicas de Saúde de Diamantina, Minas Gerais. Os voluntários foram submetidos ao ISWT e a distância percorrida em metros até a interrupção do teste foi registrada e utilizada para comparação com as equações de predição. Os voluntários apresentaram média de idade de 73,15±5,89 anos e alguns comprometimentos de saúde comuns dessa faixa etária, sendo a maioria mulheres e praticantes de atividade física. A análise estatística demonstrou que houve interação entre os fatores, ou seja, existe diferença entre as distâncias obtidas pelo ISWT e as distâncias obtidas pelas equações. Houve diferença também nas comparações entre os sexos ($p<0,05$) e a Equação 1 apresentou maior

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força de correlação ($p < 0,0001$; $r = 0,414$) com a distância real percorrida em relação às outras equações. Portanto, este estudo demonstrou uma diferença na comparação das distâncias real e calculadas por três equações de predição do ISWT, sugerindo que as equações utilizadas podem superestimar a distância percorrida pelos idosos, e que entre essas a Equação 1 apresentou uma predição mais próxima da distância percorrida para a amostra de idosos avaliada.

Descritores | Idoso; Predição; Teste de Caminhada; ISWT.

RESUMEN | El objetivo de este estudio fue evaluar la validez externa de tres ecuaciones de referencia para calcular la distancia recorrida de la *incremental shuttle walking test* (ISWT) para ancianos comunitarios, así como identificar la ecuación que mejor predice la distancia en este grupo de edad. Se seleccionaron a 84 ancianos inscritos en las Unidades Básicas de Salud de Diamantina, Minas Gerais (Brasil). Se aplicaron a los voluntarios la ISWT, y la distancia recorrida en metros hasta la interrupción de la

prueba se registró y se utilizó para comparar con las ecuaciones de predicción. Los voluntarios tenían un promedio de edad de $73,15 \pm 5,89$ años y algunos problemas de salud habituales en este grupo de edad, de los cuales la mayoría fue mujeres y practicantes de actividad física. El análisis estadístico mostró que hubo una interacción entre los factores, es decir, existe una diferencia entre las distancias obtenidas por ISWT y las distancias obtenidas por las ecuaciones. También hubo una diferencia en las comparaciones entre los sexos ($p < 0,05$), y la Ecuación 1 mostró una mayor fuerza de correlación ($p < 0,0001$; $r = 0,414$) con la distancia real recorrida en relación con las otras ecuaciones. Por lo tanto, este estudio demostró una diferencia en la comparación de las distancias reales y calculadas por tres ecuaciones de predicción de ISWT, lo que sugiere que las ecuaciones utilizadas pueden sobreestimar la distancia recorrida por los ancianos y que entre estas la Ecuación 1 presentó una predicción más cercana a la distancia recorrida por la muestra evaluada.

Palabras clave | Anciano; Predicción; Prueba de Caminata; ISWT.

INTRODUCTION

The world's older population has an accelerated growth rate. In 2008, Brazil reached 20 million older adults and projections indicated to a growing increase. Brazil is expected to occupy the sixth position in countries with the largest number of older adults by 2025, accounting for 15% of its population^{1,2}. This accelerated aging implies great challenges for care and has aroused the need for studies and research in the area^{3,4}, including clinical and methodological studies, to unify and to standardize measures and evaluations.

Aging is a physiological and highly complex phenomenon in which individuals gradually lose the ability to maintain their basic functions⁵. In this sense, functional capacity is understood as the condition to remain able to exercise the basic and instrumental activities of daily life, sufficient for and inherent in an independent life⁶. Thus, the evaluation of functional performance becomes an essential measure for this public. Functional capacity measures are used in clinical and scientific practice to infer the overall health status, clinical status monitoring, assessment of physical disability, and determination of dependency levels⁷.

