Original Article

Sit-to-stand test and 6-min walking test correlation in patients with chronic obstructive pulmonary disease

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Abstract:

BACKGROUND: The 6-min walking test (6MWT) is one of the most commonly used tests to assess exercise capacity during chronic obstructive pulmonary disease (COPD). However, it is a relatively time-consuming test. Many authors assessed the usefulness of simpler methods, as the sit-to-stand test (STST), to estimate exercise capacity.

PURPOSE: To demonstrate the feasibility of STST, in comparison to 6MWT, for the evaluation of functional status in Tunisian COPD patients and evaluate its correlation to the severity of the disease.

METHODS: We studied patients with COPD (Global Initiative for Chronic Obstructive Lung Disease A-D). All patients had plethysmography and manual quadriceps femoris muscle strength evaluation. Each patient completed a 6MWT and a STST. During the tests, dyspnea severity (Borg scale), heart rate, pulsed oxygen saturation, and blood pressure were measured.

RESULTS: In 49 patients with stable COPD (mean age 67.06 ± 8.4 years, mean forced expiratory volume in the first second 46.25% ± 19.64%), 6MWT and STST were correlated with each other ($r = 0.47$, $P = 0.001$). During 6MWT and STST, the rise in heart rate, systolic blood pressure, and severity of dyspnea were statistically significant compared to baseline ($P < 0.05$). However, cardiorespiratory stress was lower after STST than after 6MWT ($P < 0.05$). A statistically significant positive correlation was noted between the 6MWT distance and forced vital capacity ($r = 0.357$, $P < 0.05$). The 6MWT was negatively correlated with dyspnea severity at baseline ($r = -0.289$, $P < 0.05$) and with BODE index ($r = -0.672$, $P < 0.01$). STST was correlated only with age ($r = 0.377$, $P < 0.01$). No correlation was found between both tests and quadriceps femoris strength.

CONCLUSION: As like as 6MWT, STST can determine functional status during COPD. In addition, it is less time consuming and produces less hemodynamical stress compared to 6MWT. STST can be used as an alternative for 6MWT in patients with COPD.

Key words:

Chronic obstructive pulmonary disease, functional status, muscle dysfunction, pulmonary function, survival

Physical inactivity in daily life is one of the prominent features during chronic obstructive pulmonary disease (COPD).[1-4] It leads to a low daily physical activity levels with an increase of social isolation and depression.[5] At present, the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines advocates that improvement in functional status should be a major goal in COPD treatment.[6] Several tests are available for evaluation of functional exercise capacity.[7] One of the most used clinical exercise tests is the 6-min walking test (6MWT). It is a practical and well-tolerated test, which is more reflective of daily life activities than cardiopulmonary exercise tests.[8] Other objective methods such as the sit-to-stand test (STST)[9] and the hand-grip strength test[10] could be an alternative to the 6MWT. STST evaluates the ability to stand up from sitting position, which is an essential activity as walking in daily life. During COPD, STST was shown to be correlated to the timed walk distance and to daily physical activity.[11,12] Thus, we hypothesize that STST could be used as 6MWT, to determine the functional status in patients with COPD. The present study aims to demonstrate the feasibility of STST, in comparison to 6MWT, for the evaluation of functional status in a Tunisian

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COPD population and to evaluate its correlation to the severity of the disease.

Methods

Subjects

Patients with mild-to-very severe COPD referred to the Pulmonary Department of University Hospital Rabta of Tunis between January and June 2014 were considered for participation in the study.

The inclusion criteria were:

- Male/female subjects aged from 40 to 75 years with confirmed COPD according to GOLD-guidelines.
- Clinically stable state for a minimum of 2 weeks having had no recent infectious exacerbations.

The exclusion criteria were:

- Chronic respiratory failure with long term oxygen therapy.
- A recent coronary syndrome.
- Severe hypertension.
- Orthopedic pathology with walking difficulty.

Study design

Each patient performed STST and 6MWT, with an interval of 2 h between each test; the sequence of the tests was randomized. Severity of dyspnea on resting and at the end of the STST and 6MWT was evaluated by Borg scale. The study protocol was approved by the local ethic committee. The aim of the study was fully explained to participants, and all gave informed consent.

