Comparison of Wright scale and European scale peak flow meters with digital spirometer

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Abstract

Introduction: Peak expiratory flow (PEF) monitoring has been in use to measure airflow obstruction in patients with asthma. Most of the peak flow meter uses a traditional Wright scale to record PEF whilst after 2004 Peak flow meters with new European scale have been introduced. This study was done to assess the limits of agreement of PEF values measured with mini Wright's peak flow meter (Wright scale) or with new European scale with digital spirometer.

Material and Methods: 582 healthy volunteers between the age group of 18-40 years were recruited for this study. PEF was measured with mini wright's peak flow meter with traditional wright scale and new EU PEF scale. Simultaneously Spirometery of each subject was performed with Sprobank G and FVC, FEV1, FEV1%, PEF were recorded.

Results: PEF measured with wrights scale and new European scale both shows high and similar levels of correlation with digital spirometer (r=0.765 and 0.767). Despite a high correlation observed between measured PEF with different instruments, the limits of agreement are not acceptable for either of the scales.

Conclusion: The measurement of PEFR with New European scale does not seem to provide any significant advantage over traditional scale.

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INTRODUCTION

Peak expiratory flow (PEF) monitoring has been in use to measure airflow obstruction in patients with asthma ([1]). The International Consensus Report on Diagnosis and Treatment of Asthma has made peak flow measurement one of the mainstays of asthma management ([2]). Peak flow measurement is a tool for treatment by the physician, and especially a tool of self-management by the patient. The widespread availability of inexpensive, portable devices has made ambulatory PEF monitoring easier & feasible. The PEF monitoring has facilitated individualized self-management using pre-established criteria and allowed more effective communication between patients and their physicians for the assessment of maintenance therapy. The ambulatory PEF monitoring in asthmatic patients can provide early warning of incipient asthma exacerbation and can measure the severity of worsening airflow obstruction. ([3])

PEF is the largest expiratory flow achieved with a maximum forced effort after maximum inspiration. Most of the digital spirometers measures PEF along with FEV1 (Force expiratory volumein one second) and FVC (Forced vital Capacity). Previous studies have found that different spirometers and different Peak Flow Meters can record PEF differently with error rates of up to 26% in laboratory calibration tests.([4]) Most of the peak flow meter uses a

traditional Wright scale to record PEF whilst after 2004 Peak flow meters with new European scale have been introduced in the market to reduce errors. ([5]) It has not formally been assessed whether the PEF values measured with digital spirometer are in close agreement with the PEF values measured with mini wright's peak flow meter (Wright scale) or with new European scale.

MATERIAL AND METHODS

Subjects: The study was conducted on 582 healthy volunteers between the age group of 18-40 years from university healthy population. Nature of the study was explained and informed consent was obtained from each subject prior to participation in study. The protocol of the study was approved by institutional ethics committee.

A thorough history was taken and clinical examination of the subjects was performed to rule out any obvious cardio-pulmonary compromise. Subjects with history of smoking, history of severe chest trauma, with obvious chest and spinal deformity, with personal/family history of asthma, chronic obstructive pulmonary diseases and other cardio-respiratory diseases were excluded from the study.

Devices: The Spirobank G (MIR; Rome, Italy) device is a turbine with an infrared interruption spirometer. The Spirobank G device records spirometry parameters including FVC, FEV1, percentage of predicted FEV1, PEF, forced expiratory flow, midexpiratory phase, forced expiratory time along with flow/volume curve. Its has a flow range of ± 16 L/s and a maximal volume of 10 L, a flow accuracy of 5% or 200 mL/s, and a volume accuracy of 3% or 50 mL, whichever is greater. Spirobank G device have been laboratory tested, and met or exceeded the latest ATS accuracy standards.

The standard range version of the Mini-Wright Peak-Flow Meter (Clement-Clarke International; Harlow, Essex, UK) was used. It has 10-L increments from 60 to 800 L/min, and its performance has been studied.([6,7,8,9,10,11,12]) The monitoring devices used in the study were new and were acquired directly from the manufacturers. Conversion table was used for converting the PEF values on wright scale to New European Scale.

