Study of 2-min walk test and 15-step exercise oximetry test in the assessment of exercise tolerance in Egyptian patients with chronic obstructive pulmonary disease

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Abstract  Purpose: The present study was conducted to study the 2-min walk test and 15-step exercise oximetry test in determination of exercise tolerance in Egyptian patients with chronic obstructive pulmonary disease.

Methods: Sixty male patients with COPD were included in this study who were divided into three groups (mild, moderate and severe). All of the patients were subjected cardio pulmonary exercise test using ramp protocol, 6 min walk test, 2-min walk test and 15 step exercise oximetry test.

Results: In this study we found significant difference between mild, moderate and severe groups as regards VO2% predicted, distance walked during 6-MWT, distance walked during 2-MWT, and saturation difference % and exercise time/s during 15-step exercise oximetry test (p value <0.05). We found also significant correlation between 2-MWT and 6-MWT and VO2 in the mild, moderate and severe groups. (r = 0.9 and 0.85, respectively for the mild, r = 0.52 and 0.48, respectively for the moderate and r = 0.94 and 0.45, respectively for the severe p < 0.05 for all). We did not find such correlation between exercise time in 15-step exercise oximetry test and both 6-MWT and VO2 in the three groups. (r = −0.066 and −0.067, respectively for the mild, r = −0.08 and −0.07, respectively for the moderate and r = −0.07 and −0.021, respectively for the severe, P > 0.05 for all). Also there was non-significant correlation between saturation difference in 15-step exercise oximetry test and both 6-MWT and VO2 in the three groups(r = −0.371 and −0.378, respectively for the mild, r = −0.086 and −0.061, respectively for the moderate and r = −0.051 and −0.013, respectively for the severe p > 0.05 for all).

Conclusions: The study shows that the 2MWT is a valid test for the assessment of exercise capacity in patients with COPD. It is practical, simple, and well-tolerated by patients with severe COPD.

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Introduction

Chronic obstructive pulmonary disease is a preventable and treatable disease with some significant extrapulmonary effects that may contribute to the severity in individual patients. Its pulmonary component is characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases [1].

Several tests are available for the evaluation of functional capacity in patients with chronic lung diseases. These include the cardiopulmonary exercise test [2]. The CPXT is considered the gold standard but it is more expensive than other tests that were proven useful for clinical purposes [3,4]. In the past few years, walk tests have gained prominence in both clinical practice and research.

These tests are used for measuring functional capacity, monitoring treatment effectiveness, and establishing prognosis [5]. The most commonly used timed walk tests are the 6-min walk test (6MWT) and the 12-min walk test (12MWT). Subjects are instructed to walk as much as possible in the allotted time period. Both tests have been quite extensively evaluated, and have been shown to be reliable and valid in reflecting the exercise capacity in COPD patients [3,6]. It was argued that the distance covered in a 2-min interval of a 12MWT might be different from the distance walked in a 2MWT, as the pacing by the subjects might be different for the two different intervals. It was reported that a patient who knew that a walk test would only last for 2 min would walk further than a patient would in the first 2 min of a longer walk test [7]. A 2-min walk test (2MWT) was first proposed by Butland et al. [8] and was reported to be a valid test in COPD patients. A more recent study by Eiser et al. [9] reported that the 2MWT was a reliable test and was sensitive to change after bronchodilator therapy. The 15-steps climbing test oximetry has been found useful for estimating ventilatory reserve in patients with chronic obstructive pulmonary disease (COPD) and for predicting postoperative complications of lung resection. A good correlation has been found with PFTs. Several studies have also found it effective for assessing arterial hypoxemia and recommended its use as a marker of disease severity and the need for oxygen supplementation (Victorya et al. [10]).

Aim of the work

The aim of this study was to correlate the finding of cardiopulmonary exercise test as regarding VO2 to those of 2-min walk test and 15-step exercise oximetry test and to determine whether reliable functional capacity data can be obtained at a lower cost in Egyptian patients with chronic obstructive pulmonary disease.

Subjects and methods

Sixty male patients with mild to severe COPD were included in this study during the period from October 2008 to May 2011. The study protocol was approved by the local ethics committee. Informed consent was obtained from the patients.

All patients were attendant or came for follow up in Benha University outpatient clinic. Their age ranged from 36 to 75 years and all of them were cigarette smokers. The diagnosis of these patients was made according to the recommendations of GOLD, 2008 [11].

The inclusion criteria included the following: (1) mild-to-severe COPD; (2) stable condition without experiencing an acute exacerbation in the month prior to or during the study; (3) no change in medication during the study; and (4) no requirement for long-term oxygen therapy [12].