Methods

6-min walking test

Patients performed the 6MWT according to the guidelines of the American Thoracic Society (ATS).[7] The 6MWT was performed on a 30-meter indoor track while attempting to cover as much distance as possible in the allotted 6-min without supplementary oxygen. An experienced investigator timed the walk and recorded the distance traveled using standardized encouragement strategy. None of the patients used a walking aid in daily life or during the test.

Sit-to-stand test

A standard chair (height 46 cm) with no arm supports was used. Patients were instructed to stand up from and sit down on the chair with no support from the hands, repeating the procedure as many times as possible for the duration of 1-min at a patient defined pace.[9] The test was first demonstrated by a staff member and then performed by the subject. The number of stands during 1-min was determined manually.

Evaluation of the lung function

Pulmonary function tests

Spirometry, whole body plethysmography measurements were performed according to the ATS and the European Respiratory Society guidelines using a Medisoft Bodybox 5500 plethysmograph.[13,14] Forced vital capacity (FVC), mean forced expiratory volume in 1 s (FEV_1), FEV_1/FVC, total pulmonary capacity, and residual volume values were recorded.

Peripheral muscle strength

The quadriceps femoris muscle strength was tested with manual muscle test by the use of Daniels 0-5 Grading System in sitting position.[15]

Statistical analysis

A statistical software package was used for all measures (SPSS for Windows, version 11.0, Maasachussets, USA). Descriptive data were expressed as mean and standard deviation. Data comparison among different tests was performed by means of ANOVA. The correlation between results of STST and 6MWT was calculated by Pearson's and Spearman rank correlation coefficient (r). A $P < 0.05$ was considered significant. Comparisons between baseline and the end of tests were performed by means of the paired t-test. Changes from baseline were computed for each test and compared by means of ANOVA test.

Results

Forty-nine patients with stable COPD (mean age 67.06 ± 8.4 years, mean FEV_1 46.25% ± 19.64%) met the inclusion and exclusion criteria and agreed to take part in the study. Anthropometrical characteristics, pulmonary function data, and BODE index (total score) values of the patients are presented in Table 1. Patients reported the following comorbidities: diabetes mellitus (eight patients), hypertension (11 patients), coronary artery disease (three patients), and stroke (one patient). The average tobacco consumption was 59.51 package per year (PA) ± 31.29. Twenty-five patients declared they were active smokers. COPD was mild (GOLD I) in 6%, moderate (GOLD II) in 36%, severe (GOLD III) in 34%, and very severe (GOLD IV) in 24% of the patients. The majority of patients (63.2%) were "at high risk and with high symptom burden" (GOLD D). The mean degree of dyspnea on Borg scale was 4.61 ± 2.1. The mean 6MWT distance was 449.08 m ±131.88. The mean number of stands during STST was 19.31 ± 5.56.

Table 1: Baseline patient characteristics

Variable	Mean±SD	Minimum–maximum values
Number of patients (*n*)	49	—
Male/female gender (*n*)	49/0	—
Age (years)	67.06±8.45	49-87
Weight (kg)	69±14.27	48-105
Height (m)	1.68±5.91	1.57-1.80
BMI (kg/m^2)	24.8±4.67	16.9-37.1
FVC (l)	2.38±0.73	0.58-4.4
FVC (% predicted)	63.44±18.17	13-98
FEV_1 (l)	1.35±0.60	0.29-2.92
FEV_1 (% predicted)	46.25±19.64	8-86
FEV_1/FVC	56.24±10.97	30-70
TLC (l)	7.12±1.42	4.31-11.5
TLC (% predicted)	111.97±20.74	85-159
RV (L)	4.64±1.69	0.55-8.25
RV (% predicted)	191.26±38.82	79-364
RV/TLC (% predicted)	162.79±38.82	56-242
BODE index	3.62±2.32	0-8

BMI = Body mass index, FVC = Forced vital capacity, FEV_1 = Forced expiratory volume in the first second, FEV_1/FVC = Forced expiratory volume in the first second/forced vital capacity ratio, TLC = Total lung capacity, RV = Residual volume, SD = Standard deviation

