

Research Article

Six-minute walk work in patients with chronic obstructive pulmonary disease

Archana C. Dogra^{1*}, Urmil Gupta¹, Malay Sarkar², Anita Padam¹,
Arun Chauhan³, Smitacharu Thakur⁴

¹Department of Physiology, Indira Gandhi Medical College Shimla-171001, Himachal Pradesh, India

²Department of Pulmonary Medicine, Indira Gandhi Medical College Shimla-171001, Himachal Pradesh, India

³Department of Surgery, Indira Gandhi Medical College Shimla-171001, Himachal Pradesh, India

⁴Department of Radiology, Indira Gandhi Medical College Shimla-171001, Himachal Pradesh, India

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*Correspondence:

Dr. Archana C. Dogra,

E-mail: archanadogra06@gmail.com

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ABSTRACT

Background: Six Minute Walk Test (6MWT) has demonstrated good reliability and validity as an assessment for exercise tolerance for moderate to severe COPD. 6MWD is a known to be a preferred outcome for this test; however, it does not account for differences in body weight that are known to influence exercise capacity. Aim of current study was to correlate of distance product (6MWORK) with various variables in study group of patients with Chronic Obstructive Pulmonary Disease (COPD).

Methods: Sixty patients of diagnosed COPD underwent pulmonary function test and 6MWT. Correlation coefficients were calculated for the 6-Min Walk Distance (6MWD) and 6MWORK with variables of pulmonary function and 6MWT.

Results: The mean of 6MWD was 312.0 ± 21.2 meters and mean 6MWORK was 31246 ± 2414 kg.m in the study population. 6MWD significantly correlated with age ($r = 0.25$), height ($r = 0.42$), body mass index ($r = -0.32$) and body weight ($r = 0.48$). 6MWORK yielded higher correlation coefficients than did 6MWD when correlated with FEV₁ ($r = 0.66$ vs. 0.35), FEV₁/FVC ratio (-0.46 vs. -0.24). The ROC curve demonstrated that 6MWORK had a significantly larger calculated area under the curve ($P < 0.05$) than 6MWD with FEV₁.

Conclusion: 6MWORK is an improved outcome of 6MWT to monitor functional capacity in patients of chronic obstructive pulmonary disease.

Keywords: Chronic obstructive pulmonary disease, Six minutes work, Spirometry

INTRODUCTION

The 6-Min Walk Test (6MWT) is a simple tool for the evaluation of functional exercise capacity, which reflects the capacity of the individual to perform activities of daily living.^{1,2} Demographic, anthropometric, clinical, and physiological characteristics can affect the test performance in healthy elderly subjects and in patients with cardiopulmonary diseases^{3,4} and the distance walked

in this test is used as the main parameter to evaluate performance.^{5,6}

However, the 6-Min Walk Distance (6MWD) varies widely, even among healthy subjects^{1,7} these sources of variability can be body weight, height, age and gender. It has been suggested that the product of the distance walked by the body weight would better express the work of walking than the distance in itself.

We hypothesized that 6MWORK is a better tool to assess functional performance in exercise assessed by Six Minute Walk Test (6MWT). Hence, we aimed to

- To compare the pulmonary functions and six minute walk test parameters based on gender in the study group.
- To identify the correlates of 6MWD and 6MWORK in patients of COPD.
- To identify which of the two, 6MWD or 6MWORK correlates better with which variables in study in patients of COPD.

METHODS

The present study was conducted in outpatient clinic of department of pulmonary medicine, Indira Gandhi medical college and hospital, Shimla from Jan 2013 to Feb 2014. Institutional ethical clearance was obtained for the study by institutional review board. The patients were informed about the study protocol and their written consent was obtained.

