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Clinical applicability of peak expiratory flow measured with peak flow metre compared to spirometer in a resource-limited setting

Jumbo J.[1], Onini E.N.[2], Ikuabe O.P.[1]

Abstract

Background: Peak Expiratory Flow (PEF) is the maximum flow produced during a forced expiration following a full inspiration. It is useful in the management of lung diseases especially the domiciliary assessment of disease control in patients with Asthma. PEF can be measured with either a peak flow meter or a spirometer. We aimed at comparing PEF measured using a Mini Wright peak flow meter with PEF measured using Spirolab III spirometer in order to assess its clinical applicability in resource-limited settings.

Method: A method-comparison study with records of PEF values at the Niger-Delta University Teaching Hospital, Okolobiri. Hypotheses were formulated and tested after data was analyzed using the IBM SPSS version 25 software.

Results: PEF readings of a total of 100 adults were analyzed. Mean age was 48.90 ± 19.77 years. Males (51%) were slightly more than females (49%). One-sample t-test showed no statistical difference in the mean PEF values measured with the two devices ($p = 0.295$). There was significant correlation between the PEF values measured with the two devices ($p<0.0001$) with demonstration of agreement and absence of proportional bias in the PEF values measured by the two methods following linear regression analysis ($p = 0.959$).

Conclusion: PEF values obtained from the Mini wright PEF meter and the Spirolab III spirometer are comparable. Therefore, the Mini Wright peakflow meter may be effectively used in the diagnosis and monitoring of Asthma and other lung diseases in resource-limited settings.

Keywords: Peak Expiratory Flow (PEF), PEF meter, Spirometer, Resource-limited settings.

***Corresponding author**
Jumbo J.
ORCID-NO: https://orcid.org/0000-0002-9280-5580
E-mail: johnbulljumbo(@gmail.com

[1]Department of Internal Medicine, Facultv of Clinical Sciences, Niger Delta University, Wilberforce Island, Nigeria
[2]Federal Medical Centre, Yenagoa, Nigeria.

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Applicabilité clinique du débit expiratoire de pointe mesuré avec un débitmètre de pointe par rapport à un spiromètre dans un cadre à ressources limitées

Jumbo J.[1], Onini E.N.[2], Ikuabe O.P.[1]

Résumé

Contexte de l'étude : Le débit expiratoire de pointe (DEP) est le débit maximal produit lors d'une expiration forcée après une inspiration complète. Il est utile dans la gestion des maladies pulmonaires, en particulier l'évaluation à domicile du contrôle de la maladie chez les patients asthmatiques. Le DEP peut être mesuré avec un débitmètre de pointe ou un spiromètre. Nous avons cherché à comparer le DEP mesuré à l'aide d'un débitmètre de pointe Mini Wright avec le DEP mesuré à l'aide du spiromètre Spirolab III afin d'évaluer son applicabilité clinique dans les milieux à ressources limitées.

Méthode de l'étude: Une étude de comparaison de méthodes avec des enregistrements de valeurs de DEP à l'hôpital universitaire d'enseignement du delta du Niger, à Okolobiri. Les hypothèses ont été formulées et testées après analyse des données à l'aide du logiciel IBM SPSS version 25.

Résultat de l'étude : Les lectures du DEP d'un total de 100 adultes ont été analysées. L'âge moyen était de 48,90 ± 19,77 ans. Les hommes (51 %) étaient légèrement plus nombreux que les femmes (49 %). Le test t à un échantillon n'a montré aucune différence statistique dans les valeurs moyennes du DEP mesurées avec les deux appareils (p = 0,295). Il y avait une corrélation significative entre les valeurs de DEP mesurées avec les deux appareils (p<0,0001) avec démonstration d'accord et d'absence de biais proportionnel dans les valeurs de DEP mesurées par les deux méthodes après analyse de régression linéaire (p = 0,959).

Conclusion : Les valeurs de DEP obtenues avec le Mini wright DEP meter et le spiromètre Spirolab III sont comparables. Par conséquent, le débitmètre de pointe Mini Wright peut être utilisé efficacement dans le diagnostic et la surveillance de l'asthme et d'autres maladies pulmonaires dans des environnements à ressources limitées.

