Turk Thorac J 2020; 21(5): 329-33 DOI: 10.5152/TurkThoracJ.2019.19046

Original Article

Is it Possible to Use the Timed Performance Tests in Lung Transplantation Candidates to Determine the Exercise Capacity?

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Cite this article as: Pehlivan E, Balcı A, Kılıç L, Yazar E. Is it possible to use the timed performance tests in lung transplantation candidates to determine the exercise capacity? Turk Thorac J 2020; 21(5): 329-33.

Abstract

OBJECTIVES: Lung transplantation (LTx) candidates have severe exercise intolerance. This makes it difficult for them to complete the field tests used to determine the exercise capacity of patients. Therefore, there is a need for alternative tests that require less effort. We aimed to investigate the use of short-timed performance tests instead of 6-minute walk test (6MWT) in the determination of exercise capacity in LTx.

MATERIALS AND METHODS: A total of 63 LTx candidates were included in the study. Ten-meter walking speed test (10MWT), 5-times sit-to-stand test (5XSST), 6MWT were performed at one-hour intervals within the same day, and by the same physiotherapist in all patients. Maximal inspiratory (MIP) and expiratory pressure (MEP), peripheral muscle strengths, pulmonary function tests, and body mass index (BMI) were recorded for each patient.

RESULTS: The subjects' baseline mean 6-minute walking distance (6MWD) was 336m, 5XSST time was 11.59 sec, and 10MWT time was 8.45sec. There was a negative and moderate correlation between 6MWD and 10MWT ($p<0.001$, $r=0.449$). Similarly there was a negative but weak correlation between 6MWD and 5XSST ($p=0.001$, $r=0.397$). In addition, there was a strong relationship between 5XSST and 10MWT ($p<0.001$, $r=0.767$).

CONCLUSION: This study showed that 6MWT and short-timed performance tests were correlated in terms of exercise capacity assessment. In contrast, there was a strong relationship between 6MWT and 10MWT according to 6MWT and 5XSST. The timed performance tests may be alternative tests to determine exercise capacity in LTx candidates.

KEYWORDS: Exercise capacity, 6-minute walk test, lung transplantation, performance tests

Received: *2.04.2019* ***Accepted:*** *10.10.2019*

INTRODUCTION

Lung transplantation (LTx) is a comprehensive intervention, the ultimate goal of which is to maximize both the length and quality of life in end-stage pulmonary disease [1]. Exercise capacity is one of the most important parameters which should be assessed in transplantation candidates and is severely decreased in majority of the patients. This is because respiratory and circulation systems are unable to meet the increased demand due to exercise [2].

Field tests are used to determine exercise capacity and pulmonary rehabilitation (PR) efficacy. Moreover, exercise capacity assessed by field tests makes the estimation of postoperative survival and complications possible [3, 4]. The six-minute walking test (6MWT) is a widely used field test in the literature [5]. Whereas cardiopulmonary exercise test (CPET) has been recognized as the best method for the determination of aerobic performance [6], it has been stated in the guidelines that 6MWT provides a peak oxygen uptake comparable to CPET [5].

Performance tests are used in many patient groups. One of these tests, the 5-times sit-to-stand test (5XSST) causes less hemodynamic stress compared with long-timed challenging tests, thereby being easier to complete for the patient. Therefore when necessary, it is preferred more in patients with severe chronic obstructive pulmonary disease (COPD) [7] cardiac failure [8], and ischemic cerebrovascular disease [9]. The ten-meter walking speed test (10MWT) is a test used to determine the functional mobility and gait deficit in patients with neurological and orthopedic problems [10]. No study related to the use of these tests in lung transplant candidates is available. To our knowledge, there is no study on the use of these tests in lung transplantation candidates in the literature.

Our study aims to assess the usability of these tests instead of 6MWT and the patients' clinical characteristics from which these tests are affected in lung transplantation candidates undergoing PR.

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MATERIALS AND METHODS

Candidates requiring lung transplantation and referred to our PR center were included in this study. All the patients were on long-term oxygen therapy and none of them had a history of smoking. There were 13 patients (20.6%) patients using non-invasive mechanical ventilation. Patients who had problems completing the tests were excluded from the study. The inclusion criteria were:

- A diagnosis of terminal lung disease
- Listed for lung transplantation
- Clinical stable
- No comorbidities that would prevent exercising
- No problems with transfer

The study was planned as a prospective and case-controlled study. The study was approved by the Local Ethics Committee (Protocol Number: 1234), administered in accordance with the Helsinki Declaration and registered in the clinicaltrial.gov website (registration number: NCT03531138). A written informed consent was obtained from the subjects.

