RESPIRATORY CARE Paper in Press. Published on May 30, 2017 as DOI: 10.4187/respcare.05113

Physiological Requirements to Perform the Glittre Activities of Daily Living Test by Subjects With Mild-to-Severe COPD

Gérson F Souza PT PhD, Graciane L Moreira PT PhD, Andréa Tufanin PT MSc, Mariana R Gazzotti PT PhD, Antonio A Castro PT PhD, José R Jardim MD, and Oliver A Nascimento MD

BACKGROUND: The Glittre activities of daily living (ADL) test is supposed to evaluate the functional capacity of COPD patients. The physiological requirements of the test and the time taken to perform it by COPD patients in different disease stages are not well known. The objective of this work was to compare the metabolic, ventilatory, and cardiac requirements and the time taken to carry out the Glittre ADL test by COPD subjects with mild, moderate, and severe disease. METHODS: Spirometry, Medical Research Council questionnaire, cardiopulmonary exercise test, and 2 Glittre ADL tests were evaluated in 62 COPD subjects. Oxygen uptake ($\dot{V}_{O_2}$), carbon dioxide production, pulmonary ventilation, breathing frequency, heart rate, S_{pO_2}, and dyspnea were analyzed before and at the end of the tests. Maximum voluntary ventilation, Glittre peak $\dot{V}_{O_2}$/cardiopulmonary exercise test (CPET) peak $\dot{V}_{O_2}$, Glittre $\dot{V}_E$/maximum voluntary ventilation, and Glittre peak heart rate/CPET peak heart rate ratios were calculated to analyze their reserves. RESULTS: Subjects carried out the Glittre ADL test with similar absolute metabolic, ventilatory, and cardiac requirements. Ventilatory reserve decreased progressively from mild to severe COPD subjects ($P < .001$ for Global Initiative for Chronic Obstructive Lung Disease [GOLD] 1 vs GOLD 2, $P < .001$ for GOLD 1 vs GOLD 3, and $P < .001$ for GOLD 2 vs GOLD 3). Severe subjects with COPD presented a significantly lower metabolic reserve than the mild and moderate subjects ($P = .006$ and $P = .043$, respectively) and significantly lower Glittre peak heart rate/CPET peak heart rate than mild subjects ($P = .01$). Time taken to carry out the Glittre ADL test was similar among the groups ($P = .82$ for GOLD 1 vs GOLD 2, $P = .19$ for GOLD 1 vs GOLD 3, and $P = .45$ for GOLD 2 vs GOLD 3). CONCLUSIONS: As the degree of air-flow obstruction progresses, the COPD subjects present significant lower ventilatory reserve to perform the Glittre ADL test. In addition, metabolic and cardiac reserves may differentiate the severe subjects. These variables may be better measures to differentiate functional performance than Glittre ADL time. *Key words: activity of daily living; COPD; exercise test; functional capacity; outcome assessment; disability evaluation.* [Respir Care 0;0(0):1–•. © 0 Daedalus Enterprises]

Introduction

Patients with COPD experience a decline in functional capacity,[1] and in recent years, several studies have shown that limitation of functional capacity is a better predictor of disability and mortality in COPD subjects than air-flow limitation.[2-4]

Functional capacity of COPD patients is usually evaluated by self-reported questionnaires and performance-based tests.[5] However, self-reported questionnaires can be influenced by psychological factors, cognitive alterations, or

Dr Souza, Dr Moreira, Ms Tufanin, Dr Gazzotti, and Dr Castro are affiliated with the Pulmonary Rehabilitation Center, Federal University of São Paulo, São Paulo, Brazil. Dr Castro is also affiliated with the Federal University of Pampa, Rio Grande do Sul, Brazil. Drs Jardim and Nascimento are affiliated with the Respiratory Division, Pulmonary Rehabilitation Center, Federal University of São Paulo, São Paulo, Brazil.

This study was performed with financial support from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES, Brazil). The authors have disclosed no conflicts of interest.

Correspondence: José R Jardim MD, Respiratory Division (Pneumologia), Federal University of São Paulo, Rua Botucatu, 740 – 3° andar, São Paulo/SP CEP 04023-062, Brazil. E-mail: jardimpneumo@gmail.com.

