Indian J Physiol Pharmacol 2019; 63(3) : 198–202

Original Article

# Peak Expiratory Flow Rate (PEFR) Corrected for Forced Expiratory Pressure

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## Abstract

Traditionally, PEFR is a measure of airway resistance and estimate of bronchoconstriction. It is used as a diagnostic as well as prognostic marker for respiratory diseases, especially asthma. But PEFR is effort dependent parameter which not only depends upon the airway resistance but also the Forced Expiratory Pressure (FEP) generated by the respiratory muscles. This expiratory force generated needs to be considered when interpreting the results of PEFR. Therefore, present study was undertaken to explore relationship between PEFR and FEP and to find corrected PEFR.A total of 56 physically fit volunteers were examined for PEFR using Wright's peak flow meter and FEP was estimated using a mercury manometer connected to a mouth piece with airtight seal. The results of multiple linear regression model suggested that FEP has statistically significant influence on PEFR (beta coefficient = 1.18, adjusted $R^2$0.699). The formula for corrected PEFR was derived and the coefficient of variance before and after PEFR correction was 35.53% and 30.13% respectively, suggesting that for better clinical utility PEFR should be corrected for FEP. To extrapolate the present study results to other age groups and diseased population further studies are needed.

## Introduction

Peak expiratory flow rate (PEFR), expressed in liters/min, has long been used for monitoring the state of asthma (1). Normally, the expiratory flow rate is maximum during the initial 100 to 120 ms of maximal forced expiration (2). PEFR measures the initial part of expiratory flow when the lungs are full to more than 75% of the forced vital capacity. It is recorded for estimating the presence and severity of bronchoconstriction. The PEFR is dependent on airway resistance and therefore, a major determinant of PEFR is the caliber of bronchi and the larger bronchioles, which account for 50% of the airway resistance. Hence, PEFR is widely used to monitor patients with asthma who have variable degrees of bronchoconstriction. Constriction of bronchi and larger bronchioles increases frictional resistance to airflow and thereby decreases the PEFR.

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(Received on June 10, 2019)

The American Thoracic Society and Europian Respiratory Society Task Force guidelines 2005 define PEFR of a subject as the maximum expiratory flow rate attained within the initial 100 to 120 milliseconds by generating maximum expiratory pressure and initiated without hesitation following maximal inspiratory lung inflation (3). It reflects the frictional resistance to airflow in the air passages. PEFR is also effort-dependent and therefore, it depends on (a) the maximal inspiratory lung volume and (b) the maximum expiratory pressure generated by the expiratory intercostal muscles and diaphragm. The latter is determined by factors like height, weight, body mass index, gender, chest circumference, posture, pregnancy, nutritional status and physical training (4) (5). Hence, to ensure that PEFR is determined only by the bronchial diameter and is unaffected by the expiratory pressure generated, the latter too must be taken into consideration for calculating the PEFR.

On these premises, it is hereby postulated that “PEFR not only depends upon airway resistance but also depends upon the strength of the expiratory muscles”. The latter can be estimated by the Forced Expiratory Pressure (FEP) generated during maximal forceful expiratory effort. Thus, the formula for a ‘corrected PEFR’ that would not be affected by the expiratory pressure generated.

## Methodology

The present cross-sectional study was carried out in Department of Physiology, AIIMS, Jodhpur after obtaining ethical clearance from the ethics committee of our institute. Apparently healthy male and female volunteers within the age group 20-30 years were contacted. Volunteers having history or symptoms of any respiratory, cardiovascular, neurological disorder or chest wall abnormality, those with recent history of trauma or injury to chest leading to pain or restriction of respiratory movements, smokers and pregnant women were excluded from the study. A total of 56 physically fit volunteers were included in the study after their physical examination with special attention to respiratory system. The details of the study were explained to the volunteers and written informed consent was obtained from them. The height, weight, BMI and chest circumference of the participants were recorded, following which PEFR was measured as per the American Thoracic Society/ European Respiratory Society (ATS/ERS) task force guidelines using the Wright’s peak flow meter.

