

Applicability of reference equations for the six-minute walk test in healthy elderly adults in a municipality of São Paulo

Aplicabilidade das equações de referência para o teste de caminhada de seis minutos em adultos e idosos saudáveis de um município do estado de São Paulo

Aplicabilidad de las ecuaciones de referencia para el test de marcha de seis minutos en adultos y adultos mayores saludables de un municipio del estado de Sao Paulo

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ABSTRACT | The six-minute walk test (6MWT) has been considered simple, safe, easy administration, and provide representative results about normal activities of day-to-day. The objective of the study was to evaluate and compare the 6-min walk distance (6MWD) with predicted distance by reference equations available in the scientific literature in healthy elderly adults, and to verify the applicability of these reference equations in this population. Forty-three elderly adults apparently healthy (23 males) between 55 to 78 years old were assessed by means of general physical assessment, the spirometry and 6MWT. The 6MWT was performed twice, with 30-min interval between them. The 6MWD was significantly (paired t-test: $p < 0.05$) higher than those predicted by the equations of Enright and Sherrill, Masmoudi et al., Alameri, Al-Majed and Al-Howaikan and Dourado, Vidotto and Guerra, and they were significantly lower than those provided by Troosters, Gosselink and Decramer, Gibbons et al., Enright et al., Camarri et al., Ben Saad et al. and Soares and Pereira. No significant differences were observed between the 6MWD and the predicted values by the equations of Chetta et al. and Iwama et al. Most reference equations used underestimates or overestimates the 6MWD, except of the Chetta et al., and Iwama et al. that showed acceptable to this population. There difference between the distances, even when the 6MWT is realized with similar methodology and rigorous standardization, thus emphasizes the need for specific equations for each population.

Keywords | reference values; walking; physical therapy specialty.

RESUMO | O teste de caminhada de seis minutos (TC6) tem sido considerado simples, seguro, de fácil administração, além de fornecer resultados representativos sobre atividades habituais do dia a dia. Os objetivos do estudo foram avaliar e comparar a distância percorrida no TC6 com as distâncias previstas por equações disponíveis na literatura científica em adultos e idosos saudáveis do município de São Carlos (SP), e verificar a aplicabilidade dessas equações nessa população. Foram avaliados 43 indivíduos (23 homens), dos 55 aos 78 anos, por meio da avaliação física, espirometria e do TC6. Observamos que a distância percorrida no TC6 foi significativamente (teste *t*-pareado: $p < 0,05$) maior que os valores previstos pelas equações de Enright e Sherril, Masmoudi et al., Alameri, Al-Majed e Al-Howaikan e Dourado, Vidotto e Guerra, e os mesmos foram significativamente menores que os previstos por Troosters, Gosselink e Decramer, Gibbons, Enright, Camarri, Ben Saad e Soares e Pereira. Não foram observadas diferenças significativas entre a distância percorrida no TC6 e os valores previstos pelas equações de Chetta et al. e Iwama et al. A maioria das equações de referências utilizadas no presente estudo subestima ou superestima os valores obtidos no TC6, exceto as propostas por Chetta

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Presentation: Nov. 2012 – Accepted for publication: Mar. 2013 – Financing source: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior Capes – Conflict of interest: nothing to declare. Approval at the Ethics Committee n. 074/2007.

et al. e Iwama et al. que se mostraram aceitáveis para a população estudada. Existe diferença entre as distâncias, mesmo quando o TC6 é realizado com uma metodologia semelhante e rigorosa padronização, assim salienta-se a necessidade de equações específicas para cada população.

Descritores | valores de referência; caminhada; fisioterapia.