DOI: 10.4187/respcare.05113

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adoption of a sedentary lifestyle,[6] and they are often subject to recall bias, which can lead the patient to report a level of functional capacity that does not provide an accurate estimate of free-living energy expenditure.[7,8]

The 6-min walk test (6MWT) is one of the most frequently used field performance-based tests.[9] Previous studies have shown a significant correlation between distance walked and the quantified physical activities of daily life in subjects with COPD.[10-12] However, this test only evaluates the capacity of an individual to move, and it ignores activities carried out with the arms in the execution of many activities of daily living (ADLs). Furthermore, it is known that activities performed with the unsupported upper limbs can cause dyspnea in COPD patients due to competitive recruitment of muscle groups for either respiration or arm works.[13] Tests that also include arm movements should be considered as alternative tests for this population.[14,15]

Skumlien et al[16] proposed a test designed to evaluate the functional capacity of COPD patients, which is known as the Glittre activities of daily living test (Glittre ADL test). The Glittre ADL Test includes activities based on Lareau et al[17] and on the London Chest Activity of Daily Living Scale,[18] which include walking and arm movements. The Glittre ADL test involves rising from a chair, lifting, carrying, and bending, activities that are designed to represent common activities in everyday life that are known to be troublesome for patients with COPD.[5,16] The main outcome is the time taken to accomplish the 5 laps of the test. The inclusion of upper-extremity activities makes it more similar to daily activity limitations than a walking test alone.[5] The physiological responses of subjects with COPD during the course of the Glittre ADL test have been evaluated,[19,20] and it has been shown that the time course response is similar to that of the 6MWT.

However, so far there is no study that has evaluated the Glittre ADL test with COPD subjects with different functional stages. We hypothesized that the more severe the degree of air-flow obstruction of COPD subjects, the greater the proportional metabolic, ventilatory, and cardiac requirements and the longer the time taken to carry out the Glittre ADL test. Thus, the objective of this study was to evaluate the length of time and at what proportion of the maximal metabolic, ventilatory, and cardiac capacities COPD subjects with mild, moderate, and severe air-flow obstruction would carry out the Glittre ADL test in an attempt to discriminate the subjects' severity.

QUICK LOOK

Current knowledge

The Glittre activities of daily living (ADL) test is a test designed to evaluate the functional capacity of COPD patients. Recent studies have assessed the physiological responses of COPD subjects during the course of the Glittre ADL test. However, the physiological requirements during the time required to perform the Glittre ADL test in COPD subjects with different functional stages have not been studied.

What this paper contributes to our knowledge

Our study showed that subjects with mild to severe COPD presented progressive reductions in ventilatory and metabolic reserves to perform the Glittre ADL test as the severity of the disease progressed. Furthermore, the ADL time may not be a good measure to differentiate functional performance among the different disease severities, but ventilatory, metabolic, and cardiac reserves could be a marker to differentiate COPD severity.

Methods

A cross-sectional study was carried out at the Pulmonary Rehabilitation Center of Escola Paulista de Medicina, Brazil. The study was approved by the institutional review board (registry number 0938/10). The COPD subjects were selected consecutively and signed an informed consent form.

Inclusion Criteria

Subjects diagnosed according to Global Initiative for Chronic Obstructive Lung Disease (GOLD)[21] spirometric criteria, with no exacerbation in the previous 4 weeks, $>$ 40 y old, and not taking part in a pulmonary rehabilitation program in the last 2 y were included.

Exclusion Criteria

Hypoxemic patients at rest ($S_{pO_2} < 88\%$) and patients with unstable cardiovascular diseases or musculoskeletal, neurological, or rheumatological diseases that could limit them carrying out the physical tests were not included. The evaluation protocol was as follows. Data collection was carried out over the course of 3 visits. During the first visit, subjects' clinical characteristics and body mass index (BMI) were evaluated, and spirometry was performed. During the second visit, a maximal cardiopulmonary exercise test (CPET) was carried out on a treadmill. During the third visit, the Medical Research Council questionnaire was administered, and 2 Glittre ADL test were carried out according to the procedures set forth by Skumlien et al.[16] The analyzed values were chosen from the test with the shorter time.

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BMI Assessment

BMI was obtained by dividing the subject's body weight in kilograms by the height in meters squared (kg/m^2). A BMI of < 22 kg/m^2 was considered malnutrition, 22–27 kg/m^2 was considered eutrophic, and BMI > 27 kg/m^2 was considered overweight.[22]

Spirometry

The test was assessed according to American Thoracic Society standards[23] with a portable ultrasound-based spirometer (EasyOne, ndd Medical Technologies, Andover, Massachusetts). Volume was checked daily. Predicted values were calculated according to the Third National Health and Nutrition Examination Survey. FEV_1 and FVC were calculated. COPD staging was classified according to GOLD 2007.[21]

