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Comparison of the Sit-to-Stand Test with 6 min walk test in patients with chronic obstructive pulmonary disease

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KEYWORDS
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Summary
Objective: To discuss the utility of Sit-to-Stand Test (STST) compared to the 6 min walking test (6MWT) for the evaluation of functional status in patients with chronic obstructive pulmonary disease (COPD).
Material-Method: Subjects: Fifty-three patients with stable COPD (mean forced expiratory volume in 1 s (FEV_1) 46 ± 9% predicted, mean age 71 ± 12 year) and 15 healthy individuals (mean FEV_1 101 ± 13% predicted and mean age 63 ± 8) were included.
Interventions: Functional performance was evaluated by STST and 6MWT. During the tests, severity of dyspnea (by Modified Borg Scale), heart rate, pulsed oxygen saturation (SpO_2, by Modified Borg Scale) (by pulse oxymeter), blood pressure were measured. The pulmonary function (by spirometry), quadriceps femoris muscle strength (by manual muscle test) and quality of life (by Nottingham Health Profile Survey) were evaluated.
Results: The STST and 6MWT results were lower in COPD group than the healthy group ($P<0.05$). During the 6MWT the rise in the heart rate, systolic blood pressure and the decrease in SpO_2 were statistically significant according to STST in COPD groups ($P<0.05$). The STST and 6MWT were strongly correlated with each other in both groups ($P<0.05$). Similarly, they were correlated with age, quality of life, peripheral muscle strength and dyspnea severity in COPD groups ($P<0.05$).
Conclusion: Similar to 6MWT, STST is also able to determine the functional state correctly. Additionally, it produces less hemodynamical stress compared to the 6MWT. In conclusion, STST can be used as an alternative of the 6MWT in patients with COPD.

Abbreviations: STST, Sit-to-Stand Test; COPD, chronic obstructive pulmonary disease; 6MWT, 6 min walking test; MBS, Modified Borg Scale; BMI, body mass index; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 s; NHPS, Nottingham Health Profile Survey; PMC of NHPS, physical mobility category of Nottingham Health Profile Survey; QF, quadriceps femoris; systolic BP, systolic blood pressure; diastolic BP, diastolic blood pressure; SpO_2, pulsed oxygen saturation.

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Introduction

In patients with chronic obstructive pulmonary disease (COPD), pulmonary problems and peripheral muscle weakness lead to sedentary life which reduces functional status.[1] So evaluating the functional status is very important for prescribing correct medical therapy and pulmonary rehabilitation programs in these patients.[2–4]

As a submaximal exercise test, the 6 min walking test (6MWT) is a good predictor of functional status for patients with chronic respiratory disease.[1,2,5] The 6MWT is easy to administer, well tolerated and more reflective of activities of daily life than the other walk tests and cardiopulmonary exercise tests.[6]

Standing up from sitting position is a very common and essential activity which enables other vital activities possible, such as walking in daily life. The ability to stand up from a chair is an important component to maintaining independence for elderly people and for individuals with disabilities.[7,8] For this reason, Sit-to-Stand Test (STST) has been accepted as an indicator of functional status for elderly people.[9]

Therefore, we concluded that, similar to the 6MWT, STST can be used to determine the functional status in patients with COPD. So the aim of the present study is to evaluate the functional status by the STST and the 6MWT in patients with COPD, and to compare the results of both tests according to some outcome parameters of the patients (pulmonary function, severity of dyspnea and hemodynamical stress and quality of life and peripheral muscle strength) in order to investigate the utility of STST for patients with COPD.

Material and methods

Subjects

Fifty-three consecutive respiratory patients, 33 male and 20 female (the mean forced expiratory volume in 1 s (FEV_1) $46 \pm 9\%$ predicted, mean age 71 ± 12 years), admitted to the out-patient clinic of chest diseases (University of Dokuz Eylul, Department of Chest Disease). All these patients presented clinical histories consistent with moderate-to-severe COPD by the GOLD-2003.[10] All patients were in a clinically stable state for a minimum of 2 weeks and had no recent infectious exacerbations.