RESUMEN | El test de marcha de seis minutos (TM6) es considerado simple, seguro y de fácil administración, además de entregar resultados representativos sobre actividades habituales del día a día. Los objetivos del estudio fueron evaluar y comparar la distancia recorrida en el TM6 con las distancias previstas por ecuaciones disponibles en la literatura científica en adultos y adultos mayores saludables del municipio de Sao Carlos/SP, y verificar la aplicabilidad de esas ecuaciones en esta población. Fueron evaluados 43 individuos (23 hombres), entre los 55 a los 78 años, por medio de evaluación física, espirometría y del TM6. Observamos que la distancia

recorrida en el TM6 fue significativamente (test t-pareado: $p < 0,05$) mayor que los valores previstos por las ecuaciones de Enright y Sherril, Masmoudi et al. Alameri, Al-Majed y Al-Howaikan y Dourado, Vidotto y Guerra, y los mismos fueron significativamente menores que los previstos por Troosters, Gosselink y Decramer, Gibbons et al., Enright et al., Camarri et al., Ben Saad et al. y Soares y Pereira. No fueron observadas diferencias significativas entre la distancia recorrida en el TM6 y los valores previstos por las ecuaciones de Chetta et al. y Iwama et al. La mayoría de las ecuaciones de referencias utilizadas en el presente estudio subestima o superestima los valores obtenidos en el TM6, excepto las propuestas por Chetta et al. y Iwama et al. que se observaron aceptables para la población estudiada. Existe diferencia entre las distancias, incluso cuando el TM6 es realizado con una similar metodología y estandarización rigurosa, además se hace hincapié en la necesidad de ecuaciones específicas para cada población.

Palabras clave | valores de referencia; marcha; fisioterapia

INTRODUCTION

The 6-minute walk test (6MWT) is regarded as one of the alternatives to maximal tests (cardiopulmonary test) because of its good reliability and reproducibility¹⁻³, and for being a low-cost option of easy conduction. In addition to being well tolerated by patients⁴⁻⁸, it is also simple, safe, and it simulates a customary daily activity^{9,10}, enabling the patient to determine his/her own speed and the need for pausing, which is an additional advantage to elderly people⁴⁻⁸.

Moreover, the 6MWT is considered a predictor of morbimortality¹¹, and it presents great applicability in clinical practice, because it reflects the exercising capability of individuals with chronic obstructive pulmonary disease (COPD)¹². It is also a method for evaluating the necessity of prescribing oxygen therapy, since it detects oxygen desaturation in patients with COPD¹³.

Recently, the 6MWT has not been regarded solely as a specific meter of cardiovascular capacity, but also as an indicator of global physical capacity in elderly people¹⁴, considering that it evaluates the responses provided by the cardiovascular, respiratory, and peripheral vascular systems¹⁵.

In this sense, some equations have been proposed with the purpose of predicting the distance accomplished in the 6MWT, but the predicted values are influenced by sex, height, age, and weight¹⁶⁻¹⁸, as well as by physiological and clinical factors¹⁷. Among the best known equations, we highlight those proposed by Enright and Sherril¹⁶ for Americans who are over 40 years of age, and by Troosters, Gosselink, and Decramer¹⁸ for Belgians. Later, other

equations were proposed for Americans between 20 and 80 years old¹⁹ and over 68 years of age²⁰, for healthy Italians²¹, for Australians²², and for sedentary Tunisians who are between 40 and 80 years old²³. In 2009, predictive equations were devised for Arabs²⁴, Tunisians²⁵, and Brazilians²⁶. Finally, other equations, different from one another²⁹, were proposed for Brazilians^{27,28} in 2011.

Considering the number of equations predicted for the distance accomplished in the 6MWT available in scientific literature, the conduction of this study is justified; it aims at evaluating the applicability of these equations to apparently healthy adults and elderly people of the city of São Carlos (SP) and region, in addition to suggesting the most adequate ones to be used with patients in the clinical practice of this area. Therefore, this study aimed at: 1) evaluating and comparing the distance accomplished in the 6MWT by apparently healthy adults and elders of the city of Sao Carlos (SP) and region to the distances predicted by several equations available in scientific literature; 2) verifying the applicability of these equations to this population.

METHODOLOGY

Study participants

We evaluated 43 apparently healthy adults and elderly people, 23 men and 20 women, who were between 55 and 78 years of age, inhabitants of São Carlos (SP) and region.

