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

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. 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 et al.
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 reproducibility\(^4\)\(^-\)\(^8\), and for being a low-cost option of easy conduction. In addition to being well tolerated by patients\(^4\)\(^-\)\(^8\), 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 people\(^4\)\(^-\)\(^8\).

Moreover, the 6MWT is considered a predictor of morbimortality\(^11\), 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 COPD\(^13\).

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 people\(^14\), considering that it evaluates the responses provided by the cardiovascular, respiratory, and peripheral vascular systems\(^15\).

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 weight\(^16\)\(^-\)\(^18\), as well as by physiological and clinical factors\(^17\). Among the best known equations, we highlight those proposed by Enright and Sherrill\(^16\) for Americans who are over 40 years of age, and by Troosters, Gosselink, and Decramer\(^19\) for Belgians. Later, other equations were proposed for Americans between 20 and 80 years old\(^19\) and over 68 years of age\(^20\), for healthy Italians\(^21\), for Australians\(^22\), and for sedentary Tunisians who are between 40 and 80 years old\(^23\). In 2009, predictive equations were devised for Arabs\(^24\), Tunisians\(^25\), and Brazilians\(^26\). Finally, other equations, different from one another\(^27\), 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 available in scientific literature, the conduction of this study is justified; it aims at evaluating the applicability of these equations to the 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 standards\textsuperscript{30}, being healthy and over 55 years of age and considered insufficiently active or sedentary by the Physical Activity International Questionnaire (short version)\textsuperscript{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\textsuperscript{36}, Pavona di Albano, Rome, Italy), in accordance with the rules of the American Thoracic Society (ATS)/European Respiratory Society\textsuperscript{32}, 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.\textsuperscript{33}
- Six-minute walk test: Performed according to ATS’s rules\textsuperscript{1}. 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 minute\textsuperscript{1}.

The 6MWT distance values were compared to those predicted by the equations proposed by Enright and Sherrill\textsuperscript{16}, Troosters, Gosselink and Decramer\textsuperscript{18}, Gibbons et al.\textsuperscript{19}, Enright et al.\textsuperscript{20}, Chetta et al.\textsuperscript{21}, Camarri et al.\textsuperscript{22}, Masmoudi et al.\textsuperscript{23}, Alameri, Al-Majed and Al-Howaikan\textsuperscript{24}, and Soares and Pereira\textsuperscript{28}, and the values were significantly lower than those predicted by the equations of Troosters, Gosselink, Decramer\textsuperscript{18}, Gibbons et al.\textsuperscript{19}, Enright et al.\textsuperscript{20}, Camarri et al.\textsuperscript{22}, Ben Saad et al.\textsuperscript{25}, and Dourado, 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 Sherrill\textsuperscript{16}, Masmoudi et al.\textsuperscript{23}, Alameri, Al-Majed and Al-Howaikan\textsuperscript{24}, and Soares and Pereira\textsuperscript{28}, and the values were significantly lower than those predicted by the equations of Troosters, Gosselink, Decramer\textsuperscript{18}, Gibbons et al.\textsuperscript{19}, Enright et al.\textsuperscript{20}, Camarri et al.\textsuperscript{22}, Ben Saad et al.\textsuperscript{25}, and Dourado.

Table 1. Anthropometric and spirometric characteristics of the population studied

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total sample (n=43)</th>
<th>Men (n=23)</th>
<th>Women (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropometric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>66±6.4</td>
<td>65±6.4</td>
<td>66±6.4</td>
</tr>
<tr>
<td>Body mass (Kg)</td>
<td>73±13.8</td>
<td>78±12.5</td>
<td>67±12.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164±8.9</td>
<td>170±5.2</td>
<td>157±6.8</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>270±4.3</td>
<td>26±4.1</td>
<td>27±4.5</td>
</tr>
<tr>
<td>Spirometric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV(_1) (L)</td>
<td>2.8±0.7</td>
<td>3.3±0.4</td>
<td>2.2±0.4</td>
</tr>
<tr>
<td>FEV(_1)/FVC (% pred)</td>
<td>109±15.6</td>
<td>114±14.5</td>
<td>102±14.7</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>3.6±0.9</td>
<td>4.3±0.5</td>
<td>2.8±0.5</td>
</tr>
<tr>
<td>FVC (% pred)</td>
<td>111±14.6</td>
<td>117±12.6</td>
<td>103±13.6</td>
</tr>
<tr>
<td>FEV(_1)/FVC (% pred)</td>
<td>98.5±7.6</td>
<td>97.8±6.8</td>
<td>99.5±8.8</td>
</tr>
<tr>
<td>MVV (L/min)</td>
<td>113±12.2</td>
<td>135±23.1</td>
<td>86±17.7</td>
</tr>
<tr>
<td>MVV (% pred)</td>
<td>110±18.6</td>
<td>116±16.3</td>
<td>102±19.2</td>
</tr>
</tbody>
</table>

Vidotto and Guerra. However, we did not observe significant differences between the distance accomplished in the 6MWT and that predicted by the equations of Chetta et al., and Iwama et al. 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 people. Studies show correlation between the distance accomplished in the 6MWT and age, sex, height, weight, and body mass index. In a Brazilian study, only age and sex were found to be significant determinants of the distance accomplished in the 6MWT. 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 factor, thus affirming the necessity of specific equations for each country.

