DOI: 10.7860/JCDR/2015/13181.6311

Original Article

Internal Medicine Section

Correlation between Six Minute Walk Test and Spirometry in Chronic Pulmonary Disease

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ABSTRACT

Introduction: Six minute walk test (6MWT), is an exercise test, used as a clinical indicator of the functional capacity, in patients with cardiopulmonary diseases. The present study assessed the correlation of six minute walk test with pulmonary function variables, in patients with chronic pulmonary diseases, in local population.

Aims & Objectives: The objectives were to study correlation of different spirometry variables with variables of six minute walk test like percent predicted 6 minute walk distance (% Predicted 6MWD) as per Enright et al., formula and Indian reference equation, pre and post exercise pO_2 and pCO_2 and exercise desaturation.

Materials and Methods: All consecutive patients with confirmed diagnosis of chronic pulmonary diseases were included from January 2013 to June 2014 in tertiary care institute. 6MWT was performed as per the ATS guidelines. Among 130 patients 108 were also subjected to arterial blood gases pre and post test. Spirometry was performed as per ATS guidelines. Percent (%) predicted 6MWD was calculated. Correlation between spirometry and 6MWT was assessed.

Results: One hundred and thirty patients with chronic pulmonary disease were taken. Out of them there was 102 patients with obstructive airway disease and 58 patients with interstitial lung disease. FEV1 significantly correlated with %predicted 6MWD &; with basal pO_2 and pCO_2 and with post exercise pCO_2 and pO_2. FVC also correlated with %predicted 6MWD, with basal pO_2 and pCO_2 and post exercise pO_2. FEV1/FVC correlated only with post exercise pCO_2 while MVV correlated with %predicted 6MWD and only basal pCO_2. Exercise desaturation correlated only with FVC. Percent predicted 6MWD also correlated with basal pO_2 & post exercise pO_2.

Conclusion: Thus significant correlation found between 6MWT & spirometry variables (FEV1, FVC, MVV & FEV1/FVC).

Keywords: Interstitial lung diseases, Obstructive airway diseases, Spirometry

INTRODUCTION

Six minute walk test (6MWT), is a sub-maximal exercise test, used as a clinical indicator of the functional capacity, in patients with cardiopulmonary diseases [1-3]. It is an objective method to measure the ability to perform daily living activities [1]. Six minute walk test (6MWT) is a reproducible, simple and inexpensive test [2]. The purpose of the six minute walk test is to test exercise tolerance, monitor therapy and predict prognosis in patients with chronic respiratory disease like chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), pulmonary hypertension (PH) and chronic heart failure [1-12]. Its safety, validity, reliability and its correlation with several physiological parameters had been in studied in different populations [1,2]. However, there are very few published data on 6MWT, in the Indian population [2]. Besides, good correlation between six minute walk distance (6MWD) and spirometry measurements had been reported earlier in patients with COPD and ILD [4,5,7-12]. There were studies correlating arterial blood gases (ABG) i.e. oxygen and carbon dioxide with different spirometry measurements in COPD [13,14]. We are reviewing our experience with 6MWT (six minute walk distance and arterial blood gases) and assessing its correlation with pulmonary function variables, in patients with chronic pulmonary diseases including both COPD and ILD, in Indian population.

We studied patients with chronic pulmonary diseases, who underwent 6MWT and pulmonary function test in a tertiary care centre, from January 2013 to June 2014. The 6MWT was conducted according to the American Thoracic Society guidelines [15]. The confounding factors like age, weight and height were removed as percent predicted 6MWT was calculated using Enright et al., formula and Indian reference equation [16,17]. The study included the evaluation of the correlation of 6MWT with spirometric variables in patients with chronic pulmonary diseases.

