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Short Communication

4-meter gait speed test as a tool to prescribe walking exercise intensity in individuals with COPD

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Introduction

Exercise training remains the essential component of rehabilitation programs in individuals with chronic obstructive pulmonary disease (COPD)[1]. In order to guarantee the training benefits, an appropriate prescription of exercise intensity is necessary[1]. The target intensity for training is generally prescribed as a percentage of maximum exercise capacity[1]; however, a simple field test such as the 6-minute walking test (6MWT) was shown to be useful in exercise prescription for walking[2-4] .

The importance of the 6MWT to evaluate exercise capacity is undeniable[5]; nevertheless, the test requires space and time, which may hinder its use in home visits and in some clinical settings. On the other hand, the 4-meter gait speed (4MGS) is a reliable test, which requires short time and space[6-9]. It reflects global well-being and captures the multisystemic effects of disease severity[9]. Furthermore, walking is the main activity in a rehabilitation program and gait speed measure is modifiable through rehabilitation, therefore being a potential marker of functional improvement or decline[8-9].

Although the 4MGS has potential as an assessment tool, further work is necessary to confirm its utilization for exercise prescription. Therefore, the aims of this study were to verify whether it is possible to prescribe the intensity of walking exercise training and to predict the distance covered in the 6MWT through the 4MGS in individuals with moderate-to-very severe COPD. In addition, since there are different available protocols for the 4MGS, another aim was to identify which protocol better estimates these outcomes.

Methods

In this cross-sectional study, 44 individuals were submitted to assessments of lung function, performed according to international guidelines[10], and functional exercise capacity. The study was approved by the Research Ethics Committee of the University Hospital, State University of Londrina, Brazil (080/2014), all individuals signed a written informed consent and the manuscript is presented according to the STROBE guidelines.

A convenience sample was composed by individuals with the diagnosis of COPD according to Global Initiative for Chronic Obstructive Lung Disease (GOLD)[11] criteria, absence of exacerbations within the previous 3 months and not having attended a pulmonary rehabilitation program in the last year. Subjects were excluded if they had any comorbidity that might have influenced the execution of the tests or if, for any reason, they were unable to perform the proposed activities.

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Six-minute walk test: The 6MWT was performed in accordance with international standards[5] and Brazilian normal values were used[12]. Each subject performed two tests and the test with longer walked distance ($6MWT_{distance}$) was considered for analysis. The exercise intensity criteria was set at 75% of the 6MWT average speed ($6MWT_{75\%speed}$)[3], and the 6MWT speed was calculated as the walked distance (in meters) divided by the time (in seconds).

Gait speed[6,7]: Individuals were instructed to walk in a 4-meter course hallway and a stopwatch was used to record the time taken to complete the course. All individuals were submitted to four different protocols of the 4MGS (4MGS-4U; 4MGS-4M; 4MGS-8U; 4MGS-8M, as described below) in a randomized sequence. Each protocol was repeated twice without rest and the faster of the two tests was used to calculate the speed (in m/s).

4MGS-4 (static start): Two cones were placed 4 meters apart and the participant was positioned slightly behind the first cone. Timing with the stopwatch started when the participant began to move and was stopped when the participant's first foot completely crossed the second cone. Individuals were instructed to walk at the usual (4MGS-4U) and maximum (4MGS-4M) speed.

4MGS-8 (rolling start): It was performed in an 8-meter course (a 2-meter acceleration zone, a 4-meter timing area and a 2-meter deceleration zone) and the gait speed in the central 4 meters of the corridor was evaluated. The timing started when the participant's first foot completely crossed the start of the 4-meter timing area and stopped when the participant's first foot completely left this area. The instructed pace was also usual (4MGS-8U) and maximum (4MGS-8M) speed.

The statistical analysis was performed using the statistical software packages SPSS 21.0 (SPSS Inc., USA) and GraphPad Prism 6.0 (GraphPad Software Inc., USA). The normality of data distribution was checked by the Shapiro-Wilk test and described as mean±SD or median [interquartile range]. Paired t test was used to compare 4MGS and $6MWT_{75\%speed}$. Pearson correlation coefficients were calculated and models of univariate linear regression were applied with $6MWT_{distance}$ and $6MWT_{75\%speed}$ as dependent variables, and the 4MGS protocols as independent variables.

In order to verify the reliability of the regression equation, the formula developed in this study was applied *a posteriori* in a validation sample (n=12) composed by different individuals with COPD (not included in the first analysis). These individuals were selected according to the same inclusion criteria of the first sample. The Intraclass Correlation Coefficient (ICC) was used to evaluate agreement between the actual $6MWT_{75\%speed}$ and the predicted values. $P<0.05$ was set as statistical significance.

Results

The characteristics of 44 individuals with COPD are described in Table 1. The gait speed varied among the 4MGS protocols and the highest speed was achieved in the 4MGS-8M protocol (Table 1). The speed achieved in all 4MGS protocols was higher than $6MWT_{75\%speed}$ ($P<0.01$ for all).