Glittre ADL Test

The test, as described by Skumlien et al,[16] started with the subjects seated on a chair. At a starting signal, they stood up and then walked 5 m, crossed over an interposed 2-step staircase, and walked another 5 m up to a 2-shelf fixture, which was adjusted individually to the shoulder and waist height of each subject. Three bags weighing 1 kg each positioned on the top shelf had to be moved one by one to the bottom shelf, down to the floor, back to the bottom shelf, and finally to the top shelf again. The subjects then walked back to the initial chair where they had started from, crossed over the 2-step stairs, sat down, and immediately started the next lap by rising again. The subjects were asked to complete 5 laps as quickly as possible, and the main outcome of the test is time to perform its 5 laps. They were allowed to rest if necessary but were told to resume activity as soon as they could. The chronometer was not stopped. The subjects carried a backpack containing 2.5 kg (women) or 5.0 kg (men). Each step of the stair was 17 cm high and 27 cm deep.

Maximal CPET

The test was performed on a treadmill (Q35 Controlled Impact, Cybex, Medway, Massachusetts) according to the Harbor protocol.[24] The procedure started with the patient walking on the treadmill at a fixed speed, without any inclination for the first 3 min, followed by a 1% inclination increment at the end of each following minute. The test was continuously monitored with electrocardiographic CM5, AVF, and V2 leads (EP-3 Dixtal, São Paulo, Brazil). Subjects were encouraged to continue the exercise until exhaustion, but it could be immediately interrupted in the case of limiting symptoms, such as dyspnea, fatigue and/or pain in the lower limbs, dizziness or discomfort, precordial pain, severe arrhythmia, no increase in systolic pressure, or an exaggerated hypertensive response (systolic arterial pressure $>$ 260 mm Hg or diastolic pressure $>$ 120 mm Hg). The exercise test was carried out to evaluate at which proportion of the maximal metabolic and cardiac rates the Glittre ADL test was performed.

Variables Obtained in the Exercise Tests

Physiological responses during the CPET and Glittre ADL test were evaluated in a breath-by-breath mode using a portable device ($K4b^2$, Cosmed, Rome, Italy). The subjects breathed through a silicon mask firmly adjusted to their faces. The following variables were evaluated during the tests and analyzed at the basal conditions and at the end of the tests: oxygen uptake ($\dot{V}_{O_2}$), carbon dioxide production ($\dot{V}_{CO_2}$), minute ventilation ($\dot{V}_E$), breathing frequency, heart rate, oxygen pulse ($\dot{V}_{O_2}$/heart rate), S_{pO_2} (measured with a model 920M pulse oximeter; Healthdyne Technologies, Marietta, Georgia), and dyspnea (Borg score). The Glittre peak $\dot{V}_{O_2}$ was considered as the highest value reached at the end of the Glittre ADL test, and the CPET peak $\dot{V}_{O_2}$ was considered as the highest value reached at the end of the CPET; Glittre peak $\dot{V}_{O_2}$/CPET peak $\dot{V}_{O_2}$ was used to analyze the metabolic reserve. The Glittre peak $\dot{V}_E$ was considered as the highest value reached at the end of the Glittre ADL test, and the maximum voluntary ventilation (MVV) was calculated as the product of $FEV_1 \times 37.5$[25]; Glittre $\dot{V}_E$/MVV was used to analyze the ventilatory reserve. The Glittre peak heart rate was considered as the highest value reached at the end of the Glittre ADL test, and the CPET peak HR was considered as the highest value at the end of the CPET; Glittre peak heart rate/CPET peak heart rate was used to analyze the cardiac reserve.

Statistical Analyses

Sample size calculation was based on the study's primary aim, which was to compare the metabolic, ventilatory, and cardiac requirements for mild-to-severe COPD subjects to carry out the Glittre ADL test. We calculated our sample size according to the formula E/S, where E represents the expected effect or the minimum clinical difference, and S is the sample standard deviation. Since there are no energy outputs or ventilatory or cardiac values of normality for the Glittre ADL test and/or no expected minimum clinical difference for this scenario, we used for the calculation the mean difference values (final − initial) of these variables from a pilot sample in our laboratory to establish E and S values. An E value of 0.7 L and an S value of 0.2 L were found. Considering an α of .05 and a power of 80%, 17 subjects were necessary in each one of the 3 groups: mild, moderate, and severe.[26] The Shapiro-

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RESPIRATORY CARE Paper in Press. Published on May 30, 2017 as DOI: 10.4187/respcare.05113