AIMS & OBJECTIVES

1) To study correlation of following parameters with different spirometry variables {Forced Expiratory Volume in 1st second (FEV1)}, {Forced Vital Capacity (FVC)}, FEV1/FVC ratio, {Maximal Voluntary Ventilation (MVV)}.
   a) Percent predicted 6 minute walk distance (% pred 6MWD) as per Enright et al., formula and Indian reference equation.
   b) Pre and post exercise arterial oxygen (pO_2).
   c) Pre and post exercise carbon dioxide (pO_2).
   d) exercise desaturation.
2) To study the correlation of percent predicted 6 minute walk distance (% pred 6MWD) as per Enright et al., and as per the Indian reference equation with exercise desaturation.

MATERIALS AND METHODS

Patients

The prospective study was conducted in, a tertiary regional hospital, from January 2013 to Jun 2014, in consecutive patients with chronic pulmonary diseases, referred for 6MWT from the inpatient ward, or outpatient clinics. They were either having interstitial lung disease or Obstructive airway disease. Patients were included from the age of 13 to 75-years-old; they were in stable clinical conditions and were not on oxygen therapy. All the patients who had systolic blood pressure more than 180 mmHg or resting heart rate more than 120 per minute, or chest pain at the time of test were excluded. Besides, those with active neuromuscular or peripheral vascular disease were also excluded. The age, sex, weight, height and BMI of patients were recorded prior to 6MWT.

Six minute walk test

At the beginning of the test, the patient's vitals like heart rate, blood pressure and respiratory rate were measured. The oxygen saturation using pulse oximeter was also noted. The 6MWT was performed according to the ATS guidelines [15]. Patient was asked to walk at their own pace, along a 30 m long and straight hospital corridor. The patient was asked to walk as much distance as possible, in 6 minutes and was allowed to stop, if he developed severe dyspnea, chest pain, dizziness, diaphoresis, or leg cramps during the test. However, the patient was asked to resume walking as soon as possible, if he or she could. At the end of six minutes, the patient was asked to stop and vital signs like blood pressure, heart rate and respiratory rate were assessed again. Besides, postwalk oxygen saturation was also noted again using a pulse oximeter. Arterial blood gases from radial artery were taken prior and immediately after the test under all aseptic precautions and compression were given for five minutes. The patients were kept under observation for about 15 minute's period after the test, to assess any possible complications. Patients did not complete the test after beginning the test, were not excluded from the study.

The percent predicted 6MWD was then calculated from the actual 6MWD using Enright et al., formula and the Indian reference equation [16,17]. Using Enright et al., formula, the predicted 6MWD was first calculated as predicted 6MWD (male) = (7.57 x heightcm) - (5.02 x age) - (1.76 x weightkg) - 309m [16]; predicted 6MWD (female) = (2.11 x heightcm) - (2.29 x weightkg) - (5.78 x age) + 667 m [16]; Percent predicted of 6MWD as per Enright et al., formula = actual 6MWD/ predicted 6MWD x100 . Similarily, the Indian reference equation for predicted 6MWD was calculated as predicted 6MWD (Indian Males) = 561.022 - (2.507 × age {years}) + (1.505 × weight {kg}) - (0.055 × height {cm}) [17]; predicted 6MWD (Indian females) = 30.325 - (0.809 × age {years}) - (2.074 × weight {kg}) + (4.235 × height {cm}) [17].

Later, the percent predicted 6MWD (Indian reference equation) = actual 6MWD/ percent predicted 6MWD x 100.

Pulmonary Function Test (PFT)

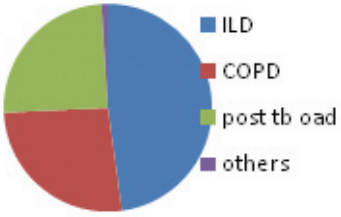
Patients with definite respiratory diagnosis underwent a pulmonary function test, using standardized protocol as ATS guidelines [18,19]. The Spirometry machine used is Medgraphics Cardiorespiratory diagnostics. Software used was Breeze Suite 7.1.0.32 and database version 521. Spirometric indices including FEV1, FVC and MVV, were tested using computerized spirometer. Reproducibility was ensured by doing at least three measurements for each lung function and the predicted values were calculated. The results are reported as mean ± standard deviation.

