Responsiveness of the six-minute step test to a physical training program in patients with COPD*

Responsividade do teste do degrau de seis minutos a um programa de treinamento físico em pacientes com DPOC

Kamilla Tays Marrara, Diego Marmorato Marino, Maurício Jamami, Antônio Delfino de Oliveira Junior, Valéria Amorim Pires Di Lorenzo

Abstract

Objective: To evaluate the responsiveness of the six-minute step test (6MST) to an aerobic physical training program (PTP) and to determine the efficacy of the PTP regarding spirometric variables during the 6MST, as well as physical performance, sensation of dyspnea, and SpO_2 during the 6MST and the six-minute walk test (6MWT), in patients with COPD. **Methods:** This was a controlled, prospective randomized study involving patients clinically diagnosed with COPD, with an FEV_1/FVC ratio < 70%, and having been clinically stable in the last two months. The patients were randomized to undergo a PTP on a treadmill, three times a week, for six weeks (PTP group) or not (control group). Histories were taken from all of the patients, who received regular respiratory therapy during the study period, undergoing physical examination and spirometry before and after bronchodilator use; incremental symptom-limited cardiopulmonary exercise testing; the 6MST; and the 6MWT. **Results:** Of the 36 patients that completed the study, 21 and 15 were in the PTP and control groups, respectively. In the PTP group, there was a significant increase in the number of steps climbed during the 6MST and in the six-minute walk distance (in m and % of predicted), as well as a significant decrease in the sensation of dyspnea during the 6MWT. **Conclusions:** The 6MST showed responsiveness to the PTP. However, the 6MWT appears to be more responsive to the PTP proposed.

Keywords: Exercise test; Exercise; Pulmonary disease, chronic obstructive.

Resumo

Objetivo: Avaliar a responsividade do teste do degrau de seis minutos (TD6) a um programa de treinamento físico (PTF) aeróbio e verificar a eficácia do PTF quanto às variáveis ergoespirométricas no TD6, assim como ao desempenho físico, sensação de dispneia e SpO_2 no TD6 e no teste de caminhada de seis minutos (TC6) em pacientes com DPOC. **Métodos:** Estudo controlado, prospectivo e randomizado com pacientes com diagnóstico clínico de DPOC que apresentassem relação VEF_1/CVF < 70% e condições clinicamente estáveis nos últimos dois meses. Os pacientes foram randomizados em grupo PTF, que realizaram um PTF em esteira por seis semanas, três vezes por semana, e grupo controle. Todos os participantes receberam cuidados usuais de fisioterapia respiratória durante o período de estudo e foram submetidos a anamnese, exame físico, espirometria antes e após o uso de broncodilatador, teste cardiopulmonar incremental sintoma limitado, TD6 e TC6 nos momentos basal e final. **Resultados:** Dos 36 pacientes que completaram o estudo, 21 e 15 foram distribuídos nos grupos PTF e controle, respectivamente. Verificou-se um aumento significativo do número de subidas no degrau no TD6, da distância percorrida no TC6 (em m e % do previsto), assim como uma redução significativa da sensação de dispneia durante o TC6 somente no grupo PTF. **Conclusões:** O TD6 apresentou responsividade ao PTF. No entanto, acreditamos que o TC6 seja mais responsivo ao PTF proposto.

Descritores: Teste de esforço; Exercício; Doença pulmonar obstrutiva crônica.

* Study carried out at the *Universidade Federal de São Carlos* – UFSCar, Federal University of São Carlos – São Carlos, Brazil.
Correspondence to: Kamilla Tays Marrara. Avenida Filomeno Rispoli, 179, Parque Santa Marta, CEP 13564-200, São Carlos, SP, Brasil.
Tel. 55 16 3351-8343. E-mail: kmarrara@hotmail.com
Financial support: None.
Submitted: 17 November 2011. Accepted, after review: 16 July 2012.

Introduction

Clinical tests have been shown to be appropriate for assessing patients with COPD and are considered representative of an activity of daily living. Among these tests, the six-minute step test (6MST) has been used as an alternative for assessing such patients, having the advantages of requiring little physical space to be carried out[1] and only a single step for use as an ergometer.[2]

However, Dal Corso et al.[1] and Swinburn et al.[3] reported that step climbing involves working against gravity and the use of muscle groups that are not frequently used during activities of daily living, which produces physiological responses that are different from those of the walk test, making the metabolic and ventilatory demands of step climbing more intense.