The inclusion criteria were: presenting spirometric values within normal standards³⁰, being healthy and over 55 years of age and considered insufficiently active or sedentary by the Physical Activity International Questionnaire (short version)³¹. Individuals who were smokers, alcoholic, had non controlled arterial hypertension and presented cardiovascular, metabolic, neurological, rheumatic and/or musculoskeletal diseases that prevented participation in the study were excluded. This study was approved by UFSCar's Ethics Research Committee (approval report number 074/2007), and all participants signed the free and informed consent form.

The individuals were submitted to a general physical assessment (anamnesis, weight, height, presence of diseases, and information on smoking, workout, medication, type of thorax and respiratory pattern, presence of cough and dyspnea, lung auscultation, blood pressure, cardiac and respiratory frequency, and peripheral oxygen saturation), in addition to spirometry and the 6MWT.

- Spirometry: Performed with a portable spirometer (COSMED microQuark PC, based Spirometer®, Pavona di Albano, Rome, Italy), in accordance with the rules of the American Thoracic Society (ATS)/European Respiratory Society³², with the purpose of including individuals with normal spirometric values in the study. The values obtained were compared to those predicted by Knudson et al.³³
- Six-minute walk test: Performed according to ATS's rules¹. The free cadence 6MWT was conducted twice on the same day, with 30-minute intervals, using the highest distance values for analysis. The individuals were instructed to walk as fast as possible during 6 minutes, and were encouraged each minute¹.

The 6MWT distance values were compared to those predicted by the equations proposed by Enright and Sherril¹⁶, Troosters, Gosselink and Decramer¹⁸, Gibbons et al.¹⁹, Enright et al.²⁰, Chetta et al.²¹, Camarri et al.²², Masmoudi et al.²³, Alameri, Al-Majed and Al-Howaikan²⁴, Ben Saad et al.²⁵, Iwama et al.²⁶, Dourado, Vidotto and Guerra²⁷, and Soares and Pereira²⁸.

Statistical analysis

The calculation of the sample size was performed by the software Ene version 2.0 (GlaxoSmithKline España S.A., Madrid, Spain, and Universidad Autónoma de Barcelona, Barcelona, Spain), based on the deviation standard (69.5 cm), and on the average of the distance variable, considering a minimum difference of 35 m³⁴

considered as important. According to these data, the sample size calculated was 33 individuals, which corresponds to a statistical power of 80%.

The results of this study were analyzed by the program *Statistical Package for Social Sciences for Windows*, version 18.0 (SPSS Inc., Chicago, Illinois, USA). We verified data distribution through Shapiro-Wilk's normality test. We used descriptive statistics for sample characterization, with data expressed in averages±standard deviations. For the analysis of the distance obtained in the 6MWT and the predicted distances we used paired t-test. A significance level of 5% was adopted.

RESULTS

Table 1 shows the anthropometric and spirometric characteristics of the population studied.

Table 2 shows the distance accomplished in the 6MWT and the distance predicted by several equations available in the literature on the sample studied.

We found that the distance accomplished in the 6MWT was significantly longer than those predicted by the equations of Enright and Sherrill¹⁶, Masmoudi et al.²³, Alameri, Al-Majed and Al-Howaikan²⁴, and Soares and Pereira²⁸, and the values were significantly lower than those predicted by the equations of Troosters, Gosselink, Decramer¹⁸, Gibbons et al.¹⁹, Enright et al.²⁰, Camarri et al.²², Ben Saad et al.²⁵, and Dourado,