STATISTICAL ANALYSIS

Correlation between the percent predicted 6MWD, arterial blood gases and spirometry variables was evaluated using Pearson's correlation coefficient (r). The criteria for statistical significance was set at p<0.05 (significant) and p<0.01 (very significant). Analysis was carried out using SPSS software (version 20)

RESULTS AND ANALYSIS

Among 130 patients, 76 were male and 54 were female. Out of 130, 58 patients were diagnosed to have interstitial lung disease (ILD) and remaining (72) were having obstructive airway diseases (OAD) which included post Tuberculosis OAD (30), COPD (32), bronchiectasis (7), Overlap syndrome (obstructive sleep apnoea and COPD) (5) [Table/Fig-1].



[Table/Fig-1]: Distribution of diseases

The mean age was 54.49 years. The mean actual 6MWD was 279.2 meters. The mean percent predicted 6MWD as per Enright et al., formula calculated was 51.7 % and as per Indian reference equation was 55.59%. Average basal pO_2 was 85.2 mm Hg, post exercise pO_2 was79.4 mm Hg and average desaturation was -0.26%. The mean basal and post exercise pCO_2 were 37.25 mmHg and 36.99mm Hg. The mean values for FEV1, FVC, FEV1/FVC & MVV were 65.33%, 68.77%, 72.70 %& 49.49% respectively. There were no complicated events or haemodynamic changes associated with or after the test performance that required emergency management. The study observed that FEV1 and FVC significantly correlated with both basal and post exercise pO_2 as well as basal pCO_2 [Table/Fig-2]. Post exercise pCO_2 correlated only with FEV1 and FEV1/FVC ratio whereas exercise desaturation only with FVC. MVV correlated significantly with pCO_2 [Table/Fig-2]. No significant correlation was found between other variables [Table/Fig-2].

Percent predicted 6MWD as per Enright et al., formula and Indian reference equation had a very significant correlation with FEV1 &

	FEV1	FVC	FEV1/FVC	MVV
Basal pO_2	p=0.005** r=0.250**	p=0.000** r=0.322**	p=0.724 r= -0.032	p=0.853 r= -0.017
Basal pCO_2	p=0.003** r= -0.265	p=0.044* r= -0.182	p=0.226 r= -0.109	p=0.020* r= -0.209*
Post exercise pO_2	p=0.029* r=0.197*	p=0.004** r=0.254**	p=0.646 r= -0.042	P=0.560 R=-0.053
Post exercise pCO_2	p=0.002** r=-0.280**	p=0.152 r= -0.130	P=0.019* R= -0.211	p=0.056 r= -0.172
Desaturation	p=0.472 r= -0.064	p=0.006** r=-0.238**	p=0.144 r=0.129	p=0.408 r=0.073

[Table/Fig-2]: The correlation between arterial blood gases pre and post exercise pO_2 & pCO_2 and different physiological indices

* -significant correlation (p<0.05)
**-very significant correlation (p<0.01)
Pearson Correlation – r
Significance (2 tailed) – p

	FEV1	FVC	FEV1/FVC	MVV
6MWD	p=0.003** r=0.260**	p=0.000** r=0.367**	p=0.835 r=0.018	p=0.093 r=0.148
% pred 6MWD(Enright et al)	p=0.000** r=0.358**	p=0.000** r=0.415**	p=0.378 r=0.078	p=0.023* r=0.2*
% pred 6MWD(Indian reference equation)	p=0.002** r=0.276**	p=0.000** r=0.390**	p=0.959 r=0.005	p=0.133 r=0.132

[Table/Fig-3]: Correlation between 6MWD and spirometry variables

* - significant correlation (p<0.05)
**-very significant correlation (p<0.01)
Pearson Correlation – r
Significance (2 tailed) - p