Outcome Measurements

6MWT, 10MWT, and 5XSST were performed at the beginning of the PR, at 1-hour intervals within the same day, and by the same physiotherapist in all patients. Each test was repeated twice and the best values obtained were recorded. At the same time, mouth pressure measurements, peripheral muscle strengths, pulmonary functions (FEV_1, FVC), and body mass index (BMI) were recorded.

Primary Outcome Measurements

6MWT: The subject was asked to walk as fast as possible on a flat 30-meter pitch for 6 minutes. During the test, every minute, the patient was reminded with standard commands. It was conducted by the guidelines [11].

5XSST: The subject was seated on a seat 43.18 cm high, with the back of the chair upright, with his feet pressed down, and the arms crossed in front of his chest. When the participant was in this position, he started the test with the command of start and the time was finally terminated by touching the person's pelvis zone in the last round. The time is recorded in seconds and the test score is set [12].

10MWT: The subject was asked to walk at a normal speed of 10 meters on a straight line, measured in advance. The time was started and terminated by the patient's feet touching the starting and ending points of the 10 lines marked. Value was saved in seconds (sec) [13].

Secondary Outcome Measurements

Modified Medical Research Council (mMRC) Dyspnea Scale: It was assessed each subject [14].

Pulmonary Function Test: It was conducted using the lung function measurement device (Sensor Medics Model 2400, CA, USA), and according to the American Thoracic Society (ATS) guidelines [15].

Maximal Inspiratory and Expiratory Muscle Strength (MIP, MEP): The mouth pressure measurement was performed (Micro-RPM®, SensorMEDIC). MIP and MEP values were recorded [16].

Peripheral Muscle Strength: It was measured three times by using a digital dynamometer (J-Tech Commander muscle testing device). The best result was taken.

Statistical Analysis

The statistical analyzes were performed using computer package program Statistical Package for Social Sciences version 15.0 (SPSS Inc.; Chicago, IL, USA). The correlation of outcome parameters was tested by Pearson correlation analysis. Significance level was accepted as $p<0.05$. We estimated that a sample size of minimum 36 patients to have 80% power with 5% type 1 error [17].

RESULTS

The mean age was 41 years; a total of 63 LTx candidates were included in our study with 43 (63.8%) of them being males. Table 1 shows the demographic and clinical characteristics and functional parameters of the patients. Table 1 also shows the functional exercise capacities and performance measurements of the cases.

A weak correlation was present between the 6MWT with 5XSST ($p=0.001$, $r=0.397$) and moderate correlation with 10MWT ($p<0.001$, $r=0.449$). There was a strong relationship between 5XSST and 10MWT ($p<0.001$, $r=0.767$). When the relationship of the performance tests with clinical features were examined, all three tests were affected by all clinical features except MEP. In addition, there was a moderate relationship between 6MWT and FEV_1 ($p=0.001$, $r=0.417$) and between 10MWT and iliopsoas muscle strength ($p=0.001$, $r=-0.424$). 5XSST test showed poor correlation with all parameters. The correlation analysis of exercise test values and clinical and demographic features are given in Table 2.

DISCUSSION

This study showed that short-timed performance tests and 6MWT are correlated in the assessment of exercise capacities. The 5XSST is affected less by the demographic and clinical characteristics of the patients than 10MWST. In contrast, there was a stronger relationship between 6MWT and 10MWT than 5XSST. Timed performance tests are alternative tests to determine exercise capacity. The appropriate test should be selected by clinicians per the clinical condition of the patient.

MAIN POINTS

- Timed performance tests are alternative tests to determine exercise capacity in patients with pulmonary diseases.
- The short-timed performance tests and 6MWT are correlated in the assessment of exercise capacity.
- There was a stronger relationship between 6MWT and 10MWT than 5XSST.
- The 5XSST is affected less by the demographic and clinical characteristics of the patients than 10MWST.