Inclusion criteria were:

1. Moderate to severe patients of COPD as per GOLD guidelines, 2011(8).
2. Age 40-75 years
3. Stable patients of moderate to severe COPD with no acute exacerbation for the past six week according to GOLD guidelines, 2011.
4. COPD patients with baseline $SpO_2 \geq 90\%$

The exclusion criteria were:

1. Those patients with historic or clinical evidence of pulmonary diseases other than COPD.
2. COPD patients who had resting heart rate of more than 120 beats per minute, systolic blood pressure of more than 180 mm or /and diastolic blood pressure more than 100 mmHg.
3. COPD patients who had unstable angina or myocardial infarction during previous 1 month.
4. COPD patients who had pulmonary hypertension, obstructive sleep/central apnoea, cardiovascular diseases, renal diseases which lead to hypoxemia.
5. COPD patients were symptomatic for neuromuscular, musculoskeletal, peripheral vascular diseases, cardiovascular diseases which limited their capacity to perform six minute walk test.

All the patients were screened for the study by a thorough medical examination and biochemical investigations such as complete blood count, lipid profile, blood sugar, serum protein, blood urea, serum creatinine, serum electrolyte profile. Plain chest radiograph, resting electrocardiogram and echocardiography were also performed to rule out any co morbidity and complications of COPD.

Pulmonary function test

All All the patients performed post-bronchodilator spirometry with an electronic portable PC based spirometer with printer (Vitalograph Compact Buckingham, England) and were staged as per GOLD guidelines,¹⁷ (postbronchodilator FEV_1/FVC ratio $<70\%$ predicted), mild ($FEV_1 \geq 80\%$ predicted), moderate ($50\% \leq FEV_1 < 80\%$ predicted), severe ($30\% \leq FEV_1 < 50\%$ predicted), and very severe ($FEV_1 < 30\%$ predicted) or $FEV_1 < 50\%$ predicted plus the presence of signs of chronic respiratory failure. Spirometric data was recorded as absolute measures and percent predicted for race, age, gender and height. The spirometric parameters recorded were FEV_1 (liters), FVC (liters), FEV_1/FVC ratio (percent predicted), FEF_{25-75} (liters/sec) and Peak Expiratory Flow Rate (PEFR) (litre/sec).

The study group with sixty normoxic moderate to severe stable COPD patients (36 males and 24 females) were subjected to detailed demographic history, occupational history, history of smoking habits, biomass exposure, history of disease with treatment history and history of any co-morbidities and complications.

Six minute walk test

The 6MWT was performed according to the ATS guidelines, 2002.³ Subjects were asked to walk at their own pace, along a 30 m long and straight hospital hallway marked at intervals of meter each. Each patient was instructed to walk as much distance as possible in 6 minutes. No other encouragement was offered to speed up, but the patients were instructed by standardized verbal phrase of encouragement.⁸ The patient was allowed to stop if symptoms of significant distress occurred, like severe dyspnoea, chest pain, dizziness, diaphoresis, or leg cramps. However, the patient was asked to resume walking as soon as possible, if he or she could.

Oxygen saturation (SpO_2) measurement was done continuously during the walk by post walk measurement of blood pressure, heart rate; dyspnoea, fatigue and the distance walked for 6 minutes were recorded. The patients were asked to be observed for a 10-15 minutes period after the test, to assess any possible complications. Patients, who started to walk but did not complete the test, were included in the study. The 6MWORK was calculated the use of the body weight-walking distance product (body weight in kg \times walking distance in meters).⁹

Statistical analysis

Statistical analysis was performed SPSS16.0 (SPSS, Inc., Chicago, IL, USA). Data was presented as mean ± Standard Deviation (SD) for normally distributed data. The variable medians of the general population studied were calculated and reordered by gender post-test.

The t-test and Mann Whitney test was used was performed to compare means of spirometric and six minute test variables. 6MWD and the 6MWORK were correlated with variables of pulmonary function test, SpO₂ and Borg scales of fatigue and dyspnoea by Pearson's and spearman rho correlation coefficients.

ROC curves were used to assess the optimal combinations of sensitivity and specificity of various case definitions through area-under-the-curve analyses. The level of significance was set at P <0.05 for all tests.

RESULTS

The demographic characteristics of the patients of study group and gender based are shown in Table 1. The mean age of the study group was 63.77 years.

Males smoked more than females (Mean packs year smoking of 66.4 ± 30.9 v/s 47.9 ± 37, P <0.05) and majority of male smokers (94.5%) smoked bidi.

Table 1: Demographic characteristics of study population.