Results of 6MWT, STST, and quadriceps femoris strength are presented in Table 2. Significant increase in dyspnea severity, heart rate, and systolic blood pressure were noted during 6MWT and STST [$P < 0.05$, Table 3]. However, STST was less hemodynamically stressful than 6MWT ($P < 0.05$). The pulsed saturation did not significantly change during the two tests [$P > 0.05$, Table 3]. There was a statistically significant positive correlation between the 6MWT distance and the number of stands during the STST [$r = 0.47$, $P = 0.001$; Figure 1]. There was a statistically significant negative correlation between the 6MWT distance with dyspnea severity at baseline [$r = -0.289$, $P < 0.05$; Table 4] and with BODE index [$r = -0.672$, $P < 0.01$; Table 4]. A statistically significant positive correlation was noted between the 6MWT distance with FVC [$r = 0.357$, $P < 0.05$; Table 4]. Number of stands during STST was associated only with age [$r = -0.377$, $P < 0.01$; Table 4]. No correlation was found between both tests and quadriceps femoris strength [$P > 0.05$, Table 4].

Discussion

The number of published studies measuring functional status during COPD is increasing rapidly over the past years.[9] It reflects clinician's awareness about functional status during COPD. Improvement of daily physical and social activities is now one of the most pertinent clinical issues in the COPD management.[6] In clinical practice, functional status can be measured by several different methods. According to Kocks *et al*., measurement tools of functional status can be categorized into: Laboratory tests (e.g.,: Cycle ergometry), semi-laboratory tests (e.g.,: The 6MWT), field tests (e.g.,: The accelerometer), and patient-reported consequences (e.g.,: MMRC dyspnea scale and the St. George's Respiratory Questionnaire).[9] The 6MWT is one of the most reliable semi-laboratory tests. It is standardized, easy to perform, and well tolerated.[7] Moreover, the time walking distance is a strong predictor of survival in patients with COPD.[8,16-21] However, the most important barrier for the use of 6MWT is that it requires trained staff, space, and equipment, which is not commonly available in many practice settings.[7,22] Over the last years, a significant amount of research has been performed to explore simpler tests like STST, to measure exercise capacity. Initially, STST was essentially used to determine the functional status of elderly patients with orthopedic diseases.[23-28] Later, it was demonstrated that, during COPD, STST is strongly associated with time walking distance, mortality, and with BODE Index.[12,29-31] These data lead us to hypothesize that STST could be used to determine the functional state of Tunisian patients with COPD. Our results show that 6MWT distance and the number of stands during STST were significantly correlated with each other. Several authors investigated the usefulness of simpler and less time-consuming tests than 6MWT, to assess daily activity during COPD. They found that, like the 6MWT distance, the number of stands during STST is correlated to daily activity.[11,32] In addition, as suggested by our results, STST is better tolerated and produces less hemodynamic stress compared to the 6MWT. Therefore, STST is a reliable and practical test that could be used for mild to moderate COPD to assess functional status.

During COPD, dyspnea is one of the strongest correlates of impaired exercise performance.[33] As shown in our study, perceived breathlessness is correlated with walking distance in patients with COPD.[17,21,34] Unlike dyspnea, FEV_1 is known to be a poor predictor of symptoms and disability during COPD.[16,19,33,34] Our results demonstrated that there is no significant correlation between COPD severity (FEV_1) and functional status (STST and 6MWT). These results lead us to emphasize that during COPD, functional tests are essential in order to assess patient's disability. This information cannot be obtained only from traditional functional findings.[17,33,35]

Table 2: Results of STST and 6MWT

Variable	Mean ± SD	Minimum–maximum values
STST (*n*)	19.31±5.56	10-30
6MWT (m)	449.08±131.88	120-645
6MWT (% predicted)	69.50±20.71	17.5-105
Strength of QF muscle (value/5)		
Left	4.31±0.79	3-5
Right	4.37±0.80	3-5

STST = Sit-to-stand test, 6MWT = 6-min walking test, QF = Quadriceps femoris, SD = Standard deviation