Protocol: Subjects were individually instructed for measuring their PEF with Mini wright's peak flow meters. Minimum five efforts at a time were recorded and best two measures with in 10 % of each other were recorded as per the reproducibility criteria of Dalhquist et. al ([13]). Also the value of PEF was recorded after conversion to the new EU PEF scale using conversion table. Simultaneously Spirometery of each subject was performed with Spirobank G as per the ATS guidelines. The test curve with the highest sum of the FVC and FEV1 was considered the best curve, and the largest FVC and FEV1 measurements were taken for analysis. PEF obtained in L/s was converted to L/min. All measurements were performed in standing position and a nose clip was used.

Accumulated data were scrutinized and those with incomplete test record or inadequate testing were rejected. Finally 553 subjects were selected for inclusion into analysis.

Statistical analysis: The mean values of PEF were calculated normality of the data was tested. All results were expressed as means and compared by independent sample ‘t'-test. The primary end point of the study was to determine if the PEF was different when recorded with different instruments, correlation analysis was then performed on Digital spirometer measured PEF and mini wright measured PEF'S with traditional wright scale and with new European scale. As the correlation analysis may be misleading, agreement was also calculated using Bland & Altman plots. ([14]) p value less than 0.05 was taken as significant.

RESULTS

A total of 553 subject's data was analyzed. All were non smokers with normal lung functions. No personal and family history of pulmonary and cardiovascular diseases in any of the subjects. Subject's characteristics are given in Table-1.

Figure 1

Table 1: Subject Characteristics

Total Subjects	553
Male	346
Female	207
Age	
Mean (SD)	23.4(2.7)
Range	18-28
Height	
Mean (SD)	166.4(8.92)
Range	148-185
Weight	
Mean (SD)	61.6(10.4)
Range	42-96
FEV1	
Mean (SD)	3.47(0.45)
Range	2.3 – 4.87
FVC	
Mean (SD)	3.92(0.54)
Range	2.48 – 5.51
FEV1%	
Mean (SD)	88.67(4.47)
Range	80.1 – 99.6

The comparison between Peak Expiratory Flow measured by

Spirometer and Mini Wright Peak Expiratory Flow Meter with traditional Wright Scale and New European Scale is given in Table-2.

Figure 2

Table 2: Comparison of Peak Expiratory Flow Measured by different meters.

Instrument	Mean PEF	±SD
Spirometer	527.46	67.11
Mini Wright	526.32	46.77
European	490.35	57.61

The mean difference between PEF measured by Spirometer and mini wright peak flow meter with traditional scale was not different significantly ($p > 0.05$). While the mean difference between PEF measured by Spirometer and Mini Wright Peak Flow Meter with New European Scale is 37.11 lit./min. which is statistically significant, ($p < 0.05$). Similarly, the mean difference between PEF measured by Mini Wright Peak Flow Meter with traditional scale and with new European scale is 35.97 lit./min. which is again statistically significant ($p < 0.05$).

The correlation between PEF measured by different instruments can be visually interpreted in the scatter plots shown in Figure-1. The correlation coefficients and their significance levels are given in Table-3.

Figure 3

Table 3: Correlation between PEF measured by different instruments

Instrument	Pearson correlation coefficient	significance
Spirometer and Mini Wright	0.765	0.000
Spirometer and European	0.767	0.000
Mini Wright and European	0.999	0.000

For calculating the limits of agreement mean difference (d) and standard deviation (s) was calculated and limits of agreement are expressed as $d + 1.96s$ and $d – 1.96s$ as given in Table-4. For graphical representation of limits of agreement Bland & Altman graphs were drawn (Figure-2). The bias ($d \pm s$) calculated for PEF measurement by Spirometer and Mini Wright Peak Flow Meter with traditional scale is 1.14 ± 43.41 lit./min. The bias calculated for PEF measurement by Spirometer and Mini Wright Peak Flow Meter with New European Scale is 37.11 ± 43.48 lit./min. The two scales i.e. Traditional and New European Scale also differed with a consistent bias of 3.97 ± 10.99.