The exclusion criteria included the following: Dementia, concomitant heart failure, diseases with mobility impairment, and medical conditions that were contraindicated for exercise testing according to American Thoracic Society guidelines including unstable angina and acute ECG changes suggestive of myocardial infarction [13].

The patients were divided into three groups according to criteria of GOLD [11]:

1. Mild COPD (20 patients): FEV1/FVC < 70% and FEV1 ≥ 80% predicted.
2. Moderate COPD (20 patients): FEV1/FVC < 70% and 50% ≤ FEV1 < 80% predicted.
3. Severe COPD (20 patients): FEV1/FVC < 70% and 30% ≤ FEV1 < 50% predicted.

All patients were subjected to the following: thorough medical history and clinical examination, Plain chest X-ray (postero-anterior and lateral views), complete blood count, liver function tests, kidney function tests and ECG. Also all subjects underwent pulmonary function testing: including resting spirometry included flow volume loop and Maximal Voluntary Ventilation (MVV) [14], measurement of lung volumes [15] and diffusing capacity for carbon monoxide (DLCO) using single breath technique [16] which were performed using computerized equipment (V. Max 225 Auto box) sensor medics system. Ambient temperature and pressure were entered with the patient data (age in years, weight in kilograms, height in centimeters and sex) so that all results were calculated as percent of predicted except for FEV1/FVC%.

Cardio pulmonary exercise test: A symptom limited maximal incremental exercise testing was done using an Ergometer, Jaeger, Oxycon Delta, Medizintechnik mit system, Mynhardt. Protocol for exercise testing [17].

Six-minute walk test [13]: The test was conducted between 10 a.m. and 4 p.m. for all patients. A thirty-meter flat, obstacle-free corridor with a chair placed at either end was used. Patients were instructed to walk as far as possible to cover the longest possible distance over 6 min under supervision.

Patient preparation:

1. Comfortable clothing should had been worn.
2. The patient usual medical regimen should had been continued (if present).
3. A light meal was acceptable at least 2 h before the test.
4. Patients should not had exercised vigorously within 2 h of beginning of the test.

Measurement of 6-min walk test:

1. The test was performed twice about the same time of the day to minimize intraday variability and the best result was reported.
2. A “warm-up” period before the test should not be performed.
3. The timer was set to 6 min and the patient moved to starting point.
4. The patient was instructed as follows:

The object of this test is to walk as far as possible for 6 min through walking back and forth in this hallway. You are permitted to slow down, to stop and to rest as necessary. You may lean against the wall while resting, but resume walking as soon as you can. The patient was then asked “are you ready to do that?”

5. As soon as the patient started to walk the timer was started.
6. After the first minute the patient was told “you were doing well. You had 5 min to go”. When the timer shows 4 min remaining the patient was told “keep up the good work. You had 4 min to go”. When the timer shows 3 min remaining the patient was told “you were doing well. You have only 2 min left”. When the timer shows 1 min remaining the patient was told “you are doing well. You have only 1 min to go”. Other words of encouragement (or body language to speed up) were not used.
7. If the patient stopped walking during the test and needed to rest, he was told “you could lean against the wall if you would like; then continue walking whenever you feel able”. The timer was not stopped.
8. If the patient stopped before the 6 min were up and refused to continue, the patient is allowed to set on the chair and the time of stopping as well as the distance walked was recorded.
9. When the 6 min were over the patient was told to stop and piece of tape was used to mark the spot where he was stopped.
10. Calculation of the distance walked was done by using number of laps multiplied by 60 plus the number of meters in the final partial lap (using the markers on the corridor), rounding it to the nearest meter.
11. Congratulation of the patient for good effort was done.
12. Two-minute walk test [18]: The same as 6-MWT but the patient was allowed to walk for 2 min only.

13. Step exercise oximetry test [19]: Patient preparation:

The same as that of 6-MWT

Test procedure: A finger oximeter (MEK, MP10, USA) with continuous recording of heart rate and oxygen saturation was connected to each patient. A step measuring 25 x 25 x 20 cm was used. Patients were asked to climb up and down the step 15 times as fast as they could (without any fixed pacing). Each test was repeated twice, and the mean value was taken. The time of exercise was recorded (exercise time). Baseline oxygen saturation and the lowest saturation were recorded as well. All the results were collected, tabulated and statistically analyzed.

**Statistical analysis**

Statistical Analysis was performed using the computer program SPSS (Statistical package for social science) version 16. To compare two independent samples we used an unpaired t-test. ANOVA (analysis of variance) used to compare between more than two groups of numerical (parametric) data. Pearson correlation coefficient test was used correlating different parameters. Inter-group comparison of categorical data was performed by using chi square test (X²-value). A P value < 0.05 was considered statistically significant (S) and a P value < 0.0001 was considered highly significant (HS) in all analyses.