Significant correlations were found between $6MWT_{75\%speed}$ with all 4MGS protocols ($0.47 \leq r \leq 0.69$, see Table 2). There were also significant correlations between $6MWT_{distance}$ with 4MGS-4M, 4MGS-8U and 4MGS-8M, ($0.40 \leq r \leq 0.49$, see Table 2). The coefficients of determination values are described in Table 2. $6MWT_{distance}$ could not be estimated satisfactorily by any of the 4MGS protocols. On the other hand, a model of univariate linear regression showed that the 4MGS-8M predicted $6MWT_{75\%speed}$, explaining 46% of its variability ($P<0.0001$) (Figure 1). According to 4MGS-8M, the reference equation for the $6MWT_{75\%speed}$ was:

$$6MWT_{75\%speed}\,(in\ m/s) = \left[0.407 + (0.329 * 4MGS\text{-}8M)\right]$$

The characteristics of the validation sample composed by 12 individuals with COPD (6 male) included in the *a posteriori* analysis were: age 68±7 years, BMI 27±4 kg/m^2, FEV_1 57±17%pred and FEV_1/FVC ratio 57±11%pred. When the reference equation for the $6MWT_{75\%speed}$ derived from the 4MGS-8M was applied in this validation sample, there was good agreement between the actual $6MWT_{75\%speed}$ (0.99 ± 0.11 m/s) and the predicted $6MWT_{75\%speed}$ (0.98 ± 0.11 m/s) obtained from the reference equation (ICC=0.80). No difference between the actual and predicted $6MWT_{75\%speed}$ was found (P=0.81) and there was moderate correlation between them (r=0.63).

Table 1. Characteristics of sample of the individuals with COPD.

	n=44
Sex (M/F)	24/20
Age (years)	69±8
BMI (kg.m^{-2})	25[22-30]
FEV_1 (L)	1.25±0.45
FEV_1 (%predicted)	49±18
FEV_1/FVC (%)	53±12
GOLD (II/III/IV)	23/15/6
$6MWT_{Distance}$ (m)	453±73
6MWT (%predicted)	85±15
$6MWT_{speed}$ (m/s)	1.28±0.20
$6MWT_{75\%speed}$ (m/s)	0.96±0.15
4MGS-4U(m/s)	1.05±0.23
4MGS-4M (m/s)	1.38±0.24
4MGS-8U (m/s)	1.29±0.23
4MGS-8M (m/s)	1.68±0.31

Data expressed as absolute frequency, mean±SD or median [IQR]. M: male; F: female; BMI: body mass index; FEV_1: forced expiratory volume in the first second; FVC: forced vital capacity; GOLD: Global Initiative for Chronic Obstructive Lung Disease; $6MWT_{75\%speed}$: 75% of the six-minute walk test average speed; $6MWT_{Distance}$: distance walked in the six-minute walk test; 4MGS-4U: four-meter gait speed at the usual speed in a 4-meter course; 4MGS-4M: four-meter gait speed at the maximal speed in a 4-meter course; 4MGS-8U: four-meter gait speed at the usual speed in an 8-meter course; 4MGS-8M: four-meter gait speed at the maximal speed in an 8-meter course.

Table 2. Pearson correlation coefficients and coefficients of determination of the four 4MGS protocols with walking exercise intensity and the distance covered in the 6MWT as dependent variables.

Protocol	r $6MWT_{75\%speed}$	r $6MWT_{Distance}$	R^2 $6MWT_{75\%speed}$	R^2 $6MWT_{Distance}$
4MGS-4U	0.47	0.28*	0.20	0.06
4MGS-4M	0.63	0.46	0.38	0.19
4MGS-8U	0.59	0.40	0.33	0.14
4MGS-8M	0.69	0.49	0.46	0.23

6MWT75%speed: 75% of the six-minute walk test average speed; 6MWTDistance: distance walked in the six-minute walk test. 4MGS-4U: four-meter gait speed at the usual speed in a 4-meter course; 4MGS-4M: four-meter gait speed at the maximal speed in a 4-meter course; 4MGS-8U: four-meter gait speed at the usual speed in an 8-meter course; 4MGS-8M: four-meter gait speed at the maximal speed in an 8-meter course; *P=0.06.