Table 1. Demographic and clinical characteristics, and functional parameters of the patients

	Mean (min-max) or n (%)
Demographic features	
Sex (male/female), n (%)	43/20 (68.3/31.7)
Age (years)	41.42 (18-68)
Anthropometric features	
BMI (kg/m^2)	21.87 (12-34)
Diagnosis, n (%)	
Alveolar proteinosis	1 (1.6)
Bronchiectasis	26 (41.3)
Cystic fibrosis	5 (7.9)
COPD	15 (23.8)
ILD	7 (11.1)
Silicosis	5 (7.9)
Sarcoidosis	2 (3.2)
RA lung involvement	1 (1.6)
NIMV use	
Yes, n (%)	13 (20.6)
No, n (%)	50 (79.4)
Receiving systemic corticosteroid therapy	
Yes, n (%)	10 (15.9)
No, n (%)	53 (84.1)
mMRC (0-4)	3 (1-4)
Pulmonary function test	
FVC, lt	1.55 (.29-3.09)
FVC%	40.65 (6.3-76.00)
FEV1, lt	1.02 (.40-2.46)
FEV1%	32.33 (10-64)
FEV1/FVC	67.63 (35-110)
Respiratory muscle strenght (cmH2O)	
MIP	76.50 (12-129)
MEP	121.12 (47-229)
Muscle strenght (lbs)*	
QF	42.41 (14-74)
Iliopsoas	41.63 (16-74)
Tibialis anterior	45.26 (11-91)
6MWD (m)	336.83 (42-548)
10MWT (sc)	8.45 (4.44-21.03)
5XSST (sc)	11.59 (3.96-32.98)

BMI: body mass index; FFM: fat free mass; ILD: interstitial lung disease; COPD: Chronic obstructive pulmonary disease; RA: Rheumatoid arthritis; NIMV: Non-invasive mechanic ventilation; mMRC: modified Medical Research Council dyspnea score; FVC: forced vital capacity; FEV1: Forced expiratory volume in one second; MIP: Maximum İnspiratory pressure; MEP: Maximum expiratory pressure; QF: Quadriceps femoris muscle strength; 6MWD: 6-minute walking distance; 10MWT:10-meter walking speed test; 5XSST: 5-times sit-to-stand test
*Dominant side assessments are given

The 6MWT is a submaximal exercise capacity measurement test which is widely used in clinical practice as it requires little equipment and is easy to perform [11]. The test may even be used in patients with severe and very severe COPD [18].

Studies have been conducted on the use of field tests which are easily applicable and completed in a short time instead of 6MWT [19, 20] in various groups of challenging patients. In a study performed in patients with COPD, the suitability of using the one minute sit-to-stand test as an alternative to 6MWT has been assessed. When cardiovascular parameters, dyspnea, and the perception of sensation of fatigue are considered, it has been concluded that this test is a valuable alternative to 6MWT [20]. Our study serves as the first study comparing 10MWT and 5XSST with 6MWT in LTx candidates with severely restricted effort capacity.

Walking speed is a validated, safe, and sensitive measurement monitoring the functional status and expressed as the "sixth vital sign" [21]. The 10MWT is a test used in patients with functional mobility- and gait-related deficits and for monitorization of rehabilitation process. In a study in older patients with COPD, it has been emphasized that 10MWT is a safe test which can be used for the detection of gait deficits [22]. In a study comparing the 6MWT and 4-meter walking speed test which is an alternative to 10MWT, walking speed has been shown to be a remarkable test which is independently associated with six-minute walking distance (6MWD) [23]. This study showed a moderate correlation between 6MWT with 10MWT in LTx candidates.

In the literature, 5XSST has been referred to as a validated and safe test which is easy to perform in COPD patients [24]. A study has investigated the correlation between 4-meter walking speed, 5XSST, and 6MWT in patients with COPD with 6MWD below 350 meters. The results of this study has shown that contrary to 4-meter walking speed, 5XSST served as a significant clinical determinant of a poor 6MWT [25]. In another study, it has been stated that 5XSST and 6MWT provided comparable results in the assessment of functional status in patients with COPD, and also 5XSST can be used as an alternative to 6MWT because it causes much less hemodynamic stress [26]. In this study, we detected a weak correlation between 5XSST and 6MWT, however, a strong correlation between 5XSST and 10MWT. Moreover, we observed a poorer association between 5XSST and clinical and demographic characteristics than 10MWT in LTx candidates.

