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Original Research Article

Clinical Comparison of Peak Flow Meter and Digital Spirometer in Measuring Peak Expiratory Flow Rate

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Abstract:

Background: Peak Expiratory Flow Rate (PEFR) is an essential measure of pulmonary function, usually being made with the help of either peak-flow meters or digital spirometers. Differences between 'the two machines can have an effect on clinical interpretation and respiratory condition management.

Aim: Compare the measurements of PEFR taken by a peak flow meter and a digital spirometer in healthy subjects, patients with asthma, and patients with Chronic Obstructive Pulmonary Disease (COPD).

Methodology: Retrospective comparative study was carried out in the Department of Physiology, Gouri Devi Institute of Medical Sciences, Durgapur, West Bengal, India. Sixty individuals were randomized into three groups of 20 each, namely, Group A (normal, healthy individuals), Group B (asthmatics), and Group C (patients with COPD). Both peak flow meter and electronic spirometer were employed for measuring PEFR, of which the best of three attempts was taken for both instruments. Statistical analysis included paired t-tests and ANOVA with adjustment for Bonferroni correction.

Results: In all groups, the digital spirometer showed consistently higher PEFR measurements than the peak flow meter ($p < 0.001$). The mean difference was 12 L/min in the healthy, 18 L/min in the asthmatic, and 22 L/min in the COPD groups. Aging-induced decline in PEFR was noted, but the digital spirometer had higher readings in all age groups.

Conclusion: Peak Expiratory Flow Rate measurements taken with peak flow meters and digital spirometers are not equal, as they have considerable variation. Both are useful tools, but the digital spirometer is more accurate, particularly in those with poor lung function.

Keywords: Asthma, COPD, Digital Spirometer**,** Peak Expiratory Flow Rate, Peak Flow Meter, Pulmonary Function Test, Spirometry.

Introduction

One of the most widely applied and significant lung function tests is Peak Expiratory Flow Rate (PEFR) due to its simplicity, reliability, and reproducibility. It is a useful clinical tool in pulmonary function assessment, particularly in asthma and chronic obstructive pulmonary disease (COPD). Hardon first introduced the concept in 1942, but it was several years later that it was accepted as part of routine spirometric testing in clinical examination [1]. The definition of PEFR is the highest rate with which air is able to be forcibly expelled from the lung, usually expressed in units of liters per minute (L/min) [2]. This measure is an essential indicator of the caliber of large airways and is an index of the force developed by the expiratory muscles, especially during the 100–200 milliseconds of forceful expiration [3].

The value of PEFR is affected by numerous intrinsic and extrinsic variables, such as sex, height, body surface area, age, and ethnicity [4]. Demographic and anthropometric variables are significant in determining what is considered a normal range. For example, the typical range for males is around 450–550 L/min, whereas for females it is 320–470 L/min. Due to this variability, proper interpretation of PEFR demands consideration of individual variables. Furthermore, PEFR is extremely sensitive in detecting obstruction of the airways in the earlier stages and is a useful index for measuring the strength of respiratory muscles. For this reason, it is found extremely useful in the follow up of respiratory diseases as well as in response to therapy with bronchodilators.

PEFR is measured with either a peak flow meter or a digital spirometer. A peak flow meter is a small, lightweight, and inexpensive handheld tool that is easy to use, appropriate for both clinical and home monitoring applications. Digital spirometers, on the other hand, offer a complete lung function assessment by measuring several parameters, including Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 seconds (FEV1), Breath Holding Time (BHT), and Maximum Voluntary Ventilation (MVV), in addition to PEFR. Unlike peak flow meters, spirometers also measure the duration of time taken and air velocity during expiration, providing a detailed analysis of lung function. Additionally, spirometry is a painless, objective means of diagnosis that is able to identify functional changes in the lungs in their earliest stages, even prior to clinical symptom onset [5].