In the literature, there are several measuring instruments for assessing the functional performance of the older

adults, such as questionnaires and performance tests^{7,8}, and their choice is based on the objective and environment available for their application. Among the performance tests stands out the incremental shuttle walking test (ISWT)⁹, an adaptation of the shuttle run test¹⁰. The ISWT is a simple, progressive, low-cost test that assesses the aerobic functional capacity of individuals and is applicable to different age groups¹¹. Thus, based on its wide application in the prediction of the ideal distance to be covered by the individual in the ISWT, some authors have proposed reference equations for the Brazilian population¹²⁻¹⁵. In this context, only three equations are based on the same type of variables, anthropometric and demographic, which were established after using the same execution protocol¹²⁻¹⁴. However, the distance to be covered in the ISWT can be either underestimated or overestimated when using equations to predict it. This interpretation can cause errors and result in an inadequate conduct by professionals and researchers¹³ and should be better investigated, especially for the older population.

ISWT is considered important due to its use for evaluating the outcome of interventions^{9,11}, quantifying functional capacity^{11,16,17} and determining prognostics^{11,16,18}. However, studies have not yet indicated which of the existing equations most accurately estimates the distance to be covered, despite the broad use of

ISWT in various health conditions and populations, including in the older adults.

The literature review study by Monteiro et al.¹¹ showed the existence of three equations for estimating the distance covered in the ISWT. Considering the significance of a proper assessment of the functional capacity in the older population, the ease of implementation of the ISWT, and the scarcity of studies that compare the results obtained using these three equations within the same population, which includes both older men and older women, our study aimed to assess the external validity of the three equations, and, finally, to identify which equation best predict the distance covered in the ISWT in this age group.

METHODOLOGY

This cross-sectional study was conducted in the municipality of Diamantina, state of Minas Gerais, Brazil, with older adults registered in the five main health centers of the city. It is part of a multicenter study approved by the Research Ethics Committees of the Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM) and the Universidade Federal de Minas Gerais (UFMG) under the opinions of number 375.689 and 349.141, respectively, CAAE: 14129513.7.1001.5149, and this study was conducted from 2013 to 2016.

Sample selection

Figure 1 shows the sample selection flowchart. Older adults registered in 2015 at the Health Centers received a household visit and answered a questionnaire with clinical, sociodemographic, and physical activity information, and the mini-mental state exam test¹⁹. Those who reported regular practice of any modality of physical activity at least twice a week were considered physically active. Adults aged 65 years or older, of both genders, who did not report hospital admissions in the last six months and symptoms of intermittent claudication, and who did not present either physical or cognitive deficits that prevented the performance of the proposed physical test were included. The eligible individuals signed the informed consent form and the day of the ISWT was scheduled. Individuals that missed or refused to perform the tests were excluded from the sample.