	Study group (60)	MALE (36)	FEMALE (24)
Age	63.0 ± 7.7	63.8 ± 6.8	61.9 ± 8.7
Height	165 ± 7.5	169 ± 5.4*	157 ± 4.9
Weight	65.1 ± 15.4	67.7 ± 14.4*	60.4 ± 16.4
BMI	21.1 ± 1.7	21.2 ± 1.8*	21.0 ± 1.6
Smoking history (pack-year)	61.9 ± 33.6	66.4 ± 30.9*	47.9 ± 37.0

*Values given as mean ± SD. BMI - body mass index. P is significant <0.01

There was statistical significant difference in weight and height of two genders (P <0.01). The male subjects weighed more and were taller than the female subjects consequent to which 6MWD also differed significantly between the two genders (P <0.01).

However, the comparisons of the physiological variables obtained in the walk test did not reveal significant differences between the two genders (Table 2). The spirometric lung function parameters too showed no differences with respect to the degrees of obstruction. Among this group, no significant difference in the degree of hyper-insufflation was found, although the lung functions were was significantly lower in the female subjects.

Table 2: Clinical characteristics on pulmonary function test and six minute walk test on six minute walk test.

	Study group (60)	Male (36)	Female (24)
FVC (liters)	1.5 ± 0.4	1.4 ± 0.3	1.7 ± 0.4
FEV ₁ (liters)	0.9 ± 0.4	0.8 ± 0.2	1.2 ± 0.5
PEFR (liters/sec)	181.8 ± 107.3	178.9 ± 81.4	184.8 ± 62.4
FEV ₁ /FVC (percent predicted)	58.6 ± 8.3	55.8 ± 8.3	62.4 ± 7.0
Baseline SpO ₂ , (percent)	93.5 ± 2.07	92.70 ± 2.1	94.59 ± 1.3
6MWD (meters)	312.0 ± 21.2	313.1 ± 175.5*	333.3 ± 203.3
6MWORK (kg.m)	31246 ± 2414	35370 ± 4464*	25,643 ± 6424
Change in dyspnoea (Borg scale)	4.2 ± 2.9	0.318 ± 0.3	0.093 ± 0.1

Results shown in median ± standard deviation

*P <0.05 compared to males (Student t-test or Mann-Whitney test)

The correlate of lung function indexes such as FVC, FEV₁, FEV₁/FVC ratio, with the 6MWD revealed, that there was a moderately positive and significant only with FEV₁ (r = 0.35, P <0.05). While, a 6MWORK correlated strongly with FEV₁ (r = 0.66, P <0.001) and FEV₁/FVC (r = -0.45, P <0.01). The change Borg scale for dyspnoea correlated inversely with both 6MWD and 6MWORK suggesting that increased breathlessness

can limit distance covered during six minute walk (Table 3).

Figure 1 shows scatter plot to depict correlation of body weight with 6MWD and 6MWORK. Figure 2 shows ROC curves for 6MWORK and 6MWD, where the category for determining FEV₁. Sensitivity and specificity with FEV₁ showed that the area under the curve was 0.76 for 6 MWORK and 0.70 for 6MWD; a

difference in areas was significant ($P < 0.05$) and a cut point for 6MWORK that achieves $>60\%$ sensitivity and 80% specificity.

Table 3: Clinical correlates of 6MWD and 6MWORK with the clinical parameters of study population.

	6MWD (meters)		6MWORK (kg.meters)	
	r	P	r	P
Age (years)	0.25	<0.05	0.06	NS
BMI (Kg/m^2)	-0.32	<0.01	-0.24	NS
Height (meters)	0.42	<0.01	0.04	NS
Weight (kg)	0.48	<0.01	0.26	NS
FVC (liters)	-0.24	NS	0.15	NS
FEV ₁ (liters)	0.35	<0.05	0.66	<0.01
PEFR (liters/sec)	-0.28	NS	0.05	NS
FEV ₁ /FVC ratio (percent predicted)	-0.24	<0.05	-0.46	<0.01
Change in SpO ₂ (percent)	-0.54	<0.01	-0.04	<0.01
Dyspnoea (Borg scale)	-0.27	<0.01	-0.30	<0.01
Fatigue (Borg scale)	0.50	NS	0.15	NS