	6MWD	%Pred (Enright et al.,)	%Pred (Indian ref eq.)
Basal po_2	p=0.001** r=0.302**	p=0.009** r=0.235**	p=0.001** r=0.302**
Basal pCO_2	p=0.148 r= -0.131	p=0.220 r= -0.111	p=0.137 r= -0.134
Post exercise po_2	p=0.000** r=0.321**	p=0.015* r=0.217*	p=0.001** r=0.299**
Post exercise pCO_2	p=0.391 r=0.078	p=0.586 r= -0.049	p=0.490 r= -0.063
Desaturation	p=0.734 r=0.030	p=0.723 r=-0.031	p=0.952 r=0.005

[Table/Fig-4]: Correlation between the 6MWD and Arterial blood gases

* -significant correlation (p<0.05)
**-very significant correlation (p<0.01)
Pearson Correlation – r
Significance (2 tailed) - p

FVC. MVV significantly correlated with % predicted 6MWD as per Enright et al., formula [Table/Fig-3].

It was also found that both basal and post exercise pO_2 significantly correlated with absolute as well as percent predicted 6MWD (Enright et al., formula and Indian reference equation) [Table/Fig-4].

DISCUSSION

The ability to walk for a distance is an easy way to measure exercise capacity in patients with cardiac and pulmonary diseases [1-3]. 6MWT is found to be an effective way of assessing exercise tolerance. There have been few studies correlating 6MWD with spirometry in different chronic pulmonary diseases like ILD, COPD [2-5,7-12]. However, there has been no comprehensive study which correlates both the 6MWD as well as pre and post exercise arterial blood gases with spirometry parameters in all the chronic pulmonary diseases as a whole. Besides there has also been no study that removes the confounding factors like age, gender, weight and height while correlating the 6MWD with chronic pulmonary diseases. In our study these confounding factors were removed by calculating percent predicted 6MWD using Enright et al., formula and Indian reference equation [16,17].

The present study showed that FEV1 and FVC had very significant positive correlation with absolute as well as percent predicted 6MWD (both Enright et al., & Indian reference equation). It meant that fall in FEV1 or FVC or both was associated with a significant fall in 6MWD. FEV1/FVC and MVV were having no correlation with 6MWD. These results were consistent with the results of previous studies by Hatem FS AL Ameri [1] and Mehta et al., [2] which also showed positive correlation between 6MWT and spirometry variables (FEV1 and FVC) [1,2]. However previous studies had confounding factors like age, gender, weight and height which were not present in our study. Besides correlation with FEV1/FVC ratio and MVV were also not studied. In another study by Khandelwal et al., there was linear relationship between 6MWD and FEV1, FVC and FEV1/FVC in patients with COPD [20]. In a study in patients with sarcoidosis by Essam Alhamad, the 6MWD positively correlated with forced expiratory volume in 1 s (FEV1)% ($\rho = 0.524$, $P = 0.006$) and forced vital capacity (FVC)% ($\rho = 0.407$, $p = 0.039$) [21]. The findings were consistent with our findings but these studies were conducted in selective chronic respiratory diseases like COPD and Sarcoidosis and confounding factors like age and BMI were also present. However, present study demonstrated positive correlation between 6MWD and spirometry variables in chronic pulmonary diseases which included both COPD and ILD.