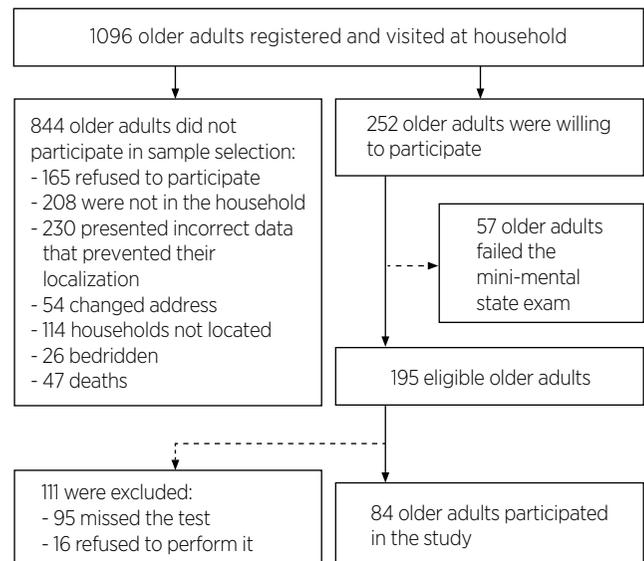


Figure 1. Sample selection flowchart

Procedures

The volunteers were subjected to the ISWT, a progressive walking speed test with a change of direction based on the orientation of different sound signs⁹. The ISWT was conducted in places close to the residences of the individuals, in a corridor of 10 meters, flat, without irregularities. Nine meters were delimited by two cones and a half meters after each cone, so that the individual turn around¹¹. The test was interrupted when the individual did not reach two cones consecutively^{15,20}, presented limiting symptoms and when the individual reached values of 85% of the maximum heart rate (HR_{Max}), predicted by the formula $(220 - age)^{9,20}$. Since the ISWT was performed in places close to the residences of the older adults and not within institutions with the presence of medical staff, we opted, for safety issues, for the submaximum protocol of 12 levels. This choice avoided the extreme fatigue of the participants and ensured that the tests were performed without complications. The distance covered, in meters, until the interruption of the test was recorded and compared with the prediction equations.

According to the literature, older women show lower functional capacity^{21,22}. Thus, the distances were compared considering the total sample and divided by sex. Furthermore, being 70 years of age or older is associated with functional disability²². Therefore, to evaluate the influence of age on the prediction ability of the equations, the relationship between age and the difference between the distance covered and the distances predicted was also evaluated.

Three equations described in the literature and used for the Brazilian population¹²⁻¹⁴ were used to predict the distance covered in the ISWT. They were chosen because they use the same application protocol of the test in our study:

$$(1) \text{ISWT}_{\text{pred}} = 374.004 - (6.782 \times \text{age (years)}) - (2.328 \times \text{weight (kg)}) + (3.865 \times \text{height (cm)}) + (115.937 \times \text{sex}^{\#})^{12};$$

$$(2) \text{ISWT}_{\text{pred}} = 34.608 - (4.384 \times \text{age (years)}) - (2.949 \times \text{weight (kg)}) + (553.336 \times \text{height (m)}) + (114.387 \times \text{sex}^{\#})^{13};$$

$$(3) \text{ISWT}_{\text{pred}} = 347.7 - (7.2 \times \text{age (years)}) - (3 \times \text{weight (kg)}) + (472.3 \times \text{height (m)}) + (137.2 \times \text{sex}^{\#})^{14}.$$

Statistical analysis

The normal distribution of the data was verified by the Shapiro-Wilk test, which detected a symmetrical distribution. The comparisons between the distance covered in the ISWT and the distances predicted by the three equations, between men and women, and the interaction between these factors, were analyzed using the mixed factorial analysis of variance (ANOVA). The *post hoc* test adopted was that of Bonferroni for multiple comparisons. The relationship between the values predicted by the equations and the value covered obtained by the ISWT, and the relationship between age and the difference between the values obtained and predicted by each equation, were evaluated by the Pearson correlation test. The 5% alpha significance level was adopted and, for data analysis, the statistical Package for the Social Science (SPSS 19.0) program was used.

For the sample calculation was considered a pilot study conducted with 10 older adults, which showed a moderate effect size ($\eta^2=0.29$), established an 80% power and a 5% alpha significance level, showing the need for a sample composed of 18 individuals.

RESULTS

In total, 84 subjects with a mean age of 73.15 ± 5.89 years participated in our study. Most participants were women and physically active. Table 1 shows the characteristics of the sample. The health conditions present in the sample were visual deficit (86.90%), arterial hypertension (77.38%), hearing deficit (50%), osteoarthritis (25%), deformity in the feet (21.43%), and memory loss (19.05%).

Table 1. Sample characteristics (n=84)

Characteristic	n (%)
Sex	
Women	66 (78.57)
Men	18 (21.43)
Age (years)	
65-69	23 (27.38)
70 to 79	48 (57.14)
80 to 89	13 (15.48)
Physical Activity	
Yes	50 (59.52)
No	34 (40.48)

Table 2 shows the distances covered in ISWT and those obtained by the three reference equations adopted. The statistical analysis showed an interaction between the factors, that is, distances covered ISWT differed from those obtained by the equations. A difference was also observed regarding sex ($p < 0.05$). Considering the total sample, the distance covered obtained by the ISWT reached 58.82%, 50.80%, and 53.14% of the distances predicted by equations 1, 2 and 3, respectively. Moreover, age and the difference between the distances covered in the ISWT and the distance predicted by each of the equations showed no significant correlation (Equation 1: $p=0.896$; Equation 2: $p=0.223$; Equation 3: $p=0.986$).