Table 1. General Characteristics of Subjects With COPD

Variables	All	GOLD 1	GOLD 2	GOLD 3	*P* (GOLD 1 vs GOLD 2)	*P* (GOLD 1 vs GOLD 3)	*P* (GOLD 2 vs GOLD 3)
Sex, *n* (%)					.38	.38	.38
Male	40 (64.5)	15 (75)	12 (54.5)	13 (65)			
Female	22 (35.5)	5 (25)	10 (45.5)	7 (35)			
Age, mean ± SD y	66.2 ± 8.2	68.3 ± 9.8	65.3 ± 6.7	64.9 ± 7.9	.47	.39	.98
BMI, mean ± SD kg/m^2	26.2 ± 4.2	26.6 ± 4.9	27 ± 3.9	24.8 ± 3,7	.95	.37	.21
MRC, mean ± SD	1.7 ± 0.7	1.2 ± 0.4	1.7 ± 0.6	2.2 ± 0.7	.031	<.001	.02
MVV, mean ± SD L	63.8 ± 24.1	87 ± 20.5	62 ± 16.7	42.6 ± 9.7	<.001	<.001	.001
FEV_1/FVC	0.53 ± 0.11	0.64 ± 0.06	0.53 ± 0.08	0.42 ± 0.05	<.001	<.001	<.001
FEV_1, mean ± SD % predicted	65.4 ± 20.1	89.4 ± 9.5	63.6 ± 8.4	43.4 ± 3,7	<.001	<.001	<.001
FVC, mean ± SD % predicted	94.2 ± 15.5	105.4 ± 12.9	95.7 ± 12.9	81.2 ± 10.1	.032	<.001	<.001
Peak $\dot{V}_{O_2}$, mean ± SD % ml/min	1,424.9 ± 451.4	1,542.0 ± 465.5	1,473.3 ± 543.4	1,254.8 ± 252.1	.87	.11	.25

n = 62.
GOLD = Global Initiative for Chronic Obstructive Lung Disease
BMI = body mass index
MRC = Medical Research Council
MVV = maximal voluntary ventilation
$\dot{V}_{O_2}$ = oxygen uptake in the cardiopulmonary exercise test

Wilk normality test showed a normal distribution of the data, allowing for the application of parametric tests using the means and SD values. The chi-square test was used to compare the proportions of men and women among the groups. A Pearson correlation was used to evaluate MVV versus ADL time. An analysis of variance was also used to compare the differences among the anthropometric variables, pulmonary function, and physiological variables obtained in the exercise tests. The Bonferroni correction was used to locate the difference when the analysis of variance results were significant ($P < .05$).

Results

From 70 subjects selected to participate in this study, 8 subjects were excluded as follows: 3 showed signs of ischemia in the incremental exercise test, 3 exacerbated during the evaluation period, and 2 had asthma. Thus, 62 COPD subjects concluded the study: 20 were in the mild stage, 22 were in the moderate stage, and 20 were in the severe stage. The groups included similar proportions of men and women ($P = .38$) with similar age ($P = .47$ for GOLD 1 vs GOLD 2, $P = .39$ for GOLD 1 vs GOLD 3, and $P = .98$ for GOLD 2 vs GOLD 3) and BMI ($P = .95$ for GOLD 1 vs GOLD 2, $P = .37$ for GOLD 1 vs GOLD 3, and $P = .21$ for GOLD 2 vs GOLD 3) means. As expected, there were statistically significant differences among the groups in Medical Research Council dyspnea score ($P = .031$ for GOLD 1 vs GOLD 2, $P < .001$ for GOLD 1 vs GOLD 3, and $P = .02$ for GOLD 2 vs GOLD 3), MVV ($P < .001$ for GOLD 1 vs GOLD 2, $P < .001$ for GOLD 1 vs GOLD 3, and $P = .001$ for GOLD 2 vs GOLD 3), and spirometric variables (Table 1). There were no significant differences in the peak $\dot{V}_{O_2}$ ($P = .87$ for GOLD 1 vs GOLD 2, $P = .11$ for GOLD 1 vs GOLD 3, and $P = .25$ for GOLD 2 vs GOLD 3) obtained in the CPET among the 3 groups (Table 1). The comorbidities found comprised the most common diseases in COPD: cardiovascular diseases, including systemic arterial hypertension, previous myocardial infarction, heart failure, and coronary ischemia, 66%; diabetes, 27%; osteoporosis, 15%; previous neoplasia, 15%; asthma, 17%.

