Interchanging spirometric and peak flow meter readings in obstructive airway diseases

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Abstract

In spite of the daily use of peak flow meters at home and in some hospitals, some schools of thought advocates that the mini-Wright peak flow (MWPF) meter peak expiratory flow (PEF) values are less accurate than spirometric values. The aim of this study was to find out if there is a difference between lung function measurement values of spirometer and peak flow meter and if this difference is significant.

This study was a case control design involving lung function assessment. A total of 120 asthma patients and their corresponding controls who have the same sociodemographic features were selected with simple sampling methods at the respiratory clinic of the University of Benin Teaching Hospital (UBTH), Benin, Nigeria. Subjects were known asthma patients on routine clinic visits. Patients' spirometric and peak flow meter readings were tested for significant differences in lung function test using student's t-test. The readings from both instruments were also correlated using the Pearson correlation coefficient. The mean of the values of lung function tests and the percentage of predicted values were calculated. The limit of agreement was also calculated.

The mean of spirometric and peak flow meter readings (and their percentage of predicted values) were 330 L/min (69.9%) and 332 L min (70%) respectively. This difference was not significant at $p<0.05$. There was a correlation coefficient of 0.99 and a linear regression fraction of 0.98 (98% coefficient of determination) between the readings from both instruments. At a 95% confidence interval, the limits of agreement were between 0.74 and 4.7.

Our results show that there is no significant difference between the spirometric and peak flow meter values.

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Introduction

Airway obstruction is the reduced radius of the airway. It is classified as upper airway and lower airway obstruction. Diseases that cause lower airway obstruction are called obstructive lung diseases. These include diseases like asthma and chronic obstructive airway diseases (chronic bronchitis and emphysema). There is airway resistance, leading to a reduced amount of air passing through the obstructed airway.[1,2] Airway resistance occurs in asthma, chronic bronchitis and emphysema.[1] Peak expiratory flow (PEF) meters have been used for years to measure PEF, both for research purposes and in clinical care in patients with asthma and chronic obstructive airway diseases.[3-5]

Peak expiratory flow (PEF) rate is the maximum air flow during a forced expiration after a maximum inspiration. It is important to note that peak flow meters measure the amount of airflow in the large airways. However, changes in airflow caused by increases in small airway tone and resistance will not be detected by peak flow meters. Nevertheless, these portable and inexpensive devices, such as the micro-Wright peak flow meter helps to recognise early changes that are signs of worsening asthma or chronic obstructive airway diseases.[6] Changes in PEF due to corresponding change in airways precede asthma symptoms by hours or days. Forced expiratory volume in one second (FEV_1) correlates with the PEFR.[7] In 2007, an expert panel of the National Asthma Education and Prevention Programme recommended the long-term use of peak flow meters for assessing pulmonary function in order to detect asthma exacerbations, worsening asthma, and response to treatment.[8]

PEFR measurement with a spirometer is considered to be more accurate and reliable than use of mini-Wright peak flow (MWPF) meters in clinical use due to the wide intrapersonal variability of MWPF meters.[9] The prediction equations of many countries like the USA estimated peak flows were obtained spirometrically without the consideration of portable peak flow meters.[9] MWPF meters are inexpensive, portable instruments that enable easier ambulatory PEF monitoring. Ambulatory PEF monitoring in asthmatic patients provides early warning of incipient asthma attacks and exacerbations.[10] It also alerts the patients, relatives and attending physicians of a worsening airflow obstruction.[10] While some

researchers have demonstrated no significant advantage of spirometric measurement of PEF over MWPF meters,[11] other researchers documented higher PEFR values with MWPF meters than with spirometers.[12] However, some of these researchers did not use the digital spirometer to measure PEF in their studies. The aim of this study is to compare MWPF meters with digital spirometric PEFR values and to find out if the instruments are exchangeable in clinical practice.

Subjects and methods

The clinical setting was the respiratory unit of the Department of Medicine, University of Benin Teaching Hospital (UBTH), Benin City, Nigeria. The study was a case control design that involved a total of 280 asthma patients and their normal controls with the same sociodemographic features; subjects were selected using simple sampling methods. The subjects recruited were known asthma patients on routine clinic visits.

Exclusion criteria were:

- Patients who had severe attacks of asthma and could not cope with the procedure.
- Patients with co-morbid conditions that could impact negatively on the lung function measurement.
- Seriously ill patients.
- Some patients were excluded because of busy schedules.