In addition, it should be borne in mind that the leg muscles in patients with COPD are impaired in terms of strength and endurance because of a reduction in muscle mass and aerobic capacity,[4] compromising performance. For this reason, it is important that leg muscle exercises be performed to improve the functional performance of these patients. Therefore, the inclusion of aerobic physical training in rehabilitation programs for patients with COPD has been essential, and the benefits of such training are observed regardless of disease stage. To Bourjeily & Rochester,[5] training programs should last an average of 6 to 12 weeks, at a frequency of three sessions per week and with exercise intensity ranging from 60% to 80% of maximal capacity. However, it is of note that although there is no scientific evidence in the literature to support that the 6MST is responsive to an aerobic physical training program (PTP) in patients with COPD, this type of program has been reported to be an additional advantage in clinical practice, involving reduced costs and the use of little physical space.

The primary objective of the present study was to evaluate the responsiveness of the 6MST to aerobic physical training in patients with stage II or III COPD. The secondary objective of the study was to determine the efficacy of this training regarding oxygen consumption (VO_2); metabolic demand, as measured by the ratio between VO_2 and peak oxygen consumption (VO_{2peak}); pulmonary ventilation (V_E); ventilatory demand, as measured by the ratio between V_E and maximal voluntary ventilation (MVV); and ventilatory equivalent for carbon dioxide, as measured by the ratio between V_E and carbon dioxide production (VCO_2), all of which during the 6MST. In addition, we assessed physical performance, dyspnea, and SpO_2 during the 6MST and the six-minute walk test (6MWT). Our hypothesis was that the 6MST would be responsive to aerobic physical training on a treadmill in terms of physiological variables, performance on the test, and dyspnea.

Methods

This was a controlled, prospective randomized study conducted at the *Universidade Federal de São Carlos* (UFSCar, Federal University of São Carlos) Special Unit for Respiratory Therapy, located in the city of São Carlos, Brazil. The patients were referred to the unit by an attending pulmonologist. The inclusion criteria were having been clinically diagnosed with COPD, having an FEV_1/FVC ratio < 70%, and having been clinically stable in the last two months (no disease exacerbations).

Pulmonary function testing (MasterScope®; Jaeger, Hoechberg, Germany) was conducted by the attending pulmonologist before and after bronchodilator use in order to assess reversibility, which was based on changes in FEV_1, with an increase of more than 12% and at least 0.2 L[6]; in addition, an FEV_1/FVC ratio < 70% and the FEV_1 value were used in order to classify patients as having moderate obstruction ($50\% \leq FEV_1 < 80\%$ of predicted) or severe obstruction ($30\% \leq FEV_1 < 50\%$ of predicted), as defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD).[7] All technical procedures, as well as the acceptability and reproducibility criteria, were in accordance with the recommendations of the American Thoracic Society.[8] At least three technically acceptable expiratory curves were obtained for measuring slow vital capacity, FVC, and MVV, and the predicted values used were those of Pereira et al.[9]

The exclusion criteria were as follows: having decompensated cardiovascular disease, rheumatic disease, neuromuscular disease, or orthopedic disease that prevented the performance of the tests by limiting exercise capacity; having attended a regular physical exercise program for six months prior to the study period; and not having performed a test or protocol of the present study for any reason.

Histories were taken from all patients, who underwent physical examination, pulmonary

function testing before and after bronchodilator use, incremental symptom-limited cardiopulmonary exercise testing (CPET), the 6MST, and the 6MWT. All tests were performed within a one-week period and were repeated after six weeks of physical training.

The tests were performed on different days, with the initial evaluation being performed at the study outset, CPET being performed on day 2, the 6MST being performed on day 3, and the 6MWT being performed on day 4. The same test sequence was used in reassessment.

For CPET, an incremental treadmill protocol was used, starting at 2 km/h for 2 min for warm-up and increasing the speed by 0.5 km/h every 2 min, with the slope being kept constant at 3%.[10-12] Testing was performed on a treadmill ergometer at incrementally increasing speeds because this approach is more specific, is functional, and is similar to an activity of daily living. Testing was stopped if the patient felt unable to proceed or if there were signs or symptoms that made it impossible to continue.[12]

The 6MST was performed on a 20-cm-high step,[1] which was 80 cm in length and 40 cm in width and was covered with anti-slip flooring. The test started from a standing position, and the patients were instructed to step up and down the step at their own pace for 6 min, to stop the test temporarily if necessary, and to alternate their legs without the support of their arms, which remained stationary at their sides; the patients performed the test at a freely chosen cadence.[1]

The general principles of the 6MST were based on the recommendations of the American Thoracic Society,[13] and functional capacity on the 6MST was measured by the total number of steps climbed with both feet and by calculating work (VO_2/number of steps climbed).