The healthy group was randomly selected from voluntary patient relatives or visitors. And 15 healthy individuals who had normal respiratory capacity in pulmonary function test (PFT) (mean FEV_1 $101 \pm 13\%$ predicted and mean age 63 ± 8 years) were evaluated and the results of two groups were compared.

Study design

In the same afternoon, each subject performed STST and 6MWT, with an interval of at least 2 h between each test; the sequence of the tests was randomized. The pulmonary function by spirometry and quadriceps femoris (QF) muscle strength by manual muscle test and quality of life by physical mobility category of Nottingham Health Profile Survey (PMC of NHPS) were evaluated.

The protocol of this study was approved by the local ethic committee. The aim of the study was fully explained to participants, and all gave oral informed consent.

Outcome measurements

The evaluation of exercise capacity

Sit-to-Stand Test (STST)

The STST was performed with a standard height (46 cm) chair without arm rests. The subjects held their arms stationary by putting their hands on their hips. The test was first demonstrated by a staff and then performed by a subject. Subjects were asked to complete the sitting and standing positions as correctly and as fully without using the arms for support while rising and sitting. When the subjects were instructed by the command ''Go!'', they stand upright and without delay sit down again, repeating the procedure as many times as possible in a 1 min period at a self-selected speed which is they felt safe and comfortable until asked if they wish to stop. It is taken care to be in full exention motion and approximately 90° flexion motion on knee joint. The number of completed repetitions was recorded. The subjects were permitted to use rest periods to complete 1 min.[11]

6 min walking test (6MWT)

We conducted the 6MWT as described by Guyatt and colleagues. Subjects were instructed to walk from end to end at the corridor of the hospital which is 40 m long at their own pace, while attempting to cover as much distance as possible in the allotted 6 min without supplemental oxygen. A research assistant timed the walk and recorded the distance traveled. The research assistant offered verbal

encouragement to each subjects. At the end of the 6MWT, the total distance covered was recorded to the nearest meter.[6,12]

Dyspnea severity by the Modified Borg Scale (MBS) and heart rate, blood pressure and pulsed oxygen saturation (SpO_2, with Palco 400 model pulse oxymeter, Palco Labs, Santa Cruz, USA) were measured before and at the end of tests. Tests were not done if SpO_2 before test was lower than 90% and test was terminated according to the patients' exhausts of the fatigue legs and/or the severity of dyspnea, etc. reasons or the request from the subjects to stop.

Rating of dyspnea

At a single point in time, the severity of dyspnea on resting and end of the STST and walking test was evaluated by MBS. The subjects were informed about use of this scale. The MBS, the Borg scale rating of perceived exertion has been modified to measure symptoms such as breathlessness. A commonly used format is a 10-point scale with a nonlinear scaling scheme using descriptive terms to anchor responses.[13]

Evaluation of the lung function

Pulmonary function tests (PFTs)

Spirometry was performed by an expert using a Sensormedics Vmax 22 machine (SensorMedics Inc., Anaheim, CA, USA) appropriately to the ATS criteria's.[14] Forced vital capacity (FVC), FEV_1 and FEV_1/FVC values had been recorded.

The peripheral muscle strength

As a criterion, only the QF muscle strength was tested with manual muscle test by the use of Daniels 0–5 Grading System in sitting position.[15]

Quality of life

The health-related quality of life was conducted with the NHPS. It is reproducible and valid in the assessment of chronic diseases and has been used to describe patients with COPD. The NHPS is a self-administered questionnaire composed of two sections containing 45 items. The first section contains 38 items assessing energy, pain, emotional reactions, sleep, social isolation and physical mobility. In this study, only the PMC (eight items) was used. All questions are yes–no questions. The dimension scores so that the best function was represented by a score of 0 and the worst function was represented by a score of 100.[16]

Statistical analysis

All results are presented as mean $\pm$ SD. Data comparison among different tests was performed by means of ANOVA, while comparisons between baseline and the end of tests and between the groups were performed by means of the paired *t*-test. Changes from baseline were computed for each test and compared by means of ANOVA. The correlation between results of STST and 6MWT was calculated by Pearson's and Spearman rank correlation coefficient (*r*). A *P*-value of less than 0.05 was considered significant.