Analysis of the Glittre ADL Test Requirements

There were no differences in the basal values of the physiological variables among the 3 disease stages (Table 2). The time taken to carry out the Glittre ADL test (Glittre ADL time) was not statistically different among the 3 groups of subjects (mild subjects, 4.5 ± 0.9 min; moderate, 4.8 ± 1.1 min; severe, 5.2 ± 1.7 min, $P = .82$ for GOLD 1 vs GOLD 2, $P = .19$ for GOLD 1 vs GOLD 3, and $P = .45$ for GOLD 2 vs GOLD 3), although there was a numerical tendency to increased times as the disease increased in severity (Fig. 1).

Table 3 shows that the energy expenditure (Glittre $\dot{V}_{O_2}$) required by the subjects in different stages of COPD to carry out the Glittre ADL test was similar ($P = .94$ for GOLD 1 vs GOLD 2, $P = .95$ for GOLD 1 vs GOLD 3, and $P = .81$ for GOLD 2 vs GOLD 3). However, the Glittre $\dot{V}_{O_2}$ analyzed in relation to the peak $\dot{V}_{O_2}$ obtained in the CPET was significantly higher in the severe COPD subjects than in the mild and moderate COPD subjects ($P = .006$ and $P = .043$, respectively), providing evidence

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Table 2. Physiologic Variables at Baseline of the Glittre Activities of Daily Living Test

Variables	All ($n = 62$)	GOLD 1 ($n = 20$)	GOLD 2 ($n = 22$)	GOLD 3 ($n = 20$)	P (GOLD 1 vs GOLD 2)	P (GOLD 1 vs GOLD 3)	P (GOLD 2 vs GOLD 3)
Heart rate, bpm	77.9 ± 12.7	75.1 ± 15.2	79.5 ± 10.5	78.9 ± 12.4	.52	.63	.99
$\dot{V}_{O_2}$/heart rate, ml/beat	3.2 ± 1.1	3.3 ± 1.3	3.0 ± 0.8	3.4 ± 1.1	.77	.77	.35
Breathing frequency, breaths/min	19.1 ± 4.0	18.6 ± 4.6	19.1 ± 4.2	19.6 ± 3.4	.87	.70	.94
$\dot{V}_E$, L/min	11.3 ± 3.6	10.4 ± 3.8	11.3 ± 3.2	12.1 ± 3.7	.72	.33	.77
S_{pO_2}, %	95.1 ± 2.0	95.9 ± 1.5	95.2 ± 1.7	94.3 ± 2.5	.51	.031	.28
$\dot{V}_{O_2}$, ml/min	251.4 ± 74.4	241.9 ± 79.9	242.9 ± 62.1	270.3 ± 81.1	.99	.45	.46
V_{CO_2}, ml/min	232.8 ± 79.4	230.1 ± 81.3	230.4 ± 83.0	238.1 ± 77.3	>.99	.95	.95
Dyspnea (Borg scale)	0.3 ± 0.8	0.2 ± 0.7	0.4 ± 1.2	0.2 ± 0.5	.49	.93	.72

Results are mean ± SD.
GOLD = Global Initiative for Chronic Obstructive Lung Disease
$\dot{V}_{O_2}$/heart rate = oxygen pulse
$\dot{V}_E$ = minute pulmonary volume
$\dot{V}_{O_2}$ = oxygen uptake
V_{CO_2} = carbon dioxide production

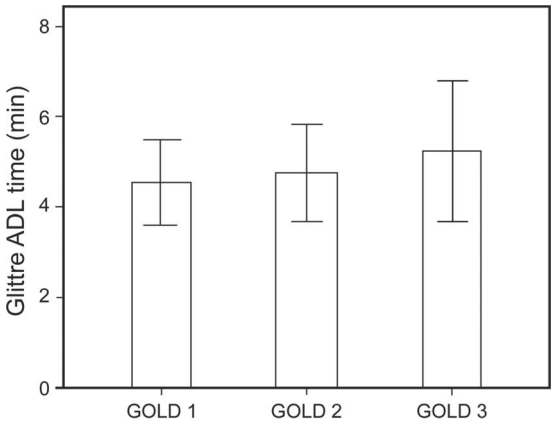

Fig. 1. Time taken to perform the Glittre activities of daily living (Glittre ADL) test by severity of COPD obstruction according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) grades. No significant difference was seen among the 3 groups ($P = .82$ for GOLD 1 vs GOLD 2; $P = .19$ for GOLD 1 vs GOLD 3; and = .45 for GOLD 2 vs GOLD 3).

of a lower metabolic reserve (Glittre peak $\dot{V}_{O_2}$/CPET peak $\dot{V}_{O_2}$) in subjects with severe air-flow obstruction.