Table 1. Anthropometric and spirometric characteristics of the population studied

| Variables | Total sample (n=43) | Men (n=23) | Women (n=20) |
|--------------------------------|---------------------|------------|--------------|
| Anthropometric | | | |
| Age (years) | 66.1±6.4 | 65.6±6.4 | 66.7±6.4 |
| Body mass (Kg) | 73.1±13.8 | 78.2±12.5 | 67.1±12.8 |
| Height (cm) | 164.4±8.9 | 170.5±5.2 | 157.3±6.8 |
| BMI (kg/m ²) | 27.0±4.3 | 26.9±4.1 | 27.1±4.5 |
| Spirometric | | | |
| FEV ₁ (L) | 2.8±0.7 | 3.3±0.4 | 2.2±0.4 |
| FEV ₁ (% pred) | 109.1±15.6 | 114.5±14.5 | 102.5±14.7 |
| FVC (L) | 3.6±0.9 | 4.3±0.5 | 2.8±0.5 |
| FVC (% pred) | 111.4±14.6 | 117.6±12.6 | 103.9±13.6 |
| FEV ₁ /FVC (% pred) | 98.5±7.6 | 97.8±6.8 | 99.5±8.8 |
| MVV (L/min) | 113.7±32.2 | 135.9±23.1 | 86.7±17.7 |
| MVV (% pred) | 110.2±18.6 | 116.3±16.3 | 102.9±19.2 |

Data expressed in averages (±standard deviation). BMI: body mass index; FEV₁: expiratory volume forced in the first second; FVC: forced vital capacity; Relation FEV₁/FVC: relation FEV₁ by FVC; MVV: maximal voluntary ventilation; pred: predicted

Vidotto and Guerra²⁷. However, we did not observe significant differences between the distance accomplished in the 6MWT and that predicted by the equations of Chetta et al.²¹, and Iwama et al.²⁶ Therefore, the latter equations are the most applicable to Brazilians in São Carlos (SP) and region (Table 2).

DISCUSSION

The 6MWT is considered a great indicator of functional capacity in elderly people¹⁵. Studies show correlation between the distance accomplished in the 6MWT and age, sex, height, weight, and body mass index¹⁷. In a Brazilian study, only age and sex were found to be significant determinants of the distance accomplished in the 6MWT²⁶. Geographical heterogeneity was revealed as another important factor in determining the distance obtained in the 6MWT. A study performed at ten centers of seven countries showed that the distance accomplished in the 6MWT by individuals who were over 40 years of age was considered a determined factor³⁵, thus affirming the necessity of specific equations for each country³⁵.

In this study, the values predicted by Enright and Sherrill's equation¹⁶ underestimated the distance achieved in the 6MWT. Corroborating this, Moreira, Moraes and Tannus³⁶, Soares et al.³⁷, and Resqueti

et al.³⁸, reported that the predicted distance¹⁶ tends to underestimate the one accomplished, considering that they did not find significant difference in patients with COPD, healthy women, and patients with *miastenia gravis*, respectively.

We found that Trooster, Gosselink, and Decramer's equation¹⁸ overestimated the distance accomplished. We believe this is due to a methodological difference, given that these authors¹⁸ adopted intervals of 2.5 hours between the 6MWTs, and 30-minute intervals were set for this study. In agreement, Barata et al.¹⁵, found overestimated predicted values¹⁸ for both sexes. It is worth highlighting that Enright and Sherrill¹⁶, and Troosters, Gosselink, and Decramer¹⁸ did not abide by ATS¹ to conduct the 6MWT.

In this study, we verified that the equations of Gibbons et al.¹⁹, and Camarri et al.²², overestimated the distance accomplished in the 6MWT for individuals of both sexes. The cause may be multifactorial, among them test standardization and different ethnicities²⁶. Gibbons et al.¹⁹, used a sample that ranged from 20 to 80 years, and ours varied from 55 to 78 years of age. Studies report that the shorter distance walked by elderly people¹⁵ is due to a decrease in strength, muscle mass, and lung functioning³⁹.

Even though Camarri et al.²², conducted the 6MWT using a methodology similar to the one adopted here, the predicted values overestimated the ones obtained, a finding that corroborates with Iwama et al.²⁶ This is attributed to Brazilians' multiracial profile, which elicited the expectation of values that were lower than those reached by Caucasians¹⁵.