Table 3: Change of cardiorespiratory parameters during the STST and 6MWT

Parameters	Baseline	End	Change from baseline	*P*
6MWT				
Dyspnea (Borg)	4.6±2.1	6.4±2.7	1.79±2.62	<0.0001
Heart rate (beats/min)	84±14	95±14	11±14	<0.0001
Systolic blood pressure (mmHg)	12.8±1.7	13.5±2.2	0.68±1.95	0.01
SpO_2 (%)	95.7±2.7	96.5±2.41	0.77±3.47	0.1
STST				
Dyspnée (Borg)	4.6±2.1	6.04±2.74	1.42±2.23	<0.0001
Heart rate (beats/min)	84±14	90±17	6±13	0.001
Systolic blood pressure (mmHg)	12.8±1.7	13.3±2	0.5±1.5	0.01
SpO_2 (%)	95.7±2.7	95.9±4.22	0.2±2.8	0.6

STST = Sit-to-stand test, 6MWT = 6-min walking test, SpO_2 = Oxygen saturation

Table 4: Correlation between STST and 6MWT and some parameters

Variables	6MWT (m)	STST (*n*)
Age	−0.114	−0.377**
BMI	−0.016	−0.035
Baseline dyspnea (Borg scale)	−0.289*	−0.115
End dyspnea (Borg scale)	−0.396**	−0.1
QF strength	0.252	0.206
Baseline SpO_2	0.092	−0.017
End SpO_2	0.207	−0.128
FVC (%)	0.357*	0.154
FEV_1 (%)	0.271	0.026
BODE index	−0.672**	−0.083

r: Pearson correlation coefficient (*$P = 0.05 \geq P > 0.01$, **$P = 0.01 \geq P > 0.001$). BMI = Body mass index, QF = Quadriceps femoris, SpO_2 = Oxygen saturation, FVC = Forced vital capacity, FEV_1 = Forced expiratory volume in the first second, STST = Sit-to-stand test, 6MWT = 6-min walking test

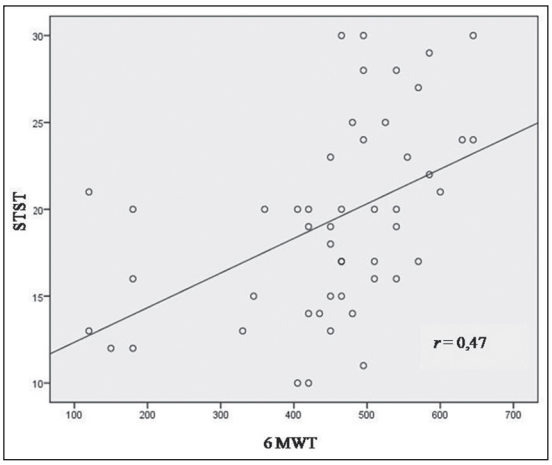

Figure 1: Correlation between the 6-min walking test distance and number of stands during sit-to-stand test

More than lung function or dyspnea, exercise capacity is consistently correlated with mortality during COPD.[36,37] The BODE Index is considered to be the best predictor of survival in patients with COPD.[38] Many authors showed a correlation between the BODE index and variables assessed during the 6MWT and STST in moderate to very severe COPD patients.[29,38] Our study demonstrated a statistically significant negative correlation between the BODE index and the 6MWT distance.

It has been recognized that skeletal muscle dysfunction is a common feature in patients with COPD.[39] Peripheral muscle weakness affects the results of performance in these patients.[18] 6MWT and STST are able to identify peripheral muscle weakness during COPD.[28,40-42] Unexpectedly, our study showed no correlation between functional status (6MWT, STST) and muscle strength. The relative muscle strength preservation in our patients could explain these findings. Moreover, quadriceps femoris muscle strength was tested manually by a physiotherapist. Use of more objective tests like the hand-grip test, may be more appropriate to accurately assess muscle strength.

Conclusion

This study proves that STST, like 6MWT, correctly determines the functional status in patients with COPD. Moreover, STST is less hemodynamically stressful and easier to apply compared to 6MWT. Thus, although STST was not correlated to COPD severity, these findings led us to emphasize the use of STST as an alternative of 6MWT to assess the functional capacity in patients with COPD.

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Conflicts of interest
There are no conflicts of interest.