Figure 4

Table 4: Limits of agreements between different measures of PEF

Instrument	d	s	d+1.96s	d-1.96s
Spirometer and Mini Wright	1.14	43.41	86.22	-83.94
Spirometer and European	37.11	43.48	122.3	-48.11
Mini Wright and European	35.97	10.99	95.41	14.42

We also compared the FEV1 with PEF measured by spirometer and Mini Wright's Peak Flow Meter with traditional scale and new European Scale. We also compared the PEF measured with diiferent instruments with FEV1 measured by Spirometer. The pearson correlation coefficient and their significance levels are given in Table-5.

Figure 5

Table 5: Comparison of PEF with FEV1

Instrument	Pearson correlation coefficient	significance
FEV1 and PEF (Spirometer)	0.559	0.000
FEV1 and PEF (Wright scale)	0.517	0.000
FEV1 and PEF (European Scale)	0.517	0.000

Figure 6

Figure 1: Scatterplot for PEF measured with Spirometer and Mini Wright Peak Flow Meter

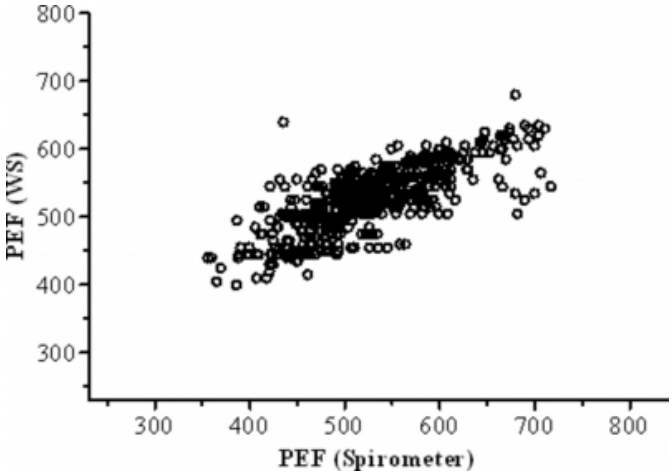


Figure 7

Figure 2: Bland & Altman plot showing limits of agreement (dotted lines represents mean difference (d) and d±1.96s)

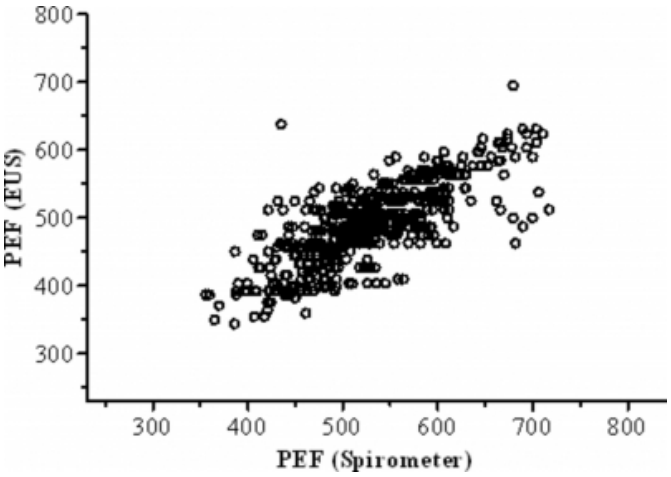
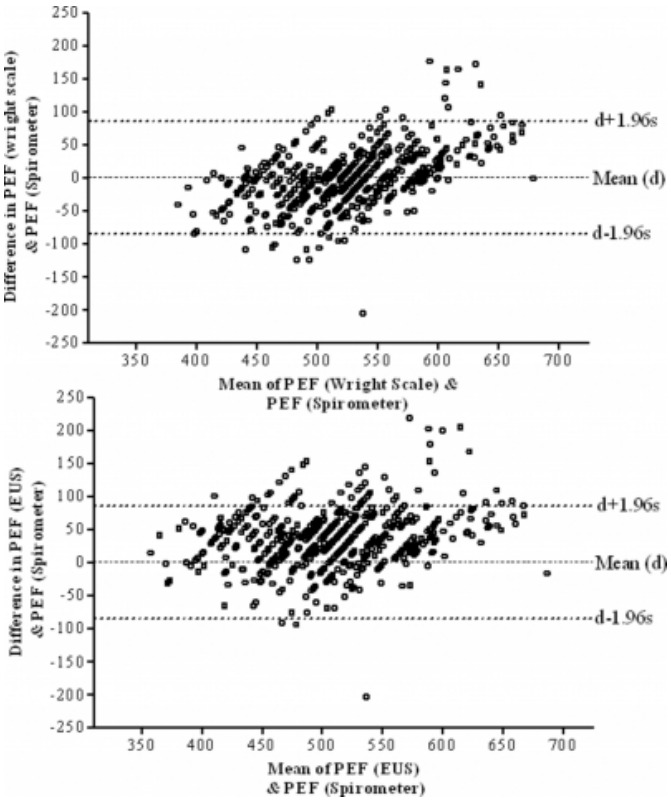