However, despite the advanced capabilities of spirometry, some studies have reported discrepancies in PEFR values obtained using different devices. Laboratory calibration tests have revealed that the values recorded by various peak flow meters and spirometers may differ significantly, with some studies reporting errors of up to 26%. Such variations raise questions about the interchangeability of these devices for accurate PEFR measurement. Therefore, while both instruments are widely used, it remains essential to evaluate whether their readings are comparable and if one may offer a clinical advantage over the other in certain settings.

The present comparative study has been undertaken with the objective of determining whether there is a statistically significant difference in the PEFR values derived from a peak flow meter and a digital spirometer. This investigation aims to clarify whether these two devices can be used interchangeably in clinical practice or if preference should be given to one based on accuracy and reliability. Ultimately, such insights will help guide physicians in selecting the most appropriate method for monitoring respiratory health in diverse populations.

Methodology

Study Design: A retrospective study was conducted in the Department of Physiology, Gouri Devi Institute of Medical Sciences, Durgapur, West Bengal, India for 12 months. The objective of the study was to compare Peak Expiratory Flow Rate (PEFR) values obtained using a peak flow meter and a digital spirometer among three groups:

- **Group A**: Healthy individuals (n=20)
- **Group B**: Asthmatic patients (n=20)
- **Group C**: Chronic Obstructive Pulmonary Disease (COPD) patients (n=20)

Sample Size

A total of 60 participants were enrolled in the study, with 30 subjects in each group (healthy, asthmatic, and COPD).

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Adults aged between 18 and 65 years
- Ability to perform reproducible spirometry maneuvers

Exclusion Criteria:

- Acute respiratory infections
- History of thoracic surgeries
- Structural abnormalities of the chest wall
- Cognitive impairments interfering with accurate testing

Asthma and COPD diagnoses were confirmed through clinical history, physical examination, and previous spirometry results based on the guidelines provided by the American Thoracic Society (ATS) and the Global Initiative for Chronic Obstructive Lung Disease (GOLD).

Procedure: Participants were recruited through purposive sampling in accordance with pre-established inclusion and exclusion criteria. All testing was carried out in a clinical setting controlled for extraneous influences. Participants were all seated upright to reduce variability in respiratory measurements. Peak Expiratory Flow Rate (PEFR) was measured with two different modalities: peak flow meter and digital spirometer. A peak flow meter, a mechanical system that was calibrated according to manufacturer recommendations, was utilized for bedside measurements. The digital spirometer was a hand-held system with a high degree of calibration and automated error-checking for ensuring reliability and repeatability.

The participants were asked to breathe deeply, seal their lips tightly on the mouthpiece of the device, and blow out forcibly and quickly. Three maximal expiratory efforts were performed by each subject with each of the devices, and the maximum value of the PEFR measured was taken for analysis. A 1–2 minute resting time was allowed between maneuvers for preventing fatigue. The order of the use of the devices was reversed among subjects for avoiding any order effect. Demographic and clinical variables, in addition to PEFR, like age, sex, smoking status, FEV1, and FVC, were also measured. Device-specific errors like those of incomplete maneuvers or calibration were noted but not included for final analysis.

Statistical Analysis: Statistical analysis was performed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were summarized using frequencies and percentages. To compare

PEFR values between the two devices, paired t-tests were employed. Subgroup comparisons across the three groups (healthy, asthmatic, and COPD) were carried out using one-way analysis of variance (ANOVA), followed by post-hoc Bonferroni correction to determine specific group differences. Agreement and correlation between the peak flow meter and digital spirometer were assessed using Bland-Altman plots and Pearson correlation coefficients. A p-value of less than 0.05 was considered statistically significant for all analyses.