The volunteers were seated comfortably at room temperature. The mouth piece of the apparatus was connected to the volunteer’s mouth and a good seal at mouth was ensured. The nostrils of the volunteer were closed with a nose clip. Care was taken that the neck of the volunteer was in a neutral position, neither flexed nor extended. The volunteers were then asked to inspire maximally and thereafter expire into the mouth piece with maximum force. The forced expiratory pressure was recorded using a mercury manometer connected to a mouth piece with airtight seal. The procedure was repeated thrice at a gap of 2 minutes each and the maximum flow rate achieved was noted as the final reading. To explore the relationship between PEFR and FEP multiple linear regression analysis model was used.

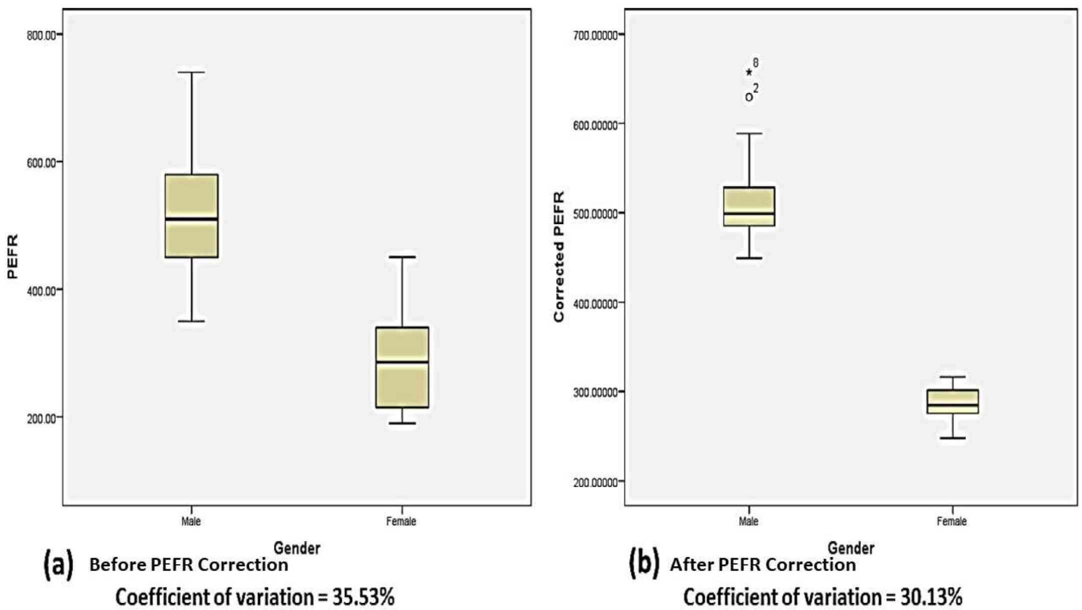
## Results

Table-I gives the mean and standard deviation of (a) PEFR and (b) Forced Expiratory Pressure (FEP).

TABLE I

| | *Peak expiratory flow rate (PEFR)* | *Forced expiratory pressure (FEP)* |
|---|---|---|
| Male (n=28) | 512±96.79 | 117.29±38.79 |
| Female(n=28) | 285.71±69.89 | 61.21±14.03 |
| Combined(n=56) | 399.28±141.88 | 89.25±40.44 |

To explore the relationship between forced expiratory flow & PEFR, we used multiple linear regression model. Firstly, we checked whether there is a linear relationship between the forced expiratory flow and PEFR using Pearson’s correlation and there was statistically significant negative correlation ($r=0.737$, $P<0.0001$). Then multiple liner regression model was built using PEFR as dependent variable and forced expiratory flow and gender as independent variables.




Graph 1: Box plot showing PEFR value before and after correction.

Results of this model is summarized as Beta coefficient and Standard error, P value less than 0.05 was considered statistically significant. To assess the goodness of model we have reported the adjusted R square (Table II).