The equations proposed by Masmoudi et al.²³, and Alameri, Al-Majed and Al-Howaikan²⁴ underestimated the distance obtained in the 6MWT. This is due to a difference between the populations, since the capacity for exercising is relatively preserved in Brazilians⁴⁰. Butland et al.⁴¹, inferred that this difference may be associated with lifestyles. In relation to Alameri, Al-Majed, and Al-Howaikan's equation²⁴, the difference may be explained by the conduction of only one 6MWT. Studies suggest that in order to establish the longest distance accomplished in the 6MWT with certainty, the test should be performed three times⁴².

The values predicted by Chetta et al.'s equation²¹ did not differ significantly from the values obtained in our conduction of the 6MWT, because both used similar methodology¹, even though these authors²¹ analyzed a younger sample than the one in this study. Contrary to our results, Iwama et al.²⁶, found a slight overestimation²⁶ using this equation²¹.

Iwama et al.²⁶, were the first to investigate predicted values and potential demographic and anthropometric factors that are determining for the 6MWT in Brazilians. Our results did not differ from the predicted

Table 2. Values of the walked distance obtained in the 6MWT, and values of predicted distance for the 6MWT according to several equations available in scientific literature

| | Total sample (n=43) | Men (n=23) | Women (n=20) |
|--|------------------------|---------------|-----------------|
| WD in the 6MWT | 532.4±86.7 | 565.7±82.0 | 494.1±74.8 |
| Enright and Sherrill ¹⁶ | 486.9±51.6* | 512.3±46.0* | 457.6±42.3* |
| Troosters, Gosselink, Decramer ¹⁸ | 607.2±69.5* | 656.0±40.9* | 553.7±53.8* |
| Gibbons et al. ¹⁹ | 636.4±43.2* | 669.4±22.9* | 598.6±28.6* |
| Enright et al. ²⁰ | 817.1±368.6* | 1131.0±147.4* | 456.1±157.3 |
| Chetta et al. ²¹ | 520.0±35.7 | 545.6±18.7 | 490.7±26.3 |
| Camarri et al. ²² | 678.6±46.2* | 713.2±23.2* | 638.8±30.8* |
| Masmoudi et al. ²³ | 502.9±59.2* | 547.6±32.2 | 454.6±42.1* |
| Alameri, Al-Majed, Al-Howaikan ²⁴ | 485.6±24.7* | 502.5±16.0* | 466.2±17.9 |
| Ben Saad et al. ²⁵ | 590.6±96.6* | 665.7±48.6* | 504.1±56.9 |
| Iwama et al. ²⁷ | 533.4±33.7 | 562.9±11.7 | 502.5±20.4 |
| Dourado, Vidotto, Guerra ³¹ | 585.9±51.5* | 622.1±32.6* | 544.3±35.0* |
| Soares and Pereira ³² | 328.0±29.0* | 330.3±28.1* | 325.4±30.4* |

Data expressed in average (±standard deviation). Paired t-test: *p<0.05 in the 6MWT#reference equations. WD: walked distance; 6MWT: six-minute walk test

values, since the methodology used for the 6MWT and the populations presented similar characteristics.

The values predicted by Dourado, Vidotto and Guerra's equations²⁷, in turn, overestimated those obtained in the 6MWT. We suggest that this is due to age and the number of individuals included in the sample, since the 6MWT methodology and the populations' nationalities are similar. On the other hand, Soares and Pereira's equations²⁸ underestimated the values obtained in the 6MWT. This is attributed to the number of individuals evaluated, race, and also the conduction of three 6MWTs.

CONCLUSION

Most of the 6MWT reference equations used in this study either underestimate or overestimate the values obtained in the 6MWT, which indicates their inadequacy to the population studied here. Moreover, we verified that the equations proposed by Chetta et al.²¹, and Iwama et al.²⁶, were applicable to the population analyzed. It is important to emphasize that there is need for other studies that evaluate the equations with a larger number of participants and in other regions of the country with the purpose of affirming the applicability of these equations to Brazilian people.

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