Result

Table 1 presents the baseline demographic and clinical characteristics of the study participants, divided equally among Group A, Group B, and Group C (n=20 each). The mean ages of participants in Groups A, B, and C were 40.1 ± 7.9, 41.3 ± 8.5, and 42.8 ± 8.7 years respectively, with no statistically significant difference (p=0.39). The gender distribution was comparable across the groups, with males comprising 60%, 55%, and 60% in Groups A, B, and C respectively, and females making up the remaining percentages; the p-value of 0.81 indicates no significant difference in gender distribution. Similarly, the mean Body Mass Index (BMI) values were closely aligned among the groups—24.7 ± 3.0 in Group A, 25.0 ± 3.4 in Group B, and 25.4 ± 3.2 in Group C—with a non-significant p-value of 0.59. Overall, the groups were well-matched in terms of age, gender, and BMI at baseline.

Table 1: Baseline Demographic and Clinical Characteristics (N = 60)

Characteristic	Group A (n=20)	Group B (n=20)	Group C (n=20)	p-value
Age (years)	40.1 ± 7.9	41.3 ± 8.5	42.8 ± 8.7	0.39
Male (%)	60	55	60	0.81
Female (%)	40	45	40	0.81
BMI (kg/m²)	24.7 ± 3.0	25.0 ± 3.4	25.4 ± 3.2	0.59

Table 2 presents the mean Peak Expiratory Flow Rate (PEFR) values measured using a Peak Flow Meter and a Digital Spirometer across three groups. In all groups, the Digital Spirometer recorded higher mean PEFR values compared to the Peak Flow Meter. Group A showed a mean difference of 12 L/min (521 ± 35 vs. 533 ± 33), Group B had a difference of 18 L/min (422 ± 38 vs. 440 ± 42), and Group C exhibited the largest difference of 22 L/min (318 ± 43 vs. 340 ± 40). All differences were statistically significant with p-values less than 0.001, indicating that the Digital Spirometer consistently measured higher PEFR values than the Peak Flow Meter across all groups.

Table 2: Mean PEFR Values by Device Across Groups

Group	Peak Flow Meter (L/min)	Digital Spirometer (L/min)	Mean Difference (L/min)	p-value
Group A	521 ± 35	533 ± 33	12	<0.001
Group B	422 ± 38	440 ± 42	18	<0.001
Group C	318 ± 43	340 ± 40	22	<0.001

Table 3 is presented below, illustrating the distribution of mean Peak Expiratory Flow Rate (PEFR) measurements by both Peak Flow Meter and Digital Spirometer for three age ranges. In all three age ranges, the Digital Spirometer was found to measure higher mean PEFR values compared with the Peak Flow Meter: 551 L/min compared with 538 L/min in the 18–30 years age range, 469 L/min compared with 448 L/min in the 31–50 years age range, and 380 L/min compared with 362 L/min in the 51–65 years age range. The differences between the two devices were significant in all three age ranges ($p < 0.001$); the values for PEFR declined with increased age, as would be expected in terms of declining lung function with age.

Table 3: PEFR Distribution by Age Groups

Age (Years)	Peak Flow Meter – Mean PEFR (L/min)	Digital Spirometer – Mean PEFR (L/min)	p-value
18–30	538 ± 32	551 ± 30	<0.001
31–50	448 ± 35	469 ± 33	<0.001
51–65	362 ± 38	380 ± 36	<0.001

Discussion

The findings of this study provide valuable insights into the comparative performance of Peak Flow Meters and Digital Spirometers in measuring Peak Expiratory Flow Rate (PEFR) across different participant groups and age categories. The baseline characteristics (Table 1) affirm that the study groups were well-matched in terms of demographic and

clinical variables such as age, gender, and BMI, minimizing confounding factors and enhancing the internal validity of the results. The PEFR number obtained from the peak flow meter was substantially higher than that recorded by the spirometer. Comparable research has been conducted. A study conducted by Tiwari et al. in 2016 [6] corroborates our findings, demonstrating elevated Peak Expiratory Flow Rate (PEFR) values in healthy individuals, diminished values in chronic obstructive pulmonary disease (COPD) patients, and comparable values in asthma patients, with no significant disparity observed between the mean values obtained from the peak flow meter and spirometer. Comparable research conducted by Takara et al. in 2010 [7] showed that the Peak Expiratory Flow Rate (PEFR) measured using a peak flow meter was superior to that obtained from a spirometer, but the result from the GaleMed meter was inferior to the spirometric measurement.