The 6MST and CPET included analysis of expired gases by means of a Medical Graphics VO_{2000} metabolic system (Medical Graphics Inc., St. Paul, MN, USA), which was operated with Aerograph® software for capture (analog-digital converter) and storage of signals with the 20-second method. Patients remained seated while a mouthpiece was put in place and was attached to the metabolic system, which was supported by a head fastener to relieve the weight of the mouthpiece, and the nostrils were blocked by a nose clip. The following parameters were evaluated: VO_2 (L/min) at standard temperature and pressure, dry; the VO_2/VO_{2peak} ratio, as calculated by using the VO_2 obtained during each activity evaluated and the VO_{2peak} obtained during CPET; V_E (L/min) at body temperature, pressure, saturated, as measured with a bidirectional pneumotachograph; the V_E/MVV ratio, as calculated by using the V_E obtained during each activity and by MVV as measured by direct spirometry[14]; and the V_E/VCO_2 ratio.

The 6MST and CPET were performed in the afternoon in order to prevent different physiological responses because of circadian changes, and in a climate-controlled environment (temperature, 22-24°C; and relative humidity, 50-60%).[15] In addition, all patients were initially instructed not to ingest caffeine, alcoholic beverages, or any other stimulating foods/drinks on the day of data collection and not to perform strenuous activities one day prior to data collection.

The 6MWT was performed in a 30-m level corridor. At each minute, standard encouragement was given; SpO_2 and HR were measured with a portable pulse oximeter (Model 8500A; Nonin Medical Inc., Plymouth, MN, USA) and a frequency meter (Polar Electro Co., Kempele, Finland), respectively; and the patient was asked about dyspnea and fatigue/pain by means of a modified Borg CR10 scale. Functional capacity during the 6MWT was measured by the six-minute walk distance (6MWD, in m), which was recorded at the end of the test, as well as by the percent predicted 6MWD. Predicted 6MWD was calculated by the following formula[16]:

$$\text{Predicted 6MWD (in m)} = 622.461 - (1.846 \times \text{age}) + (61.503 \times \text{gender})$$

where age was measured in years, male gender = 1, and female gender = 0.

Two tests were performed 30 min apart in order to eliminate the learning effect, the higher of the two values obtained being used in the analysis.[13]

The patients included in the study were randomized, by means of sealed, sequentially numbered envelopes, into two groups: PTP group (n = 22 participants) and control group (n = 21 participants).

The patients in the PTP group completed a 5-min warm-up at 2 km/h on a treadmill, followed by 30 min of aerobic physical training, with the slope being kept constant at 3%. The

training speed was 70% of the maximum speed achieved during CPET,[17] being adjusted during the sessions according to patient tolerance. The sessions were individual and were supervised by a physical therapist.

The patients in the control group and those in the PTP group received regular respiratory therapy, which involved education on diaphragmatic breathing, free arm and leg exercises, and stretching of the neck, trunk, arm, and leg muscles. In addition, the two groups of patients underwent bronchial hygiene therapy, if necessary.

The treatment program for both groups consisted of three sessions per week, on alternate days, for six consecutive weeks, totaling 18 sessions. At the beginning of the sessions, pulmonary auscultation was performed and blood pressure, SpO_2, and HR were measured. In addition, during the sessions, SpO_2 and HR were measured for monitoring.

The present study was approved by the local human research ethics committee (Protocol no. 008/2006), and all participants gave written informed consent after having been informed of the proposed protocol, in compliance with Brazilian National Health Council Resolution 196/96.

Statistical analysis was carried out with the Statistical Package for the Social Sciences, version 18.0 (SPSS Inc., Chicago, IL, USA). Normality of data distribution was assessed by the Shapiro-Wilk test, which revealed normal distribution. Values are expressed as means and standard deviations, except for dyspnea values, which are expressed as median (range). Anthropometric and spirometric variables were analyzed by the paired t-test. The remaining study variables were analyzed by two-way ANOVA and the Tukey-Kramer post hoc test. The Kruskal-Wallis test and Dunn's post hoc test were used for quantitative analysis of dyspnea. The level of statistical significance was set at $p < 0.05$ for all tests.

The two groups were compared in terms of the differences between post-intervention values and pre-intervention values, in order to assess clinical improvement in response to physical training.

In one study, 6MST responsiveness was evaluated by the difference between the mean number of steps climbed after the intervention and the mean number of steps climbed before the intervention in relation to the pre-intervention standard deviation.[18] In the present study, we used the difference between the mean number of steps climbed after the intervention and that of those climbed before the intervention.