Inclusion criteria were:

- Adult subjects 18 years and above.
- Subjects who understood the detail of the procedure and cooperated willingly.
- Known asthma patients who consented to this study.

The best of three spirometric and peak flow meter readings were recorded for the subjects and controls. Student's t-test was used to test if the difference between spirometric and peak flow meter lung function readings was significant. The readings from both instruments were also correlated using the Pearson correlation coefficient. The mean of the values of lung function tests and the percentages of predicted of normal were calculated. All results are expressed as means. The limits of agreement at 95% interval were also calculated.

Results

Table 1 demonstrates the sociodemographic features of patients and controls. Table 2 compares the subjects PEF values for spirometer and MWPF meters. The difference between the lung function values of the spirometer and peak flow meter for subjects was not significant for $p<0.05$. However, the correlation coefficient between the lung function tests of spirometer and peak flow meter was 0.99 (98%). Mean difference = 2±1.4; mean + 1.96SD = 4.7; mean - minus 1.96SD = 0.74.

Discussion

In monitoring the progress of obstructive airway disease and the effects of treatment, it is important to measure PEF as it can identify and evaluate the degree of airflow limitation. However, there are conflicting data regarding the efficacy of peak flow rate monitoring by MWPF meters for improving asthma outcome. Our studies have compared the spirometric PEFR values (as standard) with MWPF meter values. The mean difference between these values was 2 ± 1.4L/min. Statistical difference between PEFR measured using these instruments was tested. Testing for statistical difference is clinically relevant for measurement volumes between instruments if the difference is small. Our results show that the difference between PEF measured by spirometer and MWPF meter was not significantly different ($p>0.05$). The values obtained from both instruments correlated with a linear regression fraction of 0.98 as in Table 2. At a 95% confidence interval, the limits of agreement were between 0.74 and 4.7. The work of other researchers also corroborate the findings of our study.[11]

Characteristics	Subjects	Controls
Age (years)	31.2	32.2
BMI (kg/m$^{2)}$	23.9	24.2
Male	84	84
Female	124	124
PEFR L/minute (%)	330 (69.8%±9.6)	433 (91.7±8.5)
FEV_1 (L (%))	2.28 (67%±10.5)	3.36 (99%±0.98)
Key: % =Percentage predicted; S = Subjects; C=Controls		

Table 1 Mean age, BMI, PEFR, and FEV_1, and the total number of male and female subjects and controls

Instrument	Mean PEFR (L/min) (% predicted)	Male (% predicted)	Female (% predicted)
Spirometer	330±24.6 (69.8±9.8)	365±38 (67±5.6)	285±26.5 (72±5.2)
MWPF meter	332±26 (70%±8.2)	366±39.2 (67.2±4.5)	286±25.4 (72±6.4)
	r = 0.98 (98%), p>0.05		
Mean difference = 2±1.4; mean + 1.96SD = 4.7; mean - minus 1.96SD = 0.74.			

Table 2 Comparing peak expiratory flow values of measured using spirometry and MWPF meters

However, some researchers have found no reasonable agreement between MWPF meters and spirometers.[9,13-15] Various reasons may be responsible for the disagreement between the two instruments. Patients are often not well instructed on what to do and how it should be done. Since peak flow rate measurement depends significantly on patient effort and technique, clear instructions, demonstrations, and frequent review of technique are essential. Due to diurnal variation, peak flow rate should be measured at the same time every day. It is best to measure PEFR in standing position because it is decreased in a supine position.[9] In addition, some of those studies did not use the digital spirometer, different peak flow meters were used for different subjects. These factors create room for wide inter- and intra-instrument variations. Furthermore, many of these studies that showed wide variations in measurement were done among white and Asian populations. Other researchers believe the MWPF meters measure PEF better than the spirometer, and that MWPF meters should be used in general medical practice.[16-18]

The measurement of FEV_1 by the spirometer is an advantage over the measurement of PEF alone with MWPF meters because FEV_1 reflects airway caliber and measures airway obstruction. But, in the absence of a spirometer, the MWPF meters are good substitutes in measuring airway resistance. MWPF meters can be used to monitor the effects of ozone and other air pollutants on respiratory function.[4] A recent study indicated the usefulness of peak flow rate measurements in patients with chronic obstructive airway disease for daily monitoring.[2]

In conclusion, there was no significant difference between the digital spirometer and the MWPF meters in the measurement of PEFR. We advocate the increased use of peak flow meters to augment spirometric lung function tests for asthma patients at our hospitals. MWPF meters could be used interchangeably for the bulky and expensive spirometric peak flow readings, especially in rural areas that are poorly funded. Future studies of this nature are encouraged in other environments.