TABLE II : Showing results of multiple linear regression modelling for estimation of PEFR.

| *Factor* | *Beta coefficient* | *Standard error* | *Significance* |
|---|---|---|---|
| Forced expiratory pressure | 1.18 | 0.36 | <0.002 |
| Gender | –161 | 29.1 | <0.001 |
| Constant | 535.5 | 71.02 | <0.0001 |
| | Model Adjusted R square = 0.699 | | |

Using the above model, the corrected PEFR was calculated (Graph 1).

## Discussion

The peak expiratory flow rate (PEFR) is a person's maximum speed of expiration, as measured with a peak flow meter, a small, hand-held device used to monitor a person's ability to breathe out air. Traditionally, medical graduate students are taught PEFR as a measure of airway resistance and estimate of bronchoconstriction. It is also used as a diagnostic as well as prognostic marker for respiratory diseases, especially asthma. But PEFR is effort dependent parameter which not only depends upon the airway resistance but also the expiratory force generated by the respiratory muscles. This expiratory force generated needs to be considered when interpreting the results of PEFR; i.e. PEFR needs to be corrected for maximum expiratory force generated.

To test this hypothesis, we used the multiple linear regression model for estimating corrected PEFR. The multiple linear regression model summary and overall fit statistics (Table II) suggests that the adjusted $R^2$ of our model is 0.699. This means that the linear regression explains 69.6% of the variance in the data. Also, we find that Forced Expiratory pressure has significant impact on prediction of PEFR (beta coefficient = 1.18). Therefore, the results of present study suggest that Forced Expiratory pressure has influence on PEFR and for better clinical utility PEFR should be corrected for forced expiratory pressure.

Using the above model, the formula to calculate corrected PEFR for the age group between 20-30 years is :

$$\text{Corrected PEFR} = \text{Constant} + \text{PEFR} \times 1.18 + \text{For female } (-161)$$

The corrected PEFR for the present study is 399.42± 120.42. The coefficient of variance before and after PEFR correction is 35.53% and 30.13% respectively. The results of present study indicate that, variations in PEFR after correction has improved by 5%. This suggest that corrected PEFR has better clinical implication than the traditional PEFR value as it is not affected by the maximum expiratory force generated by the individual.

The maximum expiratory force generated is dependent on the strength of respiratory muscles. This strength of respiratory muscles is affected in many diseases (6) like diabetic polyneuropathy (7), malnutrition, chronic heart failure (8), various cancers (8), and drugs induced respiratory muscle myopathy seen in chronic corticosteroid therapy (9) and colchicine therapy (10). Therefore, these patients are expected to have low maximum expiratory force and ultimately the PEFR. In the monitoring of asthma treatment, PEFR is used as an important parameter to adjust the dosage as well as the type of drugs used in the treatment of asthma. But if a patient of asthma is having reduced respiratory muscle strength due to any of the above discussed conditions associated with asthma, then the reduced PEFR will not indicate the true increase in airway resistance. These patients will then be subjected to change the treatment. Therefore, the PEFR corrected for Maximum expiratory pressure needs to be considered.

On the other hand, the respiratory muscle training improves the strength of respiratory muscles (11).

The maximum expiratory pressure can be assessed by using balloon catheters to measure esophagus or gastric pressures (6), or electrophysiological studies involving electric (12) or magnetic stimulation (13) of respiratory muscles or the nerves supplying them. In the present study we assessed the maximum expiratory pressure by simple noninvasive method, using modifying the mercury sphygmomanometer. The forced expiratory pressure was recorded using a mercury manometer connected to a mouth piece with airtight seal. This measure gives us the maximum expiratory pressure generated at mouth due to action of expiratory muscles. This measure is a fair index of the expiratory muscle strength. So, it is feasible, easy, economic way.

Therefore, corrected PEFR should be done for better clinical utility. The corrected PEFR formula derived in the present study is only for the healthy adults between 20-30 years, to extrapolate to other age groups and diseased population further studies are needed.

#### Conclusion

Unlike PEFR, which is affected by the expiratory pressure generated by the expiratory muscles, ‘corrected PEFR’ is unaffected by the expiratory pressure and only indicates the state of the airways.

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