The power of our sample was calculated by the program Ene, version 2.0 (GlaxoSmithKline, Madrid, Spain), which suggested a sample size of 11 patients per group, assuming a loss of 15% and a power of over 80% for the variable minimum clinically significant 6MWD, which corresponds to a minimum increase of 35 m between pre- and post-intervention values.[18]

Results

We recruited 51 patients clinically diagnosed with COPD. Of those, 8 were excluded: 4 because they had mild obstruction; 2 because they did not participate in all evaluations; and 2 because they were unavailable to attend the proposed treatment program. Therefore, 43 male patients remained in the study. Initially, the PTP and controls groups consisted of 22 and 21 patients, respectively; however, only 21 and 15 patients, respectively, completed the study (Figure 1).

The patients who completed the study attended 18 physical therapy sessions, and the groups were found to be homogeneous in terms of anthropometric and pulmonary function data (Table 1). In addition, the groups were similar in terms of baseline MVV, VO_2, V_E, ventilatory demand, metabolic demand, ventilatory equivalent for carbon dioxide, dyspnea, and SpO_2 (Table 1).

In the PTP and control groups, 10 and 9 patients, respectively, were classified as GOLD stage II, whereas 11 and 6 were classified as GOLD stage III.[7]

Table 2 shows the pre- and post-intervention results; in either group, there were no significant differences between pre- and post-intervention VO_2, VO_2/VO_{2peak}, V_E, V_E/MVV, or V_E/VCO_{2peak}. In addition, there were no significant differences between the two groups in terms of those variables.

The number of steps climbed increased significantly in the PTP group and remained similar in the control group, the same being true for the 6MWD (in m and % of predicted; Table 3). In addition, dyspnea was reduced during the 6MST and the 6MWT in the PTP group and remained the same in the control group. Pre- and post-intervention SpO_2 values were similar, with no significant differences in either group (Table 3).

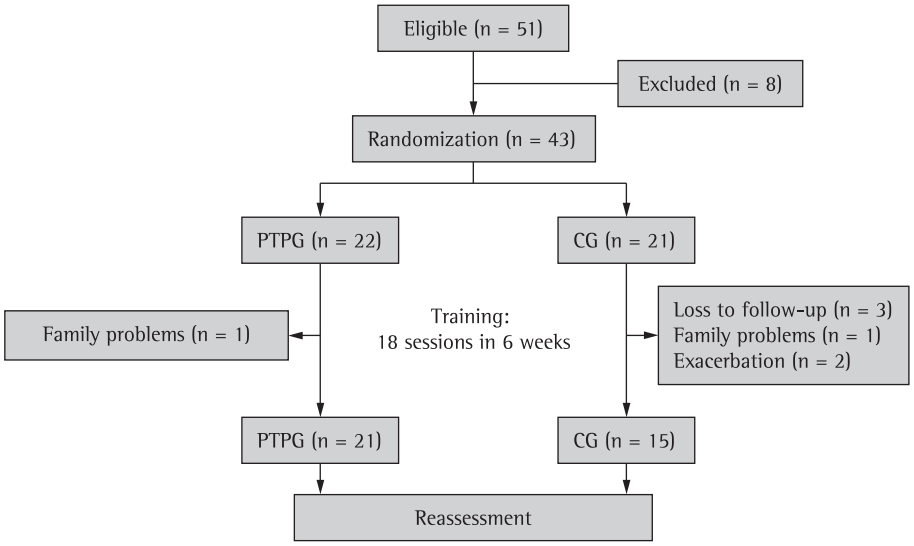

Figure 1 - Flowchart of the study. PTPG: physical training program group; CG: control group.

Table 1 - Anthropometric, spirometric, metabolic, and ventilatory characteristics of the patients at baseline.[a]

Characteristic	Groups	
	Physical training	Control
	(n = 21)	(n = 15)
Age, years	70.5 ± 8.5	68.3 ± 8.7
Weight, kg	62.2 ± 13.2	63.9 ± 11.1
Height, cm	165.5 ± 4.8	164.5 ± 5.5
BMI, kg/m^2	22.8 ± 3.4	23.4 ± 3.2
FEV_1, L	1.2 ± 0.4	1.2 ± 0.5
FEV_1, % of predicted	48.5 ± 15.4	45.4 ± 16.7
FVC, L	2.3 ± 0.6	2.4 ± 0.8
FVC, % of predicted	72.5 ± 20.5	71.3 ± 18
FEV_1/FVC, %	51.9 ± 10	49 ± 11.8
MVV, L/min	47.7 ± 15.9	46.9 ± 19.8
MVV, % of predicted	49.9 ± 17.8	45.4 ± 17.1
VO_2 at rest, mL/min	257 ± 11.2	230 ± 68.9
VO_{2peak} during CPET, mL/min	1,000.6 ± 415.5	1,055.3 ± 546.8
Ventilatory equivalent for CO_2 at rest	40.2 ± 9.8	37.5 ± 11.2
Dyspnea, modified Borg scale[b]	2 (0.5-5.0)	1 (0.5-5.0)
SpO_2 at rest, %	93.3 ± 2.5	93.3 ± 3.3

BMI: body mass index; MVV: maximal voluntary ventilation; VO_2: oxygen consumption; VO_{2peak}: peak oxygen consumption; and CPET: incremental symptom-limited cardiopulmonary exercise testing. [a]Data expressed as mean ± SD, except where otherwise indicated. [b]Data expressed as median (range).