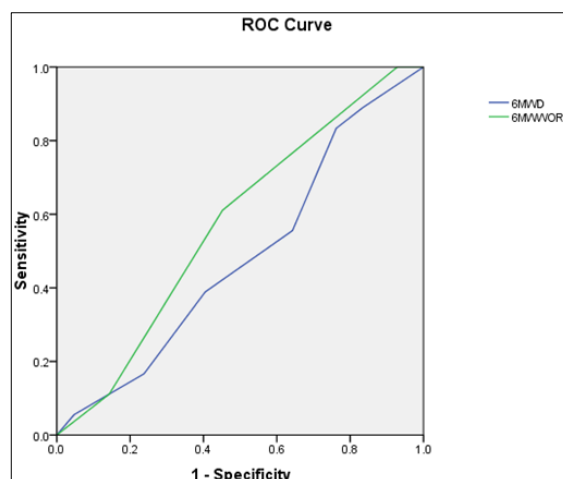


Figure 2: Receiver operator curve area under the receiver operating characteristic curve (AUROC) for the 6MWD is 0.483 and 6MWORK is 0.575, $P < 0.01$.

DISCUSSION

Exercise intolerance in COPD patients is an important development in the natural history of COPD and has important implications on health-related quality of life, hospitalization rate and survival. The 6-Min Walk Test (6MWT) is a simple tool for the evaluation of functional exercise capacity, which reflects the capacity of the individual to perform activities of daily living.^{1,2}

Since the 6MWT is a self-paced test, the results are influenced by external factors such as energy expenditure, operator encouragement and subject motivation. The inconsistencies resulting due to gait speed (height), body weight and gender are sources of error to calculate exercise tolerance by 6MWD alone.

In our study, we tested this hypothesis and found that age, height, BMI, and gender significantly influenced the 6MWD. These findings agree with those of previous studies.^{10,11} The negative influence of advanced age on the 6MWD might be explained by the gradual reduction in muscle mass, muscle strength and maximal oxygen uptake that typically occurs with aging.¹² The influence of gender on 6MWD might be attributable to the greater absolute muscle strength, body weight and height of men compared to women (Table 1). The height of the subject affects stride length. This can potentially influence the distance covered since it is a major predictor of gait speed.¹³⁻¹⁶

The main measurement end point, to date, has been the 6MWD in the allotted 6-min period. Yet, only modest correlations to other indexes of work capacity have been reported. It was Chuang et al.⁹ who on basis of his understanding of physics and work physiology by found that a better unit of measure for the 6MWT was the product of body weight (in kilograms) \times distance walked