Results

There was no significant difference between the patients with COPD and healthy groups regarding the demographic data ($P>0.05$, Table 1). PFT values were lower and smoking history was higher in patients with COPD compared with healthy subjects ($P<0.05$, Table 1).

Forty-eight subjects (40 patients with COPD, eight healthy subjects) had a history of smoking, but were not smoking currently. The distribution of smoking history among the COPD and healthy groups was statistically significant ($P<0.05$, Table 1).

STST result and 6MWT distance were found to be significantly lower in patients with COPD compared with healthy individuals ($P\leqslant0.01$). Furthermore, QF muscle strength was detected to be lower ($P<0.05$), and PFC of NHPS value was found to be higher, so the quality of life was worse in patients with COPD ($P=0.001$, Table 2).

During 6MWT, a significant increase in the heart rate and systolic blood pressure (systolic BP) and a decrease in pulsed saturation were determined in the COPD group ($P<0.05$), while no change during STST ($P>0.05$). But the severity of dyspnea significantly increased in both the tests ($P<0.05$, Table 3).

In healthy group, while no change was observed in the severity of dyspnea, heart rate and blood pressure before and after the test during STST ($P>0.05$), only the heart rate during 6MWT was found to be significantly increased ($P<0.05$, Table 3).

When the correlations of STST and 6MWT results were examined, STST and 6MWT results were associated with each other in both groups (for COPD group, $r=0.75$, $P<0.001$, for the healthy group, $r=0.54$, $P=0.04$, Table 4, Fig. 1).

No association was found between both tests and the PFT parameters in both groups ($P>0.05$). The

Table 1 Baseline patient characteristics.*

	COPD group (53)	Healthy group (15)	*P*
Male/female gender (no)	33/20	4/11	0.16
Age (yr)	71±12 (52–85)	62.80±7.65 (54–78)	0.07
Height (cm)	167±11 (150–180)	162.33±9.17 (146–180)	0.70
Weight (kg)	66±5 (48–98)	75.93±11.41 (58–102)	0.12
BMI (kg/cm^2)	23±5	27±4	0.07
FVC (l/s)	2±1	3±1	0.002
FVC (% predicted)	60±2	102±13	0.00
FEV_1 (l/s)	1±1	3±1	0.00
FEV_1 (% predicted)	46±9 (35–64)	101±13	0.00
FEV_1/FVC	62±2	82±5	0.00
The rate of smoking	%75	%53	0.01
Smoking year (yr)	38±14	22±11	0.02
Smoking consumption (packet/day)	1±0	1±1	0.15

BMI = body mass index; FVC = forced vital capacity; FEV_1 = forced expiratory volume in 1 s.
*Data are presented as mean±SD unless otherwise indicated.

Table 2 Results of STST and 6MWT, some parameters of COPD and healthy groups.*

	COPD group	Healthy group	*P*
Sit-to-stand repetitions (min^{-1})	15±5 (4–23)	20±4 (14–25)	0.01
6 min walking distance (m)	112±61 (20–300)	423±60 (320–560)	0.001
The score of PMC of NHPS	46±2	2±6	0.001
Strength of QF muscle, value/5			
Left	4±1	5±1	0.02
Right	4±1	5±1	0.03

PMC of NHPS = physical mobility category of Nottingham health profile survey; QF = quadriceps femoris.
*Data are presented as mean±SD.

result of STST showed correlation with the result of PMC of NHPS and QF muscle strength in healthy group. In COPD group, STST result was significantly associated with age, dyspnea at rest and effort in addition to these parameters ($P<0.05$). 6MWT result significantly correlated with age, PMC of NHPS result, QF muscle strength, severity of dyspnea and the last heart rate in patients with COPD while 6MWT result was found to be associated with only age and QF muscle strength in healthy group ($P<0.05$, Table 4).