By comparing the two groups, we found significantly higher 6MWD values (in m and % of predicted) in the PTP group.

In the PTP group, dyspnea was significantly reduced, although only during the 6MWT. There were no significant changes in the degree of dyspnea during the 6MST in either group. By comparing the two groups, we found that the degree of dyspnea was significantly lower in the PTP group, although only during the 6MWT (Table 3).

There were no significant differences between pre- and post-intervention SpO_2 values during the 6MST or during the 6MWT in either group,

Table 2 - Peak metabolic and ventilatory variables during the six-minute step test before and after the intervention in the groups studied.[a]

Variable	Groups					
	Physical training (n = 21)			Control (n = 15)		
	Pre-intervention	Post-intervention	Δ	Pre-intervention	Post-intervention	Δ
VO_{2peak}, mL/min	977 ± 320.9	980.3 ± 356.8	21.3 ± 343.7	895.5 ± 557.9	827 ± 187.6	−49.3 ± 483.4
VO_2/VO_{2peak}, %	116.9 ± 41.3	115.2 ± 57	−6.1 ± 40.5	89 ± 24.9	84.3 ± 38.2	−5 ± 51.4
V_{Epeak}, L/min	25.9 ± 6.7	27.6 ± 9.5	1.5 ± 7.6	20.2 ± 11.1	19.6 ± 4.5	−1.4 ± 10.6
V_E/MVV, %	53.3 ± 11.3	56.2 ± 15.7	0.7 ± 6.9	48.7 ± 13.1	43.3 ± 10.8	−6.5 ± 19.4
V_E/VCO_{2peak}	30.8 ± 12.1	31.3 ± 10.3	0.5 ± 6.2	26 ± 3.4	25.7 ± 5.2	−1.9 ± 7.7

Δ: post-intervention – pre-intervention; VO_{2peak}: peak oxygen consumption; VO_2/VO_{2peak}: metabolic demand; V_{Epeak}: peak pulmonary ventilation; V_E/MVV: ventilatory demand; V_E/VCO_2: ventilatory equivalent for carbon dioxide. [a]Data expressed as mean ± SD.

Table 3 - Results obtained for the study variables during the six-minute step test and the six-minute walk test before and after the intervention in the groups studied.[a]

Result	Groups					
	Physical training (n = 21)			Control (n = 15)		
	Pre-intervention	Post-intervention	Δ	Pre-intervention	Post-intervention	Δ
Steps climbed during the 6MST, n	43.1 ± 16.2	54.6 ± 12.9	10.6 ± 13.2*	42.6 ± 28.7	45.8 ± 30.4	2.2 ± 15.4
Work efficiency during the 6MST, mL/min/ number of steps climbed	26.5 ± 9.2	22 ± 11.1	−4.6 ± 8.0	22.6 ± 5.2	21.4 ± 10.6	−0.74 ± 11.4
Dyspnea during the 6MST, modified Borg scale[b]	1 (0.5-5.0)	0 (0-2)	0 (−4 to 1)	0.5 (0.5-5.0)	0 (0-5)	0 (−2 to 3)
SpO_2 during the 6MST, %	88.4 ± 5.4	89.5 ± 4.6	0.3 ± 3.7	88.8 ± 7.7	88.1 ± 7.0	−0.8 ± 6.9
6MWD, m	387.3 ± 159.0	452.1 ± 133.6	64.9 ± 79.3*	387.5 ± 222.1	396.7 ± 221.0	9.2 ± 133.8**
6MWD, % of predicted	69.9 ± 28.2	81.9 ± 23.9	12.0 ± 14.9*	72.3 ± 27.1	69.8 ± 39.7	−2.6 ± 21.0**
Dyspnea during the 6MWT, modified Borg scale[b]	2 (0.5-5.0)	0 (0-1)	0 (−5 to 0)*	1 (0.5-5.0)	2 (0-5)	0 (−2 to 5)**
SpO_2 during the 6MWT, %	86.2 ± 6	86.8 ± 7.1	0.7 ± 6.4	86.1 ± 6.2	85.7 ± 6.5	−0.4 ± 3.4

Δ: post-intervention – pre-intervention; 6MST: six-minute step test; DTC6: six-minute walk distance; and 6MWT: six-minute walk test. [a]Data expressed as mean ± SD, except where otherwise indicated. [b]Data expressed as median (range). *$p < 0.05$ of the within-group difference. **$p < 0.05$ of the between-group difference.

and there were no significant differences between the two groups, as shown in Table 3.