The subjects in the different stages of COPD carried out the Glittre ADL test with similar ventilatory requirements (Glittre $\dot{V}_E$, $P = .84$ for GOLD 1 vs GOLD 2, $P = .97$ for GOLD 1 vs GOLD 3, and $P = .70$ for GOLD 2 vs GOLD 3). However, when the Glittre $\dot{V}_E$ for carrying out the test was related to MVV, the severe COPD subjects presented a significantly lower ventilatory reserve (Glittre $\dot{V}_E$/MVV) than the mild ($P < .001$) and moderate ($P < .001$) COPD subjects (Table 3). In addition, the moderate COPD subjects showed a significantly lower Glittre $\dot{V}_E$/MVV than the mild COPD subjects did ($P < .001$). Just the severe subject group presented ventilatory limitation with a Glittre $\dot{V}_E$/MMV ratio > 0.8 (Table 3). There was a moderate correlation between Glittre ADL time and MVV ($r = -0.41$, $P = .001$).

The severe COPD subjects showed significantly lower cardiac reserve (Glittre peak heart rate/peak heart rate) than the mild subjects ($P = .01$) at the end of the Glittre ADL test (Table 3). The severe COPD subjects also reported a significantly greater sensation of dyspnea ($P = .001$ for GOLD 1 vs GOLD 3, $P = .02$ for GOLD 2 vs GOLD 3) and displayed a significant decrease in S_{pO_2} ($P < .001$ for GOLD 1 vs GOLD 3, $P = .002$ for GOLD 2 vs GOLD 3) at the end of the Glittre ADL test compared with the subjects in the other stages (Table 3).

Discussion

The present study showed that when mild, moderate, and severe COPD subjects performed the Glittre ADL test, the only parameter that could differentiate the 3 groups was the significant and progressively lower ventilatory reserve as the disease increased in severity. This finding may explain the significantly increased dyspnea in the severe COPD subjects compared with the moderate and mild subjects. These 2 findings point out that ventilation is the main limitation for COPD patients when performing the Glittre ADL test, which attempts to reproduce the daily activities that COPD patients face in their day-to-day life. It is possible that metabolic and cardiac function might also have played a role in the COPD subjects' limitation, but there was not a progressive decrease in their reserves, as we saw with the ventilatory reserve. Despite Skuliem et al[16] having proposed time as the primary outcome of the Glittre ADL test, we found no significant difference in the time taken to carry out the test among the 3 groups.

Analysis of metabolic, ventilatory, and cardiovascular variables is normally used to express the performance of a

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Table 3. Physiologic Variables at Peak of the Glittre Activities of Daily Living Test

Variables	All ($N = 62$)	GOLD 1 ($n = 20$)	GOLD 2 ($n = 22$)	GOLD 3 ($n = 20$)	P (GOLD 1 vs GOLD 2)	P (GOLD 1 vs GOLD 3)	P (GOLD 2 vs GOLD 3)
Glittre peak heart rate, beats/min	111.9 ± 15.9	107.1 ± 17.6	113.9 ± 14.4	114.7 ± 15.3	.35	.29	.98
Glittre peak heart rate/CPET peak heart rate, %	87.4 ± 12.7	81.4 ± 11.0	89.5 ± 13.1	92.9 ± 11.4	.08	.01	.65
$\dot{V}_{O_2}$/heart rate, mL/beat	11.0 ± 2.9	11.4 ± 2.6	11.0 ± 3.3	10.6 ± 3.0	.83	.52	.85
Breathing frequency, breaths/min	30.4 ± 5.9	29.5 ± 7.6	31.0 ± 5.2	30.6 ± 4.9	.73	.88	.96
Glittre peak $\dot{V}_E$, L/min	39.4 ± 9.8	39.0 ± 8.5	40.8 ± 11.6	38.3 ± 9.2	.84	.97	.70
Glittre peak $\dot{V}_E$/MVV	0.69 ± 0.25	0.46 ± 0.11	0.68 ± 0.18	0.92 ± 0.20	<.001	<.001	<.001
S_{pO_2}, %	90.4 ± 4.9	93.2 ± 3.4	91.3 ± 3.9	86.7 ± 4.9	.29	<.001	.002
Glittre peak $\dot{V}_{O_2}$, mL/min	1,223.6 ± 350.4	1,221.6 ± 323.9	1,256.7 ± 405.8	1,189.0 ± 323.7	.94	.95	.81
Glittre peak $\dot{V}_{O_2}$/CPET peak $\dot{V}_{O_2}$	0.88 ± 0.2	0.81 ± 0.1	0.88 ± 0.2	0.96 ± 0.2	.71	.006	.043
Glittre peak $\dot{V}_{CO_2}$, mL/min	1,022.6 ± 295.2	1,087.0 ± 303.0	1,003.9 ± 338.4	978.7 ± 234.0	.64	.48	.96
Dyspnea (Borg scale)	3.0 ± 2.4	1.9 ± 2.3	2.5 ± 2.2	4.5 ± 2.2	.63	.001	.02