Discussion

The purpose of this study is to compare the utility of the STST to that of 6MWT in the evaluation of the functional status in patients with COPD. In the literature, STST is generally used to determine the functional status of elderly patients with orthopedic diseases.[8,9,17–20] The 6MWT is usually used for patients with COPD. The timed walk distance has been demonstrated to be a strong predictor of survival in patients with COPD.[1,2,4–6,12,21] Therefore, we consider that STST could determine the functional status as the 6MWT in patients with COPD.

We found that the results of the two tests were correlated with each other in both the patients with COPD and the healthy individuals. This correlation was particularly strong in the COPD group. We hypothesized that the reason for a lower correlation coefficient in the healthy group was probably the limited number of subjects in this group. Furthermore, we found that similar to 6MWT, the results of STST were correlated with age and quality of life and severity of dyspnea and peripheral muscle strength values in patients with COPD and healthy individuals. This result led us to an assumption that the two tests are consistent with one another. As a difference, we demon-

Table 3 Change of cardiorespiratory parameters during the STST and 6MWT.[†]

	STST			6MWT		
	COPD	Healthy	*P*	COPD	Healthy	*P*
Dyspnea, Borg index						
Baseline	2±2	0	0.00	3±1	0	0.00
End	5±2	0	0.00	7±2	0±1	0.00
Change from baseline	2±1*	0	0.00	3±2*	0±1	0.00
Heart rate (beats/min)						
Baseline	87±9	79±13	0.10	87±11	78±12	0.05
End	98±22	89±11	0.10	110±20	88±12	0.001
Change from baseline	10±3	3±10	0.07	21±8*	10±7*	0.01
Systolic BP (mmHg)						
Baseline	140±3	133±1	0.18	140±3	133±4	0.16
End	142±8	138±8	0.22	148±2	138±8	0.001
Change from baseline	4±1	3±2	0.07	9±4*	3±0	0.001
Diastolic BP (mmHg)						
Baseline	78±1	71±2	0.28	78±1	74±1	0.32
End	80±0	74±0	0.08	80±1	74±1	0.08
Change from baseline	1±1	2±2	0.27	2±2	1±1	0.24
SpO_2 (%)						
Baseline	93±3	97±1	0.00	93±3	98±1	0.00
End	92±4	97±1	0.01	89±4	97±1	0.00
Change from baseline	−0±1	−0±1	0.70	−3±3*	−0±1	0.01

Systolic BP = systolic blood pressure; Diastolic BP = diastolic blood pressure; SpO_2 = pulsed oxygen saturation.
[†]Data are presented as mean±SD unless otherwise indicated.
*$P<0.05$.

strated that the cardiorespiratory stress after STST was lower than the response that was obtained after the 6MWT.

In order to compare the two tests, we tried to explore the correlation between the results obtained from both tests and main functional parameters of the subjects (pulmonary function, dyspnea, peripheral muscles strength, age, etc.).

It is determined that FEV_1 is a poor predictor of symptoms and disability in COPD patients.[1,3,5,22] We did not find a correlation between the FEV_1 and functional status (measured by STST and 6MWT) in patients with COPD and in healthy individuals. Our results supported that FEV_1 is not a strong predictor of functional status in healthy individuals either. In the relevant studies, these results about FEV_1 underline the importance of performing exercise evaluation in patients with COPD. Thus, exercise test must be performed in these patients in order to assess their disability, because this information cannot be derived from traditional functional findings.[2,3,23]

Generally, peripheral muscle weakness is a result of chronic inactivity and muscle deconditioning in patients with COPD and may play a role in the reduction of functional capacity.[24] Additionally in these patients, dyspnea and lower limb muscular weakness may be accompanied by cardiorespiratory limitation, which affects the results of performance.[4] It is known that 6MWT determines the strength of lower extremity muscles.[25,26] We found that QF muscle strength (measured by the manual muscle test and 6MWT) is lower in COPD patients compared to that of the healthy individuals.