The effect size for responsiveness of the 6MST was found to be approximately 11 steps and 2 steps for the PTP and control groups, respectively.

Discussion

To our knowledge, the present study was the first study to evaluate the responsiveness of the 6MST to aerobic physical training, having

demonstrated improved physical performance. In addition, the training led to an increase in the 6MWD (in m and % of predicted), although the degree of dyspnea was reduced only during the 6MWT.

The reduction in physical exertion in patients with COPD tends to promote disease progression and worsening, and this contributes to a spiral of inactivity, physical deconditioning, and dyspnea.[19] In the present study, aerobic physical training on a treadmill was found to result in increased physical activity levels, a finding that was confirmed by the increase in the number of steps climbed during the 6MST and by the increase in the 6MWD. Improved physical performance is, according to one group of authors,[20] an important indicator in the evaluation of the effectiveness of treatment programs in patients with COPD.

Data in the literature[21] have demonstrated that aerobic physical training results in an increase in the 6MWD and in improved exercise tolerance in patients with COPD. One study[22] also demonstrated a significant increase in the 6MWD after a program involving aerobic physical training, as did a study by Cooper,[23] who demonstrated that physical training for six weeks, three times a week, results in improved physical performance.

Puhan et al.[18] reported that an increase of 35 m in the 6MWD in relation to pre-intervention values is a clinically significant improvement. In the present study, the mean increase in the 6MWD was 64.9 m.

In the present study, metabolic energy expenditure during the 6MST was found to be high, surpassing the VO_{2peak} achieved during CPET. However, it is of note that pre- and post-training metabolic energy expenditures were similar, with performance on the test being better in the post-intervention phase. According to one group of authors,[1] VO_2/VO_{2max} has been shown to be high during step tests in comparison with the values obtained during other field tests in patients with COPD. This is probably due to the fact that step climbing requires work against gravity.[24]

In addition, it should be borne in mind that although pre- and post-intervention VO_{2peak} values during the 6MST were similar for both groups (as was work), the PTP group showed improved physical performance, with an increase of approximately 11 steps and a trend toward decreased work.

According to Ferrazza et al.,[25] it is expected that, in addition to high $VO_2/VO_{2max,}$ patients with COPD show high V_E/MVV as factors limiting exercise capacity, with V_E/MVV behaving similarly to VO_2/VO_{2max} even after intervention. Therefore, the use of the 6MST to assess patients with COPD makes it possible to quantify the limitation to exercise involving the legs alone, as well as allowing quantification of functional capacity.

We found that V_E/VCO_2 values were similar during the 6MST for an increase, on average, of 11 steps after training. According to some studies, V_E/VCO_2 has been used as an indicator of ventilatory efficiency, which makes it possible to assess the efficiency of ventilation in eliminating carbon dioxide, being a marker of the appropriateness of the ventilatory response to metabolic stimuli.[26]

Airflow limitation during exercise is assessed by the perception of dyspnea, dyspnea being a symptom attributed to airflow limitation due to a chronic imbalance between increased ventilatory demand and reduced capacity to meet the demand,[7] which is one of the factors limiting exercise capacity. Therefore, one of the goals of COPD treatment is to reduce dyspnea. In the present study, we found that aerobic physical training led to a significant reduction in the perception of dyspnea during the 6MWT. This finding corroborates those reported by one group of authors,[11] who observed a reduction in dyspnea (from 1.10 ± 1.90 to 0.05 ± 0.20) in COPD patients submitted to a treadmill test after six weeks of physical training on a treadmill.

It is known that patients with moderate to severe COPD can experience a decrease in SpO_2 during functional tests,[27] SpO_2 monitoring being therefore indispensable during such tests. In the present study, we found that, at the peak of both tests, patients in the two groups had desaturation, characterizing gas exchange dysfunction associated with chronic airway obstruction. This abnormality in gas exchange is one of the determining factors for stopping physical exercise in patients with COPD.

In addition, when reporting on the step test, one group of authors[28] recommends considering the weight and height of the patients, as well as the height of the step, because, unlike in the 6MWT, in which there is only a horizontal component in the work performed, in the step test there is the addition of vertical displacement, which tends to increase the demand level of the

test. However, in the present study, the patients performed the 6MST at a freely chosen cadence. Karsten & Lima[29] emphasized that a freely chosen cadence allows patients to adjust their pace during exercise according to their limitations, preventing early termination of the test.