Besides, FEV1 and FVC both significantly and positively correlated with pre and post exercise pO_2 while FEV1/FVC and MVV did not correlate with pO_2. It implied that if there is a fall in FEV1 or FVC or both there will be a drop in both pre and post exercise pO_2 significantly but not with exercise desaturation. The possible explanation might be that there is a wide range of pO_2 for particular saturation. The relationship between pO_2 and saturation is well explained by the Hb-O_2 dissociation curve which is a sigmoid curve. The non-linear relationship between percent saturation and pO_2 accounts for the vast majority of oxygen reserves in the blood.22. Normally at pO_2 is 27mm Hg the haemoglobin is 50% saturated [22]. Arterial blood with plasma pO_2 of 60mm Hg is normally 90% saturated with oxygen, arterial blood with plasma pO_2 of 80 mm Hg is normally 95 saturated with oxygen and arterial blood with plasma pO_2 of 97 mm Hg is normally 97% saturated with oxygen [22]. So there needs to be vast change in pO_2 for a significant change in saturation which is not seen with change in FEV1. Among all the spirometric variables only FVC correlated with exercise desaturation, It implies that there must be a vast change in pO_2 with change in FVC for a significant change in desaturation to occur. There are very limited recent studies on correlation between arterial blood gases (pre and post exercise pO_2 and pCO_2) and spirometry in chronic respiratory diseases. For instance, in a study by Yazici M, Arbak P in patients with moderate and severe COPD, significant correlation of resting FEV(1)% predicted and PaO (2) values was found [23]. However, in this study correlation with other spirometry variables FVC and MVV was not assessed. Besides pCo_2 was not correlated to any of the spirometry variables and the study was conducted only in patients with COPD. On the other hand the present study assessed the correlation of both pO_2 and pCO_2 with spirometry variables FEV1, FVC, FEV1/FVC and MVV in chronic pulmonary diseases as a whole.

It was observed that FEV1, FVC & MVV had a significant negative correlation with basal pCO_2. This meant a fall in FEV1or FVC or MVV or all cause the basal pCO_2 to rise significantly. However, post exercise pCO_2 rises significantly only when there is fall in FEV1 or FEV1/FVC or both, but had no correlation with FVC & MVV.

In the past, a study by Mansour Rahimi Fard showed that FEV1 significantly correlated with pO_2 and pCO_2 in chronic bronchitis [14]. These findings were consistent with the results of the present study. But unlike the present study it did not assess the post exercise pO_2 and pCO_2 and was conducted only in a selected group of patients with chronic bronchitis. However, no recent study on correlation between pre and post exercise pCO_2 and spirometry variables.

It was also noted that absolute and percent predicted 6MWD both significantly & positively correlated with pre & post exercise pO_2 but not with exercise desaturation. It meant that decrease in both basal & post exercise pO_2 cause a significant decrease in 6MWD however the difference between them i.e. desaturation did not significantly affect the 6MWD. This can again be explained as before by theHb-O2 dissociation curve which is a sigmoid curve [22]. Besides 6MWD did not correlate with pre & post exercise pCO_2. There were no recent studies assessing such a correlation.

Hence, the correlation of 6MWT and pulmonary function test, in patients with chronic pulmonary diseases, makes this test easy and a simple tool for assessing the disease status. It was observed; such tests have been underutilized in our local clinical and research institutes, especially in patients with severe respiratory disability, in whom the lung function test may be an insensitive tool for measuring functional status [2]. Besides the 6MWT can be safely performed even in patients with advanced respiratory conditions.

Spirometry can be an insensitive tool for assessing the functional status in patients with severe respiratory disability who at times cannot even perform spirometry. The 6MWT can play a very important role in measuring the functional status of such patients. However, it has not been commonly utilized in our local clinical and research institutes. This study supports the use of 6MWT as an additive tool in combination with other physiological parameters in assessing the lung function although it does not draw any definite conclusion on the validity of 6MWT in different chronic pulmonary diseases. This study was done in heterogenous population which included chronic pulmonary diseases like COPD, ILD, post TB sequelae, bronchiectasis. Most published data in 6MWT looked at disease specific groups, which was not considered here. The objective was to assess the correlation of 6MWT and several physiological parameters, in patients with chronic pulmonary diseases as a whole.

CONCLUSION

Thus in chronic pulmonary diseases FEV1 & FVC significantly correlated with percent predicted 6MWD, pre and post exercise pO_2 and basal pCO_2 while only FVC significantly correlated with exercise desaturation. FEV1 & FEV1/FVC correlated significantly with post exercise pCO_2 while MVV correlated only with basal pCO_2. It was also found that 6MWD also correlated with pre and post exercise pO_2.Thus there is significant correlation between 6MWT and spirometry.

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Jan 23, 2015**
Date of Peer Review: **Apr 27, 2015**
Date of Acceptance: **Jun 26, 2015**
Date of Publishing: **Aug 01, 2015**