References

1. Kapella MC, Larson JL, Patel MK, Covey MK, Berry JK. Subjective fatigue, influencing variables, and consequences in chronic obstructive pulmonary disease. Nurs Res 2006;55:10-7.
2. Donaldson GC, Wilkinson TM, Hurst JR, Perera WR, Wedzicha JA. Exacerbations and time spent outdoors in chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2005;171:446-52.
3. Decramer M, Gosselink R, Troosters T, Verschueren M, Evers G. Muscle weakness is related to utilization of health care resources in COPD patients. Eur Respir J 1997;10:417-23.
4. Garcia-Aymerich J, Lange P, Benet M, Schnohr P, Antó JM. Regular physical activity reduces hospital admission and mortality in chronic obstructive pulmonary disease: A population based cohort study. Thorax 2006;61:772-8.
5. Bourbeau J. Activities of life: The COPD patient. COPD 2009;6: 192-200.
6. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management and prevention of chronic obstructive pulmonary disease–executive summary. Ghent, Belgium: Heart, Lung, and Blood Institute, World Health Organization COPD; 2004. p. 103-4, 105-41.
7. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: Guidelines for the six-minute walk test. Am J Respir Crit Care Med 2002;166:111-7.
8. Guyatt GH, Sullivan MJ, Thompson PJ, Fallen EL, Pugsley SO, Taylor DW, *et al.* The 6-minute walk: A new measure of exercise capacity in patients with chronic heart failure. Can Med Assoc J 1985;132:919-23.
9. Kocks JW, Asijee GM, Tsiligianni IG, Kerstjens HA, van der Molen T. Functional status measurement in COPD: A review of available methods and their feasibility in primary care. Prim Care Respir J 2011;20:269-75.
10. Bossenbroek L, de Greef MH, Wempe JB, Krijnen WP, Ten Hacken NH. Daily physical activity in patients with chronic obstructive pulmonary disease: A systematic review. COPD 2011;8:306-19.
11. Van Gestel AJ, Clarenbach CF, Stöwhas AC, Rossi VA, Sievi NA, Camen G, *et al.* Predicting daily physical activity in patients with chronic obstructive pulmonary disease. PLoS One 2012;7:e48081.
12. Ozalevli S, Ozden A, Itil O, Akkoclu A. Comparison of the sit-to-stand test with 6 min walk test in patients with chronic obstructive pulmonary disease. Respir Med 2007;101:286-93.
13. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, *et al.* Standardisation of spirometry. Eur Respir J 2005;26:319-38.
14. Miller MR, Crapo R, Hankinson J, Brusasco V, Burgos F, Casaburi R, *et al.* General considerations for lung function testing. Eur Respir J 2005;26:153-61.
15. Clarkson HM, Giilewich GB, editors. Musculoskeletal Assessment, Joint Range of Motion and Manual Muscle Strength. Baltimore, MD: Williams & Wilkins; 1989.
16. Bowen JB, Votto JJ, Thrall RS, Haggerty MC, Stockdale-Woolley R, Bandyopadhyay T, *et al.* Functional status and survival following pulmonary rehabilitation. Chest 2000;118:697-703.
17. Van Stel HF, Bogaard JM, Rijssenbeek-Nouwens LH, Colland VT. Multivariable assessment of the 6-min walking test in patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2001;163:1567-71.
18. de Torres JP, Pinto-Plata V, Ingenito E, Bagley P, Gray A, Berger R, *et al.* Power of outcome measurements to detect clinically significant changes in pulmonary rehabilitation of patients with COPD. Chest 2002;121:1092-8.
19. Pinto-Plata VM, Cote C, Cabral H, Taylor J, Celli BR. The 6-min walk distance: Change over time and value as a predictor of survival in severe COPD. Eur Respir J 2004;23:28-33.
20. Carter R, Holiday DB, Nwasuruba C, Stocks J, Grothues C, Tiep B. 6-minute walk work for assessment of functional capacity in patients with COPD. Chest 2003;123:1408-15.
21. Poulain M, Durand F, Palomba B, Ceugniet F, Desplan J, Varray A, *et al.* 6-minute walk testing is more sensitive than maximal