Table 2. Distances covered in the ISWT and predicted by the three equations, considering both the total sample and the sample divided by sex

	Total (n=84)	Women (n=66)	Men (n=18)
Distance covered in ISWT (m)	208.47 \pm 111.78	195.69 \pm 103.20	255.33 \pm 131.60 [#]
Equation 1 ¹² (m)	354.40 \pm 83.26 [*]	320.97 \pm 52.62 ^a	477.00 \pm 54.79 ^b
Equation 2 ¹³ (m)	409.90 \pm 91.33 [*]	371.31 \pm 53.20 ^a	551.40 \pm 54.02 ^b
Equation 3 ¹⁴ (m)	392.31 \pm 97.83 [*]	352.29 \pm 60.04 ^a	539.07 \pm 62.60 ^b

ISWT: Incremental Shuttle Walking Test. Data represented by mean values (standard deviation). ^{*}Significant difference compared to distance covered in the ISWT in the total sample ($p < 0.001$); ^aSignificant difference between sexes regarding distance covered in ISWT ($p < 0.001$); ^bSignificant difference compared to the distance covered in the ISWT in women ($p < 0.001$); [#]Significant difference compared to the distance covered in the ISWT in men ($p < 0.001$).

Figure 2 shows that there was a significant correlation between the distances predicted by the three equations and the distance covered in the ISWT ($p < 0.0001$). However, Equation 1 showed a stronger correlation ($r=0.414$) compared to the others.

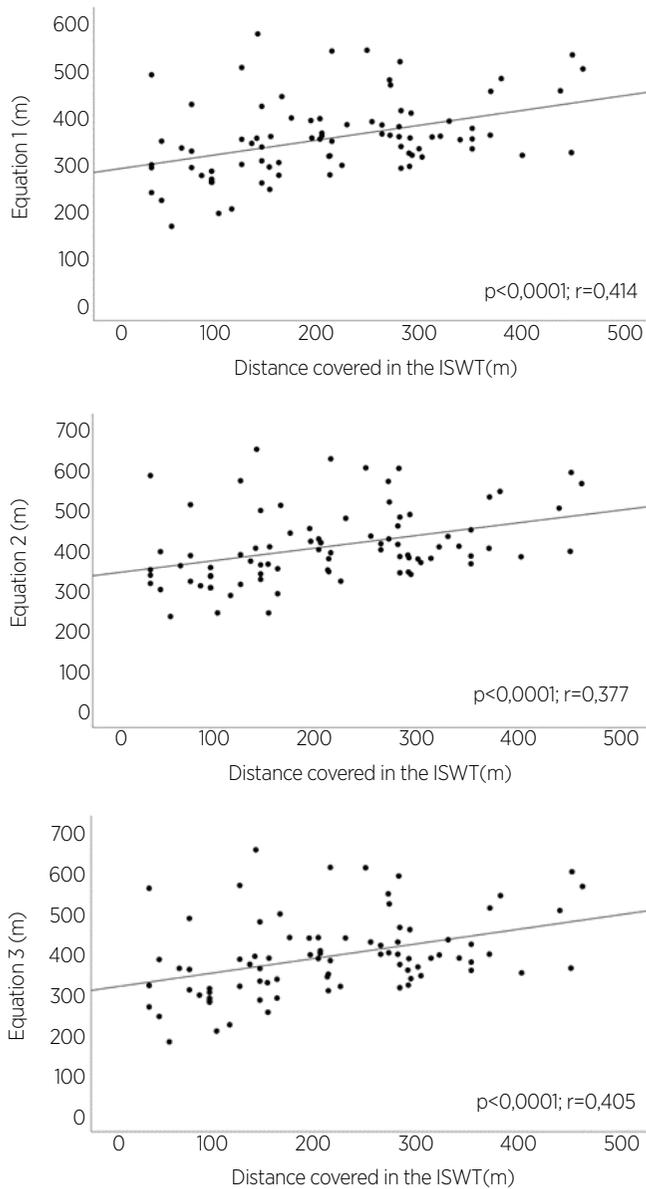


Figure 2. Correlation between distance covered in the ISWT and the distances predicted by each equation

Regarding the performance of the ISWT, none of the older adults completed the 12 levels predetermined in the test and the causes of interruption were: 61 individuals (72.62%) did not reach two consecutive cones, 21 (25%) reached 85% of the HR_{max} and two (2.38%) showed limiting pain symptoms.