Results are mean ± SD.
GOLD = Global Initiative for Chronic Obstructive Lung Disease
CPET = cardiopulmonary exercise test
$\dot{V}_{O_2}$/heart rate = oxygen pulse
$\dot{V}_E$ = minute pulmonary volume
MVV = maximum ventilatory ventilation
$\dot{V}_{O_2}$ = oxygen uptake
V_{CO_2} = carbon dioxide production

subject or a group of subjects during a physical test, since they may indicate the importance of each component in the exercise performance limitation. We analyzed these variables in COPD subjects with mild, moderate, and severe disease during their performance of the Glittre ADL test in an attempt to discriminate their severity by the test. We found no difference in absolute values in metabolic, ventilatory, and cardiac demands, required to carry out the Glittre ADL test among the 3 groups of subjects, indicating that the effort performed to carry out the test was similar in the different severity stages of the disease, despite a large variability of results in each disease group. It has been shown that the FEV_1 is not strongly correlated to either physical activity in daily life or the walking distance in the 6MWT.[12,27]

Because there were no differences in the in peak $\dot{V}_{O_2}$ during the CPET test among groups of COPD severity, it could be anticipated that the values would also not differ during Glittre ADL test. However, when the variables are looked at as a proportion of their maximal values, we observed that there was a significant decrease in the reserves of the 3 variables, but the ventilatory reserve was the only one that steadily decreased as severity of the disease increased. We believe that the ventilatory reserve decrease was the mechanism responsible for the increased dyspnea reported by the severe group of subjects at the end of the Glittre ADL test. Pitta et al[28] had already shown that ventilation as expressed by MVV is a parameter that may best associate with total energy expenditure in COPD subjects when they took into consideration the number of steps taken per day and time taken to carry out moderate and vigorous activities. We also found a significant moderate correlation between Glittre ADL time and MVV, which supports the idea that ventilatory capacity plays a role in limiting the accomplishment of the Glittre ADL test. The metabolic reserve required to carry out the Glittre ADL test exhibited a somewhat similar behavior to what was observed with the ventilatory reserve. Although subjects in the different stages of the disease presented similar absolute $\dot{V}_{O_2}$ values to perform the Glittre ADL test, contrary to the decreasing ventilatory reserve seen with increasing disease severity, only the severe subjects presented a significantly lower metabolic reserve (Glittre $\dot{V}_{O_2}$/CPET peak $\dot{V}_{O_2}$) compared with the mild and moderate COPD subjects. The lower metabolic reserve of severe COPD subjects may be another limitation factor for the severe patients to carry out their ADLs in real life. Vaes et al[29] evaluated energy expenditure in moderate, severe, and very severe COPD subjects while carrying out 5 ADLs, and they showed, as in the present study, that the ventilatory and metabolic reserves decreased with the increase in severity of the disease. Castro et al[30] also did not find any difference in the absolute $\dot{V}_{O_2}$ and $\dot{V}_E$ values measured in mild-to-very severe COPD subjects when carrying out a large number of ADLs. These authors also found that the only parameters that could differentiate their groups were $\dot{V}_E$/MVV and $\dot{V}_{O_2}$/maximum $\dot{V}_{O_2}$ ratios, both decreasing from mild to very severe subjects. Thus, the results of Vaes et al,[29] Castro et al,[30] and our own work seem to point in the same direction, that the progressive worsening

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RESPIRATORY CARE Paper in Press. Published on May 30, 2017 as DOI: 10.4187/respcare.05113

of dyspnea reported by COPD subjects when carrying out their ADLs is associated with the decrease in ventilatory and metabolic reserves as the disease severity increases. We also observed reduced cardiac reserve in the severe subject group in relation to the mild subject group. Cardiovascular disease is a major comorbidity in COPD and probably the most frequent and most important disease coexisting with COPD.[21] Our results seem to indicate that ventilatory reserve is an important functionality-limiting factor across all stages of the disease, whereas metabolic and cardiac factors may play an associated role in the more severe stages of the disease.