The most striking observation is the consistently higher PEFR values recorded by the Digital Spirometer in comparison to the Peak Flow Meter across all groups (Table 2). This pattern was evident in all three participant groups, with statistically significant differences ($p < 0.001$). Group A, likely representing individuals with better baseline pulmonary function, showed the smallest difference (12 L/min), whereas Group C, possibly representing participants with lower lung function (perhaps due to age or other factors), exhibited the greatest difference (22 L/min). These differences suggest a systematic measurement bias or increased sensitivity of the Digital Spirometer. However, some investigations indicate no significant difference in PEFR values assessed by both devices (Imbruce R 1991; Eichenhorn et al., 1982) [8,9]. Comparable research conducted by Dr. Shubhi Thomar on the correlation of PEFR readings obtained from a peak flow meter and a spirometer revealed a statistically significant mean difference ($P < 0.05$) between the two methods [10].

Furthermore, age-related trends in PEFR were clearly demonstrated in Table 3. As expected, there was a progressive decline in PEFR with advancing age, consistent with well-established literature indicating reduced lung elasticity and respiratory muscle strength over time. Notably, within each age group, the Digital Spirometer continued to record significantly higher PEFR values compared to the Peak Flow Meter ($p < 0.001$). This reinforces the observation that the Digital Spirometer may offer more precise or possibly overestimated readings. The digital spirometer surpassed the peak flow meter for accuracy and repeatability, exhibiting reduced variability in repeated measurements (John, J. 2017) [11]. This was especially apparent in cohorts with impaired lung function, such as individuals with asthma and COPD, when meticulous monitoring is essential (Kera et al., 2018; Njoku, C. 2004) [12,13]. The results highlight the necessity of employing spirometers in clinical environments that demand precision, although peak flow meters continue to serve as an effective instrument for regular monitoring owing to their ease of use and mobility (Taksande et al., 2008) [14].

The consistent pattern of higher PEFR readings from the Digital Spirometer may be attributed to several factors. Digital Spirometers are generally more sensitive and capable of capturing data over a longer and more detailed time frame compared to mechanical Peak Flow Meters, which are dependent on the user's technique and instantaneous effort. Moreover, digital devices often provide real-time feedback, potentially encouraging better performance during testing. However, this also raises concerns about interchangeability between devices, especially in clinical or epidemiological settings where uniformity of data is critical.

From a clinical perspective, the findings suggest that while both devices can track PEFR trends effectively, they should not be used interchangeably when precise measurements are critical. Digital Spirometers, due to their greater sensitivity and accuracy, may be more appropriate in diagnostic settings, while Peak Flow Meters may remain valuable for routine monitoring due to their affordability and ease of use.

In conclusion, the study highlights the importance of understanding device-related differences in PEFR measurements. The Digital Spirometer consistently recorded higher values than the Peak Flow Meter across all groups and age ranges, and these differences were statistically significant. Future research could explore calibration or correction factors between the two devices to improve consistency and clinical utility.

Conclusion

This comparative analysis shows that both the peak flow meter and the digital spirometer are effective for measuring Peak Expiratory Flow Rate (PEFR), the digital spirometer systematically recorded higher values in all groups of participants and age ranges. Implications of the analysis are that both measures are valuable, yet not interchangeable, with systematic differences in measurements. The digital spirometer is shown to be more sensitive and reliable, particularly in those with limited lung function, for example, those with asthma or COPD. Furthermore, the age-specific reduction in PEFR supports the reliability of the measuring tools in identifying expected physiologic patterns. In light of its precision and lesser variability, the digital spirometer is preferable in clinical settings where accurate pulmonary assessment is desired. Yet, the peak flow meter is a good choice for routine, budget, and transportable monitoring, notably in the home or in the non-specialist setting. In this instance, therefore, the

choice of tool should be dictated by setting, precision needs, and clinical needs.

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