In this study, the values predicted by Enright and Sherrill’s equation underestimated the distance achieved in the 6MWT. Corroborating this, Moreira, Moraes and Tannus, Soares et al., and Resque et al., reported that the predicted distance 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 equation overestimated the distance accomplished. We believe this is due to a methodological difference, given that these authors adopted intervals of 2.5 hours between the 6MWTs, and 30-minute intervals were set for this study. In agreement, Barata et al., found overestimated predicted values for both sexes. It is worth highlighting that Enright and Sherrill, and Troosters, Gosselink, and Decramer did not abide by ATS to conduct the 6MWT.

In this study, we verified that the equations of Gibbons et al., and Camarri et al., overestimated the distance accomplished in the 6MWT for individuals of both sexes. The cause may be multifactorial, among them test standardization and different ethnicities. Gibbons et al. 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 people is due to a decrease in strength, muscle mass, and lung functioning.

Even though Camarri et al., 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. This is attributed to Brazilians’ multiracial profile, which elicited the expectation of values that were lower than those reached by Caucasians.

The equations proposed by Masmoudi et al., and Alameri, Al-Majed and Al-Howaikan 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 Brazilians. Butland et al., inferred that this difference may be associated with lifestyles. In relation to Alameri, Al-Majed, and Al-Howaikan’s equation, 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 times.

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

Iwama et al., 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

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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

<table>
<thead>
<tr>
<th>Equation</th>
<th>Total sample (n=43)</th>
<th>Men (n=23)</th>
<th>Women (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WD in the 6MWT</td>
<td>532.4±86.7</td>
<td>565.7±82.0</td>
<td>494.1±74.8</td>
</tr>
<tr>
<td>Enright and Sherrill</td>
<td>486.9±51.6*</td>
<td>512.3±46.0*</td>
<td>457.6±42.3*</td>
</tr>
<tr>
<td>Troosters, Gosselink, Decramer</td>
<td>607.2±69.5*</td>
<td>656.0±40.9*</td>
<td>553.7±53.8*</td>
</tr>
<tr>
<td>Gibbons et al.</td>
<td>636.4±43.2</td>
<td>669.4±22.9*</td>
<td>598.6±28.6*</td>
</tr>
<tr>
<td>Enright et al.</td>
<td>8171±368.6</td>
<td>1131±147.4*</td>
<td>4561±157.3</td>
</tr>
<tr>
<td>Chetta et al.</td>
<td>520.0±35.7</td>
<td>545.6±18</td>
<td>490.7±26.3</td>
</tr>
<tr>
<td>Camarri et al.</td>
<td>678.6±46.2</td>
<td>713.2±23.2*</td>
<td>638.8±30.8*</td>
</tr>
<tr>
<td>Masmoudi et al.</td>
<td>502.9±59.2</td>
<td>547.6±32.2</td>
<td>454.6±42.1*</td>
</tr>
<tr>
<td>Alameri, Al-Majed, Al-Howaikan</td>
<td>485.6±24.7</td>
<td>502.5±16.0*</td>
<td>466.2±17.9</td>
</tr>
<tr>
<td>Ben Saad et al.</td>
<td>590.6±96.6</td>
<td>665.7±48.6*</td>
<td>5041±56.9</td>
</tr>
<tr>
<td>Iwama et al.</td>
<td>5334±337*</td>
<td>562.9±17.7</td>
<td>502.5±20.4</td>
</tr>
<tr>
<td>Dourado, Vidotto, Guerra</td>
<td>585.9±515*</td>
<td>622.1±32.6*</td>
<td>544.3±35.0*</td>
</tr>
<tr>
<td>Soares and Pereira</td>
<td>328.0±29.0*</td>
<td>330.3±28.1*</td>
<td>325.4±30.4*</td>
</tr>
</tbody>
</table>

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

The values predicted by Dourado, Vidotto and Guerra’s equations, in turn, overestimated those obtained in the 6MWT. We suggest that this is due to 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 equations 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., and Iwama et al., 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.

**REFERENCES**