STST performance is influenced by some factors associated with balance and mobility. It is determined that STST performance is influenced not only by lower limbs muscle strength but also multiple physiological and psychological processes and represents a particular transfer skill.[8,17] But, it is obviously known that quadriceps muscle strength is extremely important to develop the movement across the knee that is necessary to enable functionally limited elders to arise from a chair.[20,27] So, it was concluded that the STST provided a reasonably reliable and valid indicator of lower extremity muscle performance in

Table 4 Relationship between the results of STST and 6MWT and some outcome parameters.

	Sit-to-Stand test		6 min walking test	
	COPD *r*	Healthy *r*	COPD *r*	Healthy *r*
Sit-to-stand repetitions (min^{-1})	—	—	0.75***	0.54*
Age (yr)	−0.87***	0.07	−0.65**	−0.69**
BMI (kg/cm^2)	0.16	−0.20	0.11	−0.13
FVC (%)	−0.14	−0.30	0.13	−0.09
FEV_1 (%)	−0.22	−0.35	0.29	−0.06
FEV_1/FVC	−0.18	−0.09	0.05	−0.10
The score of PMC of NHPS	−0.63**	−0.69**	−0.55*	−0.28
Strength of QF muscle				
Left	0.65**	0.48*	0.62**	0.42*
Right	0.65**	0.45*	0.60**	0.34*
Baseline dyspnea, Borg index	−0.75***	—	−0.75***	—
End dyspnea, Borg index	−0.80***	—	−0.85***	−0.28
Baseline heart rate (beats/min)	0.25	0.40	−0.33	−0.40
End heart rate (beats/min)	0.04	0.38	−0.47*	−0.26
Baseline systolic BP (mmHg)	0.09	−0.08	0.02	−0.04
End systolic BP (mmHg)	0.06	−0.15	0.30	−0.03
Baseline SpO_2 (%)	−0.11	−0.06	−0.24	−0.06
End SpO_2 (%)	−0.20	−0.01	−0.24	−0.09

r: Pearson's and Spearman rank correlation coefficient.
BMI = body mass index; FVC = forced vital capacity; FEV_1 = forced expiratory volume in 1 s; PMC of NHPS = physical mobility category of Nottingham health profile survey; QF = quadriceps femoris; Systolic BP = systolic blood pressure; SpO_2 = pulsed oxygen saturation.
*$0.05 \geqslant P > 0.01$.
**$0.01 \geqslant P > 0.001$.
***$P \leqslant 0.001$.

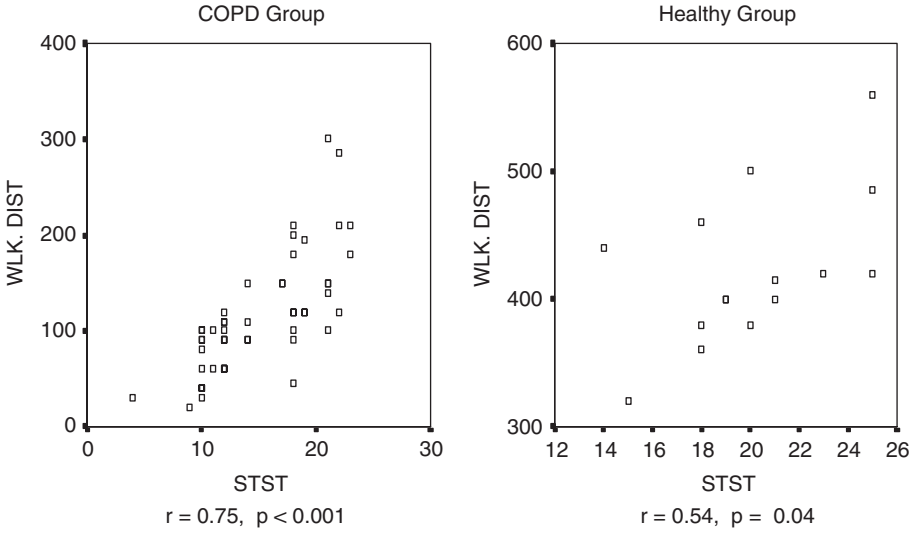

Figure 1 Relationship between the 6 min walking distance and result of STST in healthy and COPD groups.