Some studies have employed the same step test duration as that employed in the present study, i.e., 6 minutes.[1] Data in the literature also recommend this duration for a better evaluation of the test results, a recommendation that was confirmed by one group of authors,[30] because there is a correlation with the 6MWT; this correlation was more evident in the last minutes of the test with respect to the variables related to the subjective perception of exertion, increasing the sensitivity of the test and facilitating its comparison with the 6MWT. However, the type of protocol used for CPET in the present study might have influenced the responses to exercise in the patients with COPD, although the protocol has been developed in the laboratory and used in several previous studies. In addition, CPET was performed on a treadmill, as was physical training. Although walking on a treadmill reflects an activity of daily living, it is not a specific training protocol for the muscle group involved in performing the 6MST, as it is for the muscle group involved in performing the 6MWT.

On the basis of our results, we can conclude that the 6MST showed responsiveness to aerobic physical training on a treadmill in terms of physical performance and that it can be recommended in clinical practice, although there is no scientific evidence that defines a clinically significant increase in the number of steps climbed. Aerobic physical training was shown to be beneficial for patients with stage II or III COPD. However, because the 6MWT was more specific than the 6MST, we believe that the former was more responsive to the proposed training protocol, as evidenced by improved physical performance and reduced dyspnea.

References

1. Dal Corso S, Duarte SR, Neder JA, Malaguti C, de Fuccio MB, de Castro Pereira CA, et al. A step test to assess exercise-related oxygen desaturation in interstitial lung disease. Eur Respir J. 2007;29(2):330-6. http://dx.doi.org/10.1183/09031936.00094006
2. Andrade CH, Cianci RG, Malaguti C, Corso SD. The use of step tests for the assessment of exercise capacity in healthy subjects and in patients with chronic lung disease. J Bras Pneumol. 2012;38(1):116-24. http://dx.doi.org/10.1590/S1806-37132012000100016
3. Swinburn CR, Cooper BG, Mould H, Corris PA, Gibson GJ. Adverse effect of additional weight on exercise against gravity in patients with chronic obstructive airways disease. Thorax. 1989;44(9):716-20. PMid:462051.
4. Miranda EF, Malaguti C, Corso SD. Peripheral muscle dysfunction in COPD: lower limbs versus upper limbs. J Bras Pneumol. 2011;37(3):380-8. http://dx.doi.org/10.1590/S1806-37132011000300016
5. Bourjeily G, Rochester CL. Exercise training in chronic obstructive pulmonary disease. Clin Chest Med. 2000;21(4):763-81.
6. Lung function testing: selection of reference values and interpretative strategies. American Thoracic Society. Am Rev Respir Dis. 1991;144(5):1202-18. PMid:1952453.
7. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. Bethesda: Global Initiative for Chronic Obstructive Lung Disease; 2011.
8. Standardization of spirometry--1987 update. Statement of the American Thoracic Society. Am Rev Respir Dis. 1987;136(5):1285-98. PMid:3674589.
9. Pereira CA, Barreto SP, Simões JG, Pereira FW, Gerstler JG, Nakatani J. Valores de referência para espirometria em uma amostra da população brasileira adulta. J Pneumol. 1992;18(1):10-22.
10. Pires Di Lorenzo VA, Silva AB, Sampaio LM, Jamami M, Oishi J, Costa D. Efeitos do treinamento físico e muscular respiratório em pacientes com doença pulmonar obstrutiva crônica (COPD) grave submetidos a BiPAP. Rev Bras Fisioter. 2003;7(1):69-76.
11. Marrara KT, Marino DM, de Held PA, de Oliveira Junior AD, Jamami M, Di Lorenzo VA. Different physical therapy interventions on daily physical activities in chronic obstructive pulmonary disease. Respir Med. 2008;102(4):505-1. PMid:18242069.
12. II Diretrizes da Sociedade Brasileira de Cardiologia sobre teste ergométrico. Arq Bras Cardiol. 2002;78(Suppl. II):3-17. http://dx.doi.org/10.1590/S0066-782X2010000800001
13. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166(1):111-7. PMid:12091180.
14. Neder JA, Nery LE. Fisiologia clínica do exercício: Teoria e Prática. São Paulo: Artes Médicas; 2003.
15. Guimarães JI, Stein R, Vilas-Boas F. Normatização de técnicas e equipamentos para realização de exames em ergometria e ergoespirometria. Arq Bras Cardiol. 2003;80(4):457-64.
16. Iwama AM, Andrade GN, Shima P, Tanni SE, Godoy I, Dourado VZ. The six-minute walk test and body weight-walk distance product in healthy Brazilian subjects. Braz J Med Biol Res. 2009;42(11):1080-5. Erratum in: Braz J Med Biol Res. 2010;43(3):324. http://dx.doi.org/10.1590/S0100-879X2009005000032
17. Maltais F, Simard AA, Simard C, Jobin J, Desgagnés P, LeBlanc P. Oxidative capacity of the skeletal muscle and lactic acid kinetics during exercise in normal subjects and in patients with COPD. Am J Respir Crit Care Med. 1996;153(1):288-93. PMid:8542131.
18. Puhan MA, Mador MJ, Held U, Goldstein R, Guyatt GH, Schünemann HJ. Interpretation of treatment changes