DISCUSSION

Our study showed that there is a significant difference between the distances predicted by the three equations evaluated and the actual distance covered in the ISWT. The analysis also showed a difference when the sample

was divided by sex. These differences indicated that the distance covered was statistically smaller than that predicted by the three equations, thus suggesting that the use of these reference equations for the older population may overestimate the actual distance to be covered.

On the other hand, the studies that proposed the equations¹²⁻¹⁴ did not rely on a sample composed exclusively of older adults, but of individuals over 40 years old, only included healthy individuals; with ISWT protocol composed of 15 levels to avoid the ceiling effect, and considered it as a maximal test. Furthermore, these studies did not adopt the reaching of 85% HR_{max} as a criterion of test interruption.

Considering the ISWT as a maximal test, Soares et al.²³ studied obese women aged 18 to 65 years (mean 44 years) and identified a significant difference of 146 meters between the distance covered and that predicted by the equation of Jurgensen et al.¹². This study analyzed exclusively individuals aged 65 years or older with health conditions common to their age group²⁴, and with a submaximal protocol, as previously reported. Thus, the difference in the characteristics of the samples of both studies, such as obesity or other health conditions, can justify the difference between the distances predicted by the equations and those covered in the ISWT.

Besides, more than 70% of the sample of our study were adults over 70 years of age, and although the literature indicates that functional disability is associated with this age group²², no significant correlation was identified between age and difference in the predicted distances and those covered in the ISWT, which reinforces that the health condition of the sample may be the main explanation for the difference between the distances predicted and covered.

Another important point regarding the sample of our study is the higher proportion of physically active older adults, which would be expected to result on a better performance in the ISWT. However, this was not supported by the results, which is possibly due to the overestimation of the practice of physical activity evaluated by self-report. Thus, important and common health impairments in this age group, such as those presented by the sample of our study, should be considered when proposing an equation for the older population that seeks greater external validity.

Regarding the difference between women and men, our data are in agreement with the results of Jüngen et al.¹² and Dourado, Vidotto and Guerra¹³, which observed that men covered significantly longer distances in the ISWT

compared to women. This difference in distance can be explained by the fact that men have greater strength, muscle mass, and greater stature¹². In this case, future studies should investigate the ratio between muscle strength and stride size.

The greater number of women in this study reflects the phenomenon of “feminization of aging,” which is consequence of the higher male mortality index²⁵. It is in agreement with other studies^{21,26,27} and with 2010 Census²⁸ regarding the higher proportion of women compared to men in Brazil. This difference in the number of men and women in the sample did not affect the results, since the three equations analyzed consider the variable sex.

Our study has some limitations. One of them refers to the choice of the original ISWT protocol with 12 levels and of submaximal nature. Although the studies that originated the prediction equations used the adapted protocol of 15 levels and of maximal nature, this choice seemed to be the safest and most suitable for the group of population studied. We emphasize that none of the older adults completed all levels, which reinforces that the protocol adopted was adequate and safe for this population. Another limitation was that the ISWT was performed only once, unlike the studies that propose the equations. However, this decision was made to suit the research context in the community, which is characterized by low time availability and restricted. On the other hand, a strength of our study refers is the fact that the ISWT was applied by the same evaluator and with its original protocol, which reinforces the reliability of its application.

CONCLUSION

Our study showed a difference between distances covered and those estimated by three ISWT prediction equations, thus suggesting that the equations used may overestimate the distance covered by older adults with some health impairments. However, Equation 1 presented a prediction closer to the distance covered by the older adults of the sample. These results point to the need for new studies specific to this population.

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