Figure 8



DISCUSSION

This study was aimed at comparing the PEF measured by spirometer and Mini Wright Peak Flow Meter with traditional scale and New European Scale. Although similar studies have been published in past, but most of these were done on patient population. Patients, with obstructive airway disease, were purposefully excluded because the intra subject variability in asthmatics has been reported to be higher than in normal subjects. Moreover maneuver-induced bronchospasm in patients with obstructive airway disease also could effect measurement. ([15]) This is perhaps the preliminary study with large number of healthy subjects where the PEF measurements, with different instruments, have been compared.

In this study, despite a high correlation observed between measured PEF with different instruments, the limit of agreement is not acceptable as per either the ATS guidelines or European guidelines. This large difference in PEF with different instruments clearly is not acceptable clinically too. While calculating limits of agreement and bias we compared the difference in the PEF values with different instruments against the mean value of the PEF with different instruments, assuming that the actual PEF value might lie somewhere between the two PEF values. In the absence of actual PEF values the mean PEF is the best substitute for the actual PEF value.

The PEF values with spirometer and Mini Wright peak flow meter also correlates well with FEV1 as expected and the correlation levels are almost similar to that reported in previous studies. ([16,17,18,19,20]) The probable explanation of the observed difference between two parameters could be that FEV1 reflects airway caliber of proximal and peripheral airways, whereas PEFR reflects primarily proximal airway caliber.([21,22,23])

The inadequate performance of the Mini-Wright Peak Flow Meter is consistent with the observations of other studies. ([6,7,8,11]) The PEF measured with New European scale does not seem to provide any advantage over Wright scale as indicated by similar levels of correlation and limits of agreement. The lack of linear response in mini wright peak flow meters is not necessarily due to only mechanical reasons as was assumed while creating newer scale ([24]). The mean PEF with New European scale is lower than the mean PEF with Wright scale. The two scales are not related exactly in linear fashion and they coincide only at PEF value of 639 L/Min. The observed difference can be explained and attributed to the fact that the PEF value of 526.32 on Wright scale corresponds approximately near to 490.35 on New European Scale.

Originally the Wright Peak Flow Meter was developed to measure Peak Expiratory Flow. This requires the subject to exhale as quickly as possible into a recording device following maximum inspiration. Maximal expiratory flow lasts for only a fraction of a second and occurs very early in

expiration. It is not necessary for the subject to continue exhaling to residual volume. For most subjects, a short but forceful blow will be sufficient to register the maximal expiratory flow ("PEF technique"). The FVC measurement requires a blow that starts from maximal inspiration and proceeds to residual volume. Although PEF measurements and FEV1/FVC measurements both require a rapid exhalation, the instructions given to the subject are different and it is possible that the two techniques are not interchangeable. ([21,22,25]) The PEF of children, when measured using a PEF technique was 3% higher (although clinically insignificant) than with FVC technique on a turbine spirometer. ([26]) But the measurements with turbine spirometer were not compared with the Peak Flow meter.

Digital Spirometer expresses the peak flow in body temperature and pressure saturated with water vapor (BTPS) conditions, but for Mini Wright Peak Flow Meters there is no provision for such corrections. Further the Intra subject variability in measuring PEF is high, which could account for the observed differences. ([20,27,28])

The measurement of PEF with New European scale does not seem to provide any significant advantage over traditional scale. The mean PEF with new European scale differs with mean PEF with spirometer and mean PEF with wright scale in normal healthy Indian subjects, and should be tested further, in different group of healthy as well as asthmatic subjects.

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