We observed that severe subjects showed a significantly lower peripheral oxygen desaturation at the end of the Glittre ADL test than subjects with mild and moderate disease. Similar results were found by Cutaia et al,[31] who showed a decreased S_{pO_2} directly associated with severity of the disease in COPD subjects during daily activities. Andrianopoulos et al[32] showed a relationship between impaired lung function and oxygen desaturation during the exercise in non-hypoxic COPD subjects. COPD subjects with an $FEV_1 < 45\%$ of predicted generally present oxygen desaturation during the 6MWT, which is in agreement with our results. Arterial desaturation is associated with low ventilation-perfusion ratios.

The time measured to complete the Glittre ADL test was described as the primary outcome of the Glittre ADL test by Skumlien et al,[16] but in their original study, they did not evaluate subjects with different disease severities. In our study, we evaluated the ADL time in mild-to-severe COPD subjects but did not find a significant difference among the 3 groups, despite a tendency to a longer time in moderate subjects compared with mild subjects and in the severe subjects compared with moderate subjects. We did not study very severe subjects, but considering the increasing time from the mild to severe subjects, it is possible that the time to perform the Glittre ADL test could differentiate the very severe subjects from the mild or even moderate subjects. It is not easy to explain why there was not a difference in time for the performance of the test. However, we grouped the subjects by bronchial obstruction, whereas the COPD disease is a multisystemic disease, and each one of its components may account for different proportions of its activity limitation. Despite ventilatory limitation being most probably the main limiting factor, in some subjects, the cardiac component may play an important role, whereas in others, it could be a peripheral factor. Pitta et al[28] also did not find a difference among COPD subjects in the moderate, severe, and very severe stages of the disease in terms of time taken to carry out vigorous activities demanding 6–9 metabolic equivalents.

We might consider a few limitations in our study. We did not compare COPD subjects with a healthy age-matched control group. Notwithstanding this, our aim was to assess the physiological requirements and the time spent to accomplish the Glittre ADL test in COPD subjects within 3 disease severity stages; therefore, the lack of a control group did not influence our outcomes. Another possible limitation was the exclusion of very severe COPD subjects. This exclusion was due to the fact that during a pilot study, all very severe subjects had tremendous difficulty accomplishing the CPET and the Glittre ADL test. We present only the basal and peak values obtained at the end of the Glittre ADL test of the physiological variables studied. Our objective was to compare the metabolic, ventilatory, and cardiac requirements in subjects with mild to moderate COPD at the end of performing the Glittre ADL test and not to study the behavior of such variables throughout the test. The behavior of such variables throughout the test has already been presented in the study by Tufanin et al[19] A strength of our study is (1) to have evaluated a powerful calculated sample, (2) to have included a larger number of subjects than in the Karloh et al[20] and Tufanin et al[19] studies, and (3) to have evaluated the performance of COPD subjects with different degrees of disease.

Our results are similar to those presented by other authors who assessed the ventilatory and metabolic reserves of subjects accomplishing ADLs. The Glittre ADL test was developed for use in clinic practice, because it encompasses activities similar to very common activities of daily living. However, the ADL time that is considered the primary outcome of the test was not a good outcome to differentiate functional performance among the different disease severities, but the metabolic, ventilatory, and cardiac reserves could be a marker to differentiate COPD severity. However, these measurements are not readily available in the routine evaluation of COPD subjects and are not easily captured in clinical practice, because they are time-consuming, and specific equipment is necessary for gas analysis. Maybe these measurements could be restricted to research. Moreover, other tests have already been used to assess functionality in COPD subjects and are easier to perform. The 6MWT has been correlated with disease staging, health status, dyspnea at rest, maximum exercise capacity, and mortality.[33,34] The shuttle test, despite less use than the 6MWT, also has the ability to measure physical capacity changes in COPD submitted to an intervention.[35] In addition, unsupported upper-limb tests could also describe the functionality of COPD patients[36] and could be taken alone or in conjunction with the 6MWT or shuttle test.

Thus, we conclude that as the degree of air-flow obstruction progresses, COPD subjects present significantly lower ventilatory reserve to perform the Glittre ADL test. In addition, the metabolic reserve to perform the Glittre ADL test was significantly lower in severe than in mild and moderate COPD subjects. It is possible that the cardiac reserve may also differentiate COPD patients by their

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RESPIRATORY CARE Paper in Press. Published on May 30, 2017 as DOI: 10.4187/respcare.05113

severity. These variables may be better measures for differentiating functional performance among the different disease severities than ADL time.

ACKNOWLEDGMENTS

We thank the multidisciplinary team from the Pulmonary Rehabilitation Center, Federal University of São Paulo.

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