The 5XSST indicates the functional strength of the lower extremity, the balance, and the risk of falling. Balance is also affected by age and burden of COPD. However, it should be kept in mind that the results of all three tests may be affected by clinical features such as lower extremity muscle strength and age. On the contrary, we think that the short duration of 5XSST makes it possible to demonstrate the exercise capacity without fatigue.

The determination of the demographic and clinical characteristics affecting exercise capacity and efficacy of PR is an issue of concern. In patients with respiratory problems, one of the main factors affecting the exercise capacity is pulmonary function. It has been reported that in COPD, 6MWT (m) is as-

Table 2. Correlation analysis of exercise test values and the clinical and demographic features

	6MWD	10MWT	5XSST	QF	Iliops	MIP	MEP	FEV_1%	BMI
6MWD									
r		-0.449**	-0.397**	0.282*	0.265*	0.273*	-0.025	0.417**	0.364**
p		0.000	0.001	0.026	0.037	0.032	0.847	0.001	0.004
10MWT									
r	-0.449**		0.767**	-0.297*	-0.424**	-0.324**	-0.203	-0.377**	-0.355**
p	0.000		0.000	0.018	0.001	0.010	0.111	0.002	0.005
5XSST									
r	-0.397**	0.767**		-0.254*	-0.269*	-.221*	-0.171	-0.388**	-0.202
p	0.001	0.000		0.045	0.033	.082	0.179	0.002	0.115

6MWD: Six-minute walking distance; 10MWT: 10-meter walking speed test; 5XSST: 5-times sit-to-stand test; QF: Quadriceps femoris muscle strength (lbs); Iliops: Iliopsoas muscle strength (lbs); MIP: Maximum inspiratory pressure; MEP: Maximum expiratory pressure; FEV1: Forced expiratory volume in one second; BMI: Body mass index. *Correlation statistical significance level is 0.05 (2-tailed),**Correlation statistical significance level is 0.01 (2-tailed)

sociated with FEV_1 and diffusion capacity [27] and might be a predictor of spirometric changes in severe and very severe cases [18]. In this study, we detected a moderate correlation between 6MWT and FEV_1 and weak correlation between 10MWT and 5XSST and FEV_1. We have shown that all performance tests are affected by FEV_1.

The mMRC scores of the patients are also given in our study. When the mMRC interval of the patient group was examined, it was seen that it ranged from 1 to 4. This may mean that patients have different exercise capacities. However, the issue examined in our study is the relationship analysis of the results obtained from three tests of each case.

In a longitudinal study performed in 108 LTx candidates, it has been suggested that peripheral muscle strength may be a predictor for 6MWD [28]. In our study, we only detected an association between peripheral muscle strength and 10MWT. Considering that peripheral muscle strength is generally insufficient in terminal term lung diseases, this suggests that, that is a negative against 10MWT.

In a previous randomized controlled trial, we detected that providing inspiratory muscle strengthening training together with PR improves the exercise capacity even more [29]. In this study, we observed that all three tests correlate with inspiratory muscle strength but there was no relationship between test scores and MEP.

Limitations of our study consisted of patient groups with different diagnoses. This is due to the relatively small number of patients. The patients could not be divided into subgroups.

In conclusion, 10MWT and 5XSST tests can be used as an alternative to 6MWT in LTx candidates, especially in patients with severely restricted exercise capacity. Our results have demonstrated that 10MWT and 5XSST correlates with 6MWT. The 5XSST may be preferred in clinical practice to determine the exercise capacity of LTx candidates as it is less affected by clinical and demographic characteristics. In contrast, there was a strong relationship between 6MWT and 10MWT. Timed performance tests are alternative tests to determine exercise capacity in lung transplantation candidates. The appropriate test should be selected by the clinicians per the clinical condition of the patient.

Ethics Committee Approval: Ethics Committee approval for the study was obtained from the Clinical Research Ethics Committee of İstanbul Training and Research Hospital (Protocol Number: 1234).

Informed Consent: Written informed consent was obtained from the from the subjects.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - E.P.; Design - E.P.; Supervision - L.K., E.Y.; Resources - E.P., A.B., L.K., E.Y.; Materials - E.P., A.B.; Data Collection and/or Processing - E.P., A.B.; Analysis and/or Interpretation - E.P.; Literature Search - E.P.; Writing Manuscript - E.P.; Critical Review - E.P., L.K., E.Y.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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