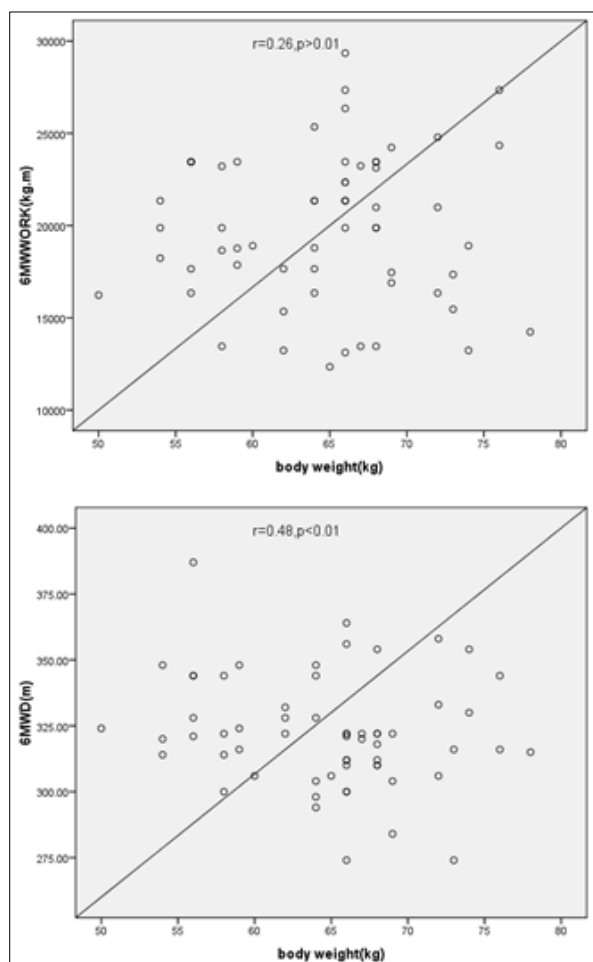


Figure 1: Scatter plot to depict correlation of body weight with 6MWD and 6MWORK. $P < 0.01$ is significant

(in meters) as an index of work. It considers the factor of body weight (force) which is ignored in 6MWD hence can be considered as an improved outcome of 6MWT.

Some researchers^{17,18} had found that the air flow obstruction does not correlate with the exercise capacity in COPD patients, while others,¹⁸⁻²⁰ reported that the FVC, FEV₁ and DLCO in patients with air flow obstruction are correlated with the distance walked. In patients with lung disease, the 6MWORK rate has demonstrated better sensitivity and specificity in identifying exercise intolerance than has 6MWD.^{9,21,22}

In the present study, a highly significant correlation between 6MWORK and FEV₁, FEV₁/FVC were noted than for 6MWD. However, no other pulmonary function correlated with 6MWD and 6MWORK. This can be understood by fact that pulmonary function is not the only factor that limits exercise tolerance in patients of COPD. A seriously impaired pulmonary function is the determined factor which limits exercise tolerance of the patients with severe to very severe COPD, when the body can no longer compensate at this time.

Since, 6MWT evaluates the global and integrated responses of all the systems involved in exercise, including the pulmonary and cardiovascular systems, systemic circulation, peripheral circulation, blood, neuromuscular units, and muscle metabolism.^{3,17,18} There is a role of other factors besides impaired pulmonary function, one such factor was also revealed in our study. We found an inverse correlation between the degree of the breathlessness measured at the end of the test via the Borg scale with the distance and the work of walking. The increased breathlessness could also limit the distance covered and work performed on 6MWT.

6MWORK was also found to be more precise, it showed less scatter on correlation analysis than 6MWD. We also found that the sensitivity and specificity of 6MWORK was found to be better than that of six minute walk distance (Figure 1). Similar to Carter et al.²¹ who in their study of 90 men and 34 women showed that there was major correlation between the work of walking with the lung function variables and found the work of walking had greater sensitivity and specificity for showing the exercise capacity in the COPD patients. This could be probably, because 6MWORK calculation takes into account the mass of the body which is a major source of variation when distance is being covered in 6MWT.

Based on our observation; we would like to suggest that 6MWORK is a better parameter than 6MWD to assess functional capacity in patients with COPD because of its more precision and less variation. Further by expressing the 6-Min Walk (6MW) in work units we can improve its accuracy and hence extend the utility of the 6MWT test.

The work measure, can also be easily converted to caloric equivalents or power, which is defined as work per unit

of time.^{9,23} Thus, the utility of this conversion is substantial as caloric equivalents are commonly used in nutritional and performance calculations. Furthermore, by using this convention for expressing the results of the 6MWT, researchers and clinicians can relate the results to other standardized indexes in physiology and medicine.

Limitation to the study

Some potential limitations of our study should be considered. Males far outnumbered female patients; a possible reason for this may be less prevalence and lack of seeking medical care due to socioeconomic reasons by females.

Potential sources of 6MWD variance other than age, gender or height should be considered. One such source is the psychological status related to exercise capacity in healthy subjects and in patients with pulmonary disease.^{3,24,25} We should have excluded psychological ailments such as depression and anxiety in the present analysis.

We however advocate a study on large cohort of patients with COPD for the validation of our results.

CONCLUSION

We have demonstrated that the product of body weight and distance or 6MWORK is a good measure for reporting exercise capacity in patient with COPD. 6MWORK calculation can be used in future studies to better characterize the functional capacity of patients with COPD.

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Conflict of interest: None declared

Ethical approval: The study was approved by the institutional review board

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