**Results**

These tables show that there was significant correlation between 2-MWT and 6-MWT and VO2% predicted in the mild, moderate and severe groups.

**Discussion**

Different exercise tests are used to evaluate the functional capacity in chronic obstructive pulmonary disease. The cardiopulmonary exercise test is considered the gold standard [20]. Functional walk tests are exercise tests that measure functional status or capacity, mainly the ability to undertake physically demanding activities of daily living [21]. They are considered objective measures that provide a means of monitoring response to treatment [22]. Compared to traditional laboratory indexes

<table>
<thead>
<tr>
<th>Table 1 Demographic data and pulmonary function. *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Age/years</td>
</tr>
<tr>
<td>SI</td>
</tr>
<tr>
<td>Duration of illness/years</td>
</tr>
<tr>
<td>FEV1/FVC</td>
</tr>
<tr>
<td>FEV1% predicted post BD</td>
</tr>
<tr>
<td>FEV1% change post BD</td>
</tr>
<tr>
<td>T/L% predicted</td>
</tr>
<tr>
<td>RV/TLC% predicted</td>
</tr>
<tr>
<td>Dlco/TLC% predicted</td>
</tr>
</tbody>
</table>

SI = smoking index; FEV1 = forced expiratory volume in the first second; FVC = forced vital capacity; BD = bronchodilator; RV = residual volume; TLC = total lung capacity; Dlco = diffusion capacity of the lung for carbon monoxide.
of exercise capacity such as cycle, treadmill, and step ergometry, walk tests require less technical expertise and equipment, making them inexpensive and easy to administer [23].

In our study we found that there was significant difference between mild, moderate and severe groups as regards VO2% predicted (Means ± SD, 82.3 ± 6.54, 61.15 ± 7.3, 44.9 ± 5.77, respectively, P value <0.05). This indicates that with increasing severity of COPD there is progressive decrease in VO2% predicted. These results match with those of Go¨khan et al. [24] who revealed that exercise capacity correlates with FEV1 and the degree of disease severity in stable COPD patients. Also, there was significant difference between mild, moderate and severe groups as regards distance walked during 6-MWT (Means ± SD were 426 ± 69.3, 308 ± 85.115, and 196.15 ± 37.73, respectively, P value <0.05). This means that there is progressive decrease in distance walked during 6-MWT with increasing severity of COPD. These results are in agreement with those of Martijn et al. [25]. Who found that severe airflow limitation by GOLD stage is a significant clinical determinant of poor 6MWD performance. There was significant difference between the mild, moderate and severe groups as regards distance walked during 2-MWT (Means ± SD were 163 ± 20.79, 119.8 ± 17.72, and 98.45 ± 17.361 meter, respectively, P value <0.05). This indi-

Table 2 Comparison between different groups as regards CPET parameter (VO2% predicted).

<table>
<thead>
<tr>
<th>No.</th>
<th>Mean ± S.D.</th>
<th>Range</th>
<th>F</th>
<th>p</th>
<th>Between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>82.3000</td>
<td>6.54619</td>
<td>75–95</td>
<td>162.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Moderate</td>
<td>61.1500</td>
<td>7.30735</td>
<td>50–75</td>
<td>80.5</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Severe</td>
<td>44.9000</td>
<td>5.77563</td>
<td>35–55</td>
<td>40.5</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

P value >0.05 = non-significant. P value <0.05 = significant. P value <0.05 = highly significant.

Table 3 Comparison between different groups as regards distance walked (meter) during the 6-MWT.

<table>
<thead>
<tr>
<th>No.</th>
<th>Mean ± S.D.</th>
<th>Range</th>
<th>f</th>
<th>p</th>
<th>Between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>426.0000</td>
<td>69.31241</td>
<td>340–580</td>
<td>3.6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Moderate</td>
<td>308.0000</td>
<td>85.115</td>
<td>200–385</td>
<td>2.1</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Severe</td>
<td>196.1500</td>
<td>37.73352</td>
<td>150–270</td>
<td>1.5</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

P value >0.05 = non-significant. P value <0.05 = significant. P value <0.05 = highly significant.

Table 4 Comparison between different groups as regards distance walked (meter) during the 2-MWT.