Acknowledgement

We are grateful to the management of the University of Benin Teaching Hospital for allowing us to carry out this research.

References

1. Woolcock AJ, Yan K, Salome CM. Effect of therapy on bronchiahyper responsiveness in the long-term management of asthma. *Clin Allergy* 1988; 18: 165–176.
2. Cohn L, Elias JA, Chupp GL. Asthma: mechanisms of disease persistence and progression. *Ann Rev Immunol* 2004; 22: 789–815.
3. Enright P, McCormack M. Assessing the airways. *Chron Respir Dis.* 2008; 5(2): 115-9.
4. Chan CC, Wu TH. Effects of ambient ozone exposure on mail carriers' peak expiratory flow rates. *Environ Health Perspect* 2005; 113(6): 735-8.
5. de la Iglesia F, Díaz JL, Pita S, et al. Peak expiratory flow rate as predictor of inpatient death in patients with chronic obstructive pulmonary disease. *South Med J* 2005; 98(3): 266-72.
6. Brouwer AF, Brand PL. Asthma education and monitoring: what has been shown to work. *Paediatr Respir Rev* 2008; 9(3): 193-9; quiz 199-200.
7. Gibson PG. Monitoring the patient with asthma: an evidence-based approach. *J Allergy Clin Immunol* 2000; 106 (1 Pt 1): 17-26.
8. National Asthma Education and Prevention Program. Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma; Full Report 2007. Bethesda, MD, U.S: Department of Health and Human Services, National Institutes of Health, National Heart, Lung and Blood Institute; 2007.
   Brusasco V. Usefulness of peak expiratory flow measurements: is it just a matter of instrument accuracy? *Thorax* 2003; 58: 375-6.
10. Scottish Intercollegiate Guidelines Network & The British Thoracic Society (July 2007). 'British Guidelines on the management of asthma-Annex 8: Personal Asthma Action Plan' (PDF). *Thorax* 58: Suppl I.
11. Goyal M, Goel A, Kumar P, Bhattacharya S, Bajpai M, Verma N,Tiwari S, Kant S. Comparison of Wright scale and European scale peak flow meters with digital spirometer. *Int J Pul Med* 2008; 9(2): 10.5580/23a4.
12. Nazir Z, Razaq S, Mir S, Anwar M, Al Mawlawi G, Saiad M, Shehab A, Taylor R. Revisiting the accuracy of peak flow meters: a double- blind study using formal methods of agreement. *Resp Med* 2005; 99(5): 592-595.
13. Said M, Sastroasmoro S, Supriyatno B, Ananta Y. Comparism of peak expiratory flow measurement by Mini-Wright peak flow meter and electronic spirometer in healthy elementary school children. *Paediatrica Indonesiana* 2004; 44: 11-12.
14. Sly PD, Cahill P, Willet K, Burton P. Accuracy of mini peak flow meters in indicating changes in lung function in children with asthma. *BMJ* 1994; 308: 572-4.
15. Miller MR, Ouanjer PH. Peak flow meters: a problem of scale. *BMJ* 1994; 308:548-9.
16. Jones KP, Mullee MA. Measuring peak expiratory flow in general practice: Comparison of mini Wright peak flow meter and turbine spirometer. *BMJ* 1990; 300: 1629.
17. Pothel E, Just J, Tournier G, Grimfeld A. Reliability and reproducibility of 3 peak flowmeters determined in a population of primary school children. *J. Rev Pneumol Clin* 1992;48(6):247-50.
18. Pessola GR, O'Donnell P, Pesola GR,Chinchilli VM,Saari AF. Peak expiratory flow in normals: comparison of the mini Wright versus spirometric predicted peak flows. *J Asthma* 2009; (8): 845-8.
19. Murata GH, Kapsner CO, Lium DJ, Busby HK. Patient compliance with peak flow monitoring in chronic obstructive pulmonary disease. *Am J Med Sci* 1998; 315(5): 296-301.