generally active older adults and renal transplant candidates.[11,19,20] Lord et al.[17] indicated that STST performance is influenced by quadriceps strength, which was the most important variable in explaining the result of STST. Lindemann et al.[18] showed that STST was able to measure power during performance of a daily task and it might detect decline in muscle function earlier than measurement of the functional status. It has been estimated that the STST is a practical mean of documenting lower extremity muscle performance.[11] We found that STST was related with

muscle strength like 6MWT in both COPD and healthy groups although it is not a strength test. Thus, we concluded that the STST is able to identify peripheral muscle weakness in patients with COPD.

Age and dyspnea are the strongest and most consistent correlates of impaired exercise performance in patients with chronic airway obstruction.[3] It has been reported that perceived breathlessness is correlated with walking distance in patients with COPD.[2,21,22] But, Torres et al.[4] found that 6MWT provides independent information regarding the functional status of COPD patients as it does not correlate with the changes in dyspnea severity and quality of life. In contrast, Wijkstra et al. found that the 6MWT is correlated with quality of life and dyspnea.[6,23] We found that, similar to the 6MWT, STST is correlated with severity of dyspnea, age and quality of life. These results show that the STST is sensitive for respiratory symptoms and clinic of patients with COPD.

Stel et al.[2] determined a relationship between the 6MWT and desaturation and heart rate. In COPD patients, systolic BP and heart rate and dyspnea were significantly increased and pulsed saturation was significantly decreased at the end of the 6MWT.[28] Likewise, in our study, the 6MWT revealed similar results in COPD patients. Since STST does not cause an increase in heart rate systolic BP and a decrease in pulsed saturation as in the 6MWT, its application is easier and it produces less cardiac stress. Anyway, it is widely known that standing from a sitting position is a very common, yet essential activity in daily life.[7] Since STST was found to be related with result of NHP evaluating functional independence in daily living activities, it can define the independence of the patient in daily life activities.

Celli et al.[29] and Delgado et al.[30] showed that the arm muscles are active during walking exercise in some patients with COPD and this might be a source of reflex impulses to the respiratory centers, leading to dis-synchronous breathing and consequently impairing gas exchange. As we compared the two tests, we hypothesized that upper extremity muscle activation might be affected by the motivation and encouragement of the patients by the researchers. However, in STST, arm activities are absent in contrast to 6MWT, so arm muscles are not active as in walking. It should be mentioned that STST may be a familiar form of exercise for our patients and may need less ventilatory demand than the 6MWT. We did not measure breathing pattern or ventilatory demand during the STST and 6MWT, and further studies are needed.

Similarly, it was found that encouragement significantly increased the distance walked in 6MWT.[31] The lack of encouragement influenced patient response in the STST test. Since this test is easier than 6MWT, STST can evaluate the exercise capacity more accurately than 6MWT in patients with COPD.

In addition, Poulain et al.[21] and Schenkel et al.[32] determined that daily activities, such as walking, etc., are associated with transient oxygen desaturation in patients with moderate-to-severe COPD, even without marked resting hypoxemia. We also found that 6MWT caused desaturation in patients with COPD. The absence of desaturation in STST shows that STST can evaluate the exercise capacity more accurately.

In conclusion, we prove that STST determines the functional state correctly like 6MWT in patients with moderate-to severe COPD as STST is comparably less hemodynamically stressful, easier to apply and more sensitive for the patient's clinical status compared to 6MWT. These findings led us to the idea of using STST as an alternative of 6MWT to assess the functional capacity in patients with moderate-to-severe COPD.

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