incremental cycle testing for detecting oxygen desaturation in patients with COPD. Chest 2003;123:1401-7.
22. Puhan MA, Zoller M, ter Riet G. COPD: More than respiratory. Lancet 2008;371:27-8.
23. Millington PJ, Myklebust BM, Shambes GM. Biomechanical analysis of the sit-to-stand motion in elderly persons. Arch Phys Med Rehabil 1992;73:609-17.
24. Gross MM, Stevenson PJ, Charette SL, Pyka G, Marcus R. Effect of muscle strength and movement speed on the biomechanics of rising from a chair in healthy elderly and young women. Gait Posture 1998;8:175-85.
25. Lord SR, Murray SM, Chapman K, Munro B, Tiedemann A. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. J Gerontol A Biol Sci Med Sci 2002;57:M539-43.
26. Lindemann U, Claus H, Stuber M, Augat P, Muche R, Nikolaus T, *et al.* Measuring power during the sit-to-stand transfer. Eur J Appl Physiol 2003;89:466-70.
27. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport 1999;70:113-9.
28. Moxley Scarborough D, Krebs DE, Harris BA. Quadriceps muscle strength and dynamic stability in elderly persons. Gait Posture 1999;10:10-20.
29. Rocco CC, Sampaio LM, Stirbulov R, Corrêa JC. Neurophysiological aspects and their relationship to clinical and functional impairment in patients with chronic obstructive pulmonary disease. Clinics (Sao Paulo) 2011;66:125-9.
30. Regueiro EM, Di Lorenzo VA, Basso RP, Pessoa BV, Jamami M, Costa D. Relationship of BODE Index to functional tests in chronic obstructive pulmonary disease. Clinics (Sao Paulo) 2009;64:983-8.
31. Puhan MA, Siebeling L, Zoller M, Muggensturm P, ter Riet G. Simple functional performance tests and mortality in COPD. Eur Respir J 2013;42:956-63.
32. Rausch-Osthoff AK, Kohler M, Sievi NA, Clarenbach CF, van Gestel AJ. Association between peripheral muscle strength, exercise performance, and physical activity in daily life in patients with Chronic Obstructive Pulmonary Disease. Multidiscip Respir Med 2014;9:37.
33. Foglio K, Carone M, Pagani M, Bianchi L, Jones PW, Ambrosino N. Physiological and symptom determinants of exercise performance in patients with chronic airway obstruction. Respir Med 2000;94:256-63.
34. Mak VH, Bugler JR, Roberts CM, Spiro SG. Effect of arterial oxygen desaturation on six minute walk distance, perceived effort, and perceived breathlessness in patients with airflow limitation. Thorax 1993;48:33-8.
35. Wijkstra PJ, TenVergert EM, van der Mark TW, Postma DS, Van Altena R, Kraan J, *et al.* Relation of lung function, maximal inspiratory pressure, dyspnoea, and quality of life with exercise capacity in patients with chronic obstructive pulmonary disease. Thorax 1994;49:468-72.
36. Marquis K, Debigaré R, Lacasse Y, LeBlanc P, Jobin J, Carrier G, *et al.* Midthigh muscle cross-sectional area is a better predictor of mortality than body mass index in patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2002;166:809-13.
37. Puhan MA, Garcia-Aymerich J, Frey M, ter Riet G, Antó JM, Agustí AG, *et al.* Expansion of the prognostic assessment of patients with chronic obstructive pulmonary disease: The updated BODE index and the ADO index. Lancet 2009;374:704-11.
38. Celli BR, Cote CG, Marin JM, Casanova C, Montes de Oca M, Mendez RA, *et al.* The body-mass index, airflow obstruction, dyspnea, and exercise capacity index in chronic obstructive pulmonary disease. N Engl J Med 2004;350:1005-12.
39. Swallow EB, Reyes D, Hopkinson NS, Man WD, Porcher R, Cetti EJ, *et al.* Quadriceps strength predicts mortality in patients with moderate to severe chronic obstructive pulmonary disease. Thorax 2007;62:115-20.
40. Bean JF, Kiely DK, Leveille SG, Herman S, Huynh C, Fielding R, *et al.* The 6-minute walk test in mobility-limited elders: What is being measured? J Gerontol A Biol Sci Med Sci 2002;57:M751-6.
41. Hendrican MC, McKelvie RS, Smith T, McCartney N, Pogue J, Teo KK, *et al.* Functional capacity in patients with congestive heart failure. J Card Fail 2000;6:214-9.
42. Hughes MA, Myers BS, Schenkman ML. The role of strength in rising from a chair in the functionally impaired elderly. J Biomech 1996;29:1509-13.