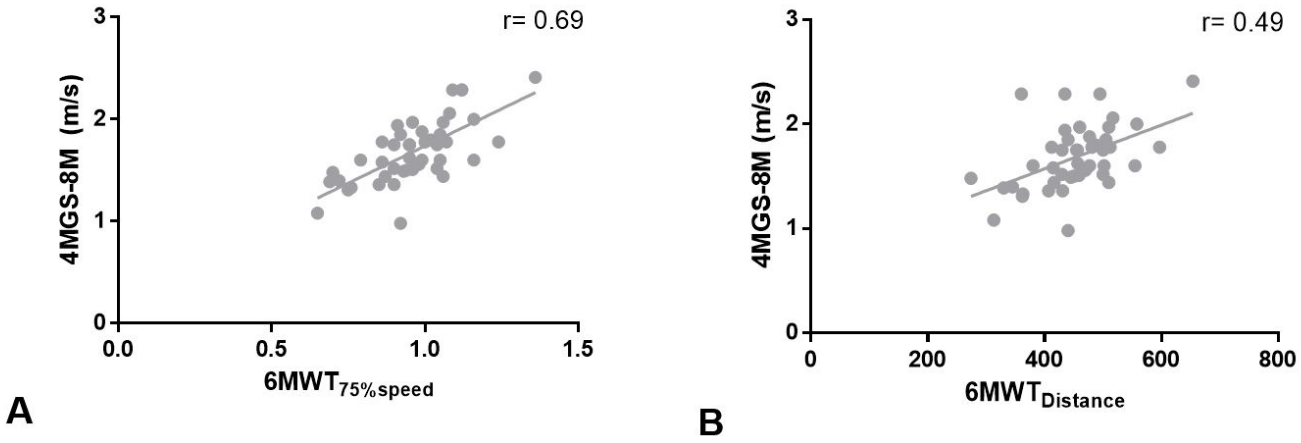

Figure 1. Correlation between 4MGS-8M and 6MWT (A: 75% of the average speed; and B: distance walked; $P \leq 0.001$ for both). 6MWT: six-minute walk test; 4MGS-8M: four-meter gait speed at the maximal speed in an 8-meter course.

Discussion

Although the 4MGS can be used as an assessment tool of physical function in individuals with COPD[6-9], to the authors' best knowledge this is the first study to assess its capacity to prescribe exercise. In addition, the findings were extended to different 4MGS measurement protocols. Among the four studied protocols, the 4MGS performed at maximum speed in an 8-meter corridor seems to be a suitable option to prescribe walking exercise intensity for individuals with COPD. The present results also demonstrated that these four studied protocols were not able to properly predict the distance achieved in the 6MWT.

Although the 6MWT has a submaximal profile, it can be used to prescribe walking exercise intensity since it provides sufficient physiological stress in individuals with COPD[2]. Responses concerning maximal oxygen consumption (VO_2max) are similar during the execution of the 6MWT and during the cardiopulmonary exercise test (CPET)[13]. Although the 4MGS provides less physiological information and was not able to identify the need for oxygen supplementation when compared to the 6MWT[14], it was applicable to prescribe walking exercise training intensity in an easy-to-perform way. Furthermore, in accordance with previous studies[6,15,16], the present study also found a significant association between gait speed and exercise capacity.

Simple functional tests which simulate everyday tasks and involve basic movements are increasingly used in clinical practice[14] and the literature should focus more deeply in the understanding of some gaps regarding these tests. Meaningful information can come from the use of gait speed tests for chronic respiratory diseases, more than just the speed of the test[17]. For instance, it can also be used as a screening tool for exercise intolerance[6,9], as an outcome measure for frail individuals[6,9] and even as an indicator that predicts end of life in COPD[17]. Moreover, the 4MGS offers some advantages in daily practice since it does not require a special place to be performed (e.g., 30-meter corridor), has a short administration time and requires simple and low cost equipment[6,7,14].

Gait speed measurements are reliable in individuals with COPD regardless of the instructed pace and distance[7]; however, according to the present results, walking exercise intensity can be better explained by the 4MGS-8M protocol. This discrepancy happens because a greater number of steps and a rolling start in the test might be more accurate for estimating gait speed[18]. A static start in short distances can result in slower speed[18]. None of the protocols could explain more than 23% of $6MWT_{distance}$, and this is likely because speed and distance have different constructs. Therefore, the 4MGS does not predict well the $6MWT_{distance}$ and cannot replace it, although it seems to provide a feasible way to prescribe walking exercise.

Despite all efforts, the present study has limitations. The use of a convenience sample, with no individuals classified as GOLD I, restricts the results to individuals with moderate-to-

very severe degree of airflow obstruction. Moreover, no oxygen consumption analysis was performed. Larger studies could provide more robust prediction models. Furthermore, future studies should investigate whether using the 4MGS for walking exercise intensity prescription is able to lead to clinically significant improvements after pulmonary rehabilitation.

In conclusion, the clinical usefulness of the 4MGS may be larger than previously expected since all 4MGS protocols are significantly associated with 6MWT. Furthermore, the 4MGS at the maximum speed in a corridor of 8 meters proved to be the best option in the prescription of walking exercise intensity for individuals with moderate-to-very severe COPD.

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Conflict of interest

None.

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Author contributions

GWB and FP had full access to the data and take responsibility as guarantors for the integrity of the data and the accuracy of the analysis and conclusions; GWB, AAM, FVCM, and AR made substantial contributions to the conception or design of the work. All authors contributed substantially to the acquisition, analysis or interpretation of data for the work and provided final approval of the article.

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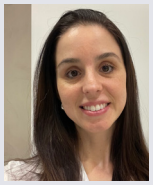

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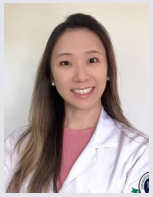

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