in 6-minute walk distance in patients with COPD. Eur Respir J. 2008;32(3):637-43. PMid:18550610.
19. Spruit MA, Troosters T, Trappenburg JC, Decramer M, Gosselink R. Exercise training during rehabilitation of patients with COPD: a current perspective. Patient Educ Couns. 2004;52(3):243-8. http://dx.doi.org/10.1016/S0738-3991(03)00098-3
20. Wehrmeister FC, Knorst M, Jardim JR, Macedo EC, Noal RB, Martínez-Mesa J, et al. Pulmonary rehabilitation programs for patients with COPD. J Bras Pneumol. 2011;37(4):544-55. http://dx.doi.org/10.1016/S0738-3991(03)00098-3
21. Skeletal muscle dysfunction in chronic obstructive pulmonary disease. A statement of the American Thoracic Society and European Respiratory Society. Am J Respir Crit Care Med. 1999;159(4 Pt 2):S1-40.
22. Neder JA, Nery LE, Cedon Filha SP, Ferreira IM, Jardim JR. Reabilitação Pulmonar: fatores relacionados ao ganho aeróbico de pacientes com DPOC. J Pneumol.1997;23(3):115-23.
23. Cooper CB. Exercise in chronic pulmonary disease: aerobic exercise prescription. Med Sci Sports Exerc. 2001;33(7 Suppl):S671-9. PMid:11462076
24. Sociedade Brasileira de Pneumologia e Tisiologia [homepage on the Internet]. Brasília: Sociedade Brasileira de Pneumologia e Tisiologia. [cited 2012 Jul 1]. Teste da caminhada e do degrau. [Adobe Acrobat document, 22p.]. Available from: http://www.sbpt.org.br/downloads/arquivos/Revisoes/REVISAO_06_TESTE_CAMINHADA_DEGRAU.pdf
25. Ferrazza AM, Martolini D, Valli G, Palange P. Cardiopulmonary exercise testing in the functional and prognostic evaluation of patients with pulmonary diseases. Respiration. 2009;77(1):3-17. PMid:19145106.
26. Pasqualoto AS. Comparação das respostas fisiológicas no teste de exercício cardiopulmonar e em três testes de exercício submáximo em pacientes com doença pulmonar obstrutiva crônica [thesis]. Porto Alegre: Universidade Federal do Rio Grande do Sul; 2009.
27. Soguel Schenkel N, Burdet L, de Muralt B, Fitting JW. Oxygen saturation during daily activities in chronic obstructive pulmonary disease. Eur Respir J. 1996;9(12):2584-9. PMid:8980973.
28. Rabinovich RA, Vilaró J, Roca J. Evaluation exercise tolerance in COPD patients: the 6-minute walking test [Article in Spanish]. Arch Bronconeumol. 2004;40(2):80-5. PMid:814746731.
29. Karsten M, Lima WC. Análise da cadência utilizada por idosos independentes funcionalmente durante o teste do banco com cadência livre [abstract]. Rev Bras Fisioter. 2006;1(Suppl 1):82.
30. Silvestre MV. Utilização do teste do degrau com cadência livre em pacientes com DPOC estável [dissertation]. Florianópolis: Universidade do Estado de Santa Catarina; 2009.

About the authors

Kamilla Tays Marrara
Professor. *Centro Universitário Central Paulista* – UNICEP, Central Paulista University Center – São Carlos, Brazil.

Diego Marmorato Marino
Doctoral Student in Physical Therapy. *Universidade Federal de São Carlos* – UFSCar, Federal University of São Carlos – São Carlos, Brazil.

Maurício Jamami
Professor. Department of Physical Therapy, *Universidade Federal de São Carlos* – UFSCar, Federal University of São Carlos – São Carlos, Brazil.

Antônio Delfino de Oliveira Junior
Pulmonologist. São Carlos Unimed Hospital, São Carlos, Brazil.

Valéria Amorim Pires Di Lorenzo
Professor. Department of Physical Therapy, *Universidade Federal de São Carlos* – UFSCar, Federal University of São Carlos – São Carlos, Brazil.