<table>
<thead>
<tr>
<th>No.</th>
<th>Mean ± S.D.</th>
<th>Range</th>
<th>f</th>
<th>p</th>
<th>Between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>163.0000</td>
<td>20.79890</td>
<td>130–200</td>
<td>61.9</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Moderate</td>
<td>119.8000</td>
<td>17.72183</td>
<td>90–150</td>
<td>3.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Severe</td>
<td>98.45</td>
<td>17.361</td>
<td>70–125</td>
<td>1.9</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

P value >0.05 = non-significant. P value <0.05 = significant. P value <0.05 = highly significant.

Table 5 Comparison between different groups as regards parameters of 15-step exercise oximetry test (saturation difference% and exercise time/s).

<table>
<thead>
<tr>
<th>No.</th>
<th>Mean ± S.D.</th>
<th>Range</th>
<th>f</th>
<th>P</th>
<th>Between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturation difference Mild</td>
<td>0.6000</td>
<td>0.50262</td>
<td>0–1</td>
<td>61.6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Moderate</td>
<td>2.1000</td>
<td>.71818</td>
<td>1–3</td>
<td>71.2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Severe</td>
<td>5.0000</td>
<td>2.02614</td>
<td>3–9</td>
<td>75.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Exercise time Mild</td>
<td>33.5000</td>
<td>6.20272</td>
<td>21–45</td>
<td>135.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Moderate</td>
<td>55.2000</td>
<td>6.57427</td>
<td>45–65</td>
<td>147.2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Severe</td>
<td>69.1000</td>
<td>7.80621</td>
<td>58–80</td>
<td>159.8</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

P value >0.05 = non-significant. P value <0.05 = significant. P value <0.05 = highly significant.

Table 6 Correlation between 2-MWT and 6-MWT and VO2% predicted:

<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>p &lt;0.05</td>
<td>0.524 &lt;0.05</td>
<td>0.945 &lt;0.05</td>
</tr>
<tr>
<td>VO2% pred.</td>
<td>0.855 &lt;0.05</td>
<td>0.485 &lt;0.05</td>
<td>0.458 &lt;0.05</td>
</tr>
</tbody>
</table>

P value >0.05 = non-significant. P value <0.05 = significant. P value <0.05 = highly significant.
icates that there is progressive decrease in distance walked during 2-MWT with increasing severity of COPD. These results are in agreement with those of Butland et al. [8] who validated the 2MWT as a similar measure of exercise tolerance as the 6MWT and 12MWT in patients with COPD. Table 5 showed that there is significant difference between the mild, moderate and severe groups as regards saturation difference % (Mean ± SD were 0.6 ± 0.5, 2.1 ± 0.71, and 5 ± 2.02, respectively, p value <0.05) and exercise time/s (Mean ± SD were 33.5 ± 6.2, 55.2 ± 6.57, and 69.1 ± 7.8, respectively, p value <0.05). It means that desaturation during 15-step exercise oximetry test as well as exercise time both increase with increasing severity of COPD. These results are in agreement with those of Daniel et al. [19] who revealed that there was significant difference between mild, moderate and severe groups as regards saturation difference and exercise time. Table 6 showed correlation between 2-MWT and 6-MWT and VO2. There was significant correlation between 2-MWT and 6-MWT and VO2 in the mild, moderate and severe groups. These results match with those of Amy et al. [12]. The significant correlations between the 2MWT and VO2 support the validity of the 2MWT as a measure of exercise capacity in COPD patients with mild-to-severe disease. The strongest correlation was observed between the 2MWT and 6MWT, since they are both walking tests and their results were in agreement with those of previous studies. (Butland et al. [8]; Bernstein et al. [26]. Table 7 shows that there is non-significant correlation between exercise time in 15-step exercise oximetry test and both 6-MWT and VO2 in the three groups. These results are in agreement with those of Daniel et al. [19] who found that there was no correlation noted between the 15 step exercise oximetry test result (saturation difference) and either the CPET or the 6 min walk. Table 8 shows that there is non-significant correlation between saturation difference and 6-MWT and VO2 in the three groups. These results match with those of Daniel et al. [19] who found that there was no correlation noted between the 15 step exercise oximetry test result (saturation difference) and either the CPET or the 6 min walk. These results were not match with those of Victorya et al. [10] who said that there was a statistically significant correlation between all parameters of the 15-steps climbing test and both VO2 on the CPET, and carbon monoxide diffusion in the lungs (DLCO). The difference between the current and the previous study may be due to difference as regarding patient characteristics.

In conclusion

The 2MWT was shown to be valid test for the assessment of exercise capacity in patients with COPD. It is practical, simple, and well-tolerated by patients with severe COPD. The 15 step exercise oximetry test had no correlation to the CPET or to the 6MWT in patients with COPD. Further studies on large scales is recommended.

References