Mots-clés : Débit expiratoire de pointe (DEP), compteur DEP, spiromètre, paramètres de ressources limitées

***Corresponding author**
Jumbo J.
ORCID-NO: https://orcid.org/0000-0002-9280-5580
E-mail: johnbulljumbo(@gmail.com

[1]Department of Internal Medicine, Facultv of Clinical Sciences, Niger Delta University, Wilberforce Island, Nigeria
[2]Federal Medical Centre, Yenagoa, Nigeria.

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INTRODUCTION

Peak Expiratory Flow (PEF) is the maximum flow produced during a forced expiration following a full inspiration.(1,2) It is a simple measure of airflow limitation that can be performed both in the in-patient and out-patient settings (3). Although not precise, it correlates with forced expiratory flow in one second (FEV1) measured by spirometry (4). PEF has found use in the diagnosis of Asthma, but more importantly in the domiciliary assessment of disease control in patients with Asthma (5), including self-monitoring by patients on treatment for asthma and adjustment of their medications based on the traffic sign rule (6). It has also been used in monitoring the effect of ozone (7) and other air pollutants on pulmonary function as well as monitoring of Chronic Obstructive Pulmonary Disease (COPD) (8).

Measurement of PEF is commonly carried out by the use of a portable flow device called peak flow meter but may also be obtained by a transducer that converts flow to electric output during spirometry (9). In routine clinical practice, the standard for diagnosis and monitoring of obstructive airway disease is spirometry with parameters such as forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) being the most useful measurements (10).

In resource limited settings as with most developing countries, availability of functional spirometers has been a constant challenge to clinicians and the pulmonologist in particular (11). As a result, most patients with obstructive airway diseases do not have a reliable diagnosis in these settings. Rather, they receive treatment only on the basis of assumption probably from symptomatology. Another problem of spirometry is that it needs trained personnel to ensure acceptable and reproducible performance (10). Hence, for both diagnosis and monitoring of disease, spirometry requires personnel with expertise to produce clinically reliable information.

Furthermore, the cost of owning a spirometer is by far huge compared to owning a peak flow meter. This is significant for both patients and the institutions. Even if patients do not have to own a spirometer, in the absence of a peak flow meter, they would have to present to the health facility repeatedly for monitoring of their disease. This would eventually increase the cost of their treatment and the burden of having to leave their homes for medical care.

For the above reasons, considering institutions in resource-poor settings, especially primary care institutions, owning a peak flow meter is far more cost-effective than owning a spirometer. In theory, with some limited precision, PEF can effectively serve the purposes of both diagnosis and monitoring of obstructive lung diseases. For example, it is useful in the diagnosis of asthma by assessment of variability. However, due to its relegated use, this clinical applicability is not widespread (12). Determination of its comparative applicability, therefore, becomes necessary in order to make informed recommendations for its use as a surrogate for spirometry in resource-limited settings. Thus, we aimed at assessing the clinical applicability of PEF measured using peak flow meter as compared with PEF measured with a spirometer.

MATERIALS AND METHODS

This was a Method-Comparison Study that assessed PEF values measured with a Peak Expiratory Flow meter as compared with those measured with a Spirometer. In each session of spirometry, PEF was also measured using Mini Wright Peak Flow meter at no additional cost to the patient. Information on PEF values measured by these two different devices for adults who presented for spirometry over a period of two years (2019-2021) at the cardiopulmonary laboratory of the Niger Delta University Teaching Hospital,(NDUTH) Okolobiri, was accessed from the medical record of the spirometry unit of the cardiorespiratory laboratory for analysis. Two hypotheses were formulated and tested for acceptance and rejection respectively.

Ethical clearance was obtained from the research and ethical committee of the NDUTH. The ethical clearance protocol number was REC 0015.

Hypothesis

Null hypothesis (Ho): There is no difference between PEF values measured with the MiniWright PeakFlowmeter and those measured with the Spirolab III Spirometer.

Alternate Hypothesis (HA): There is a difference between the PEF values measured with the Mini wright Peak Flow meter and those measured with the Spirolab III Spirometer.

Data analysis

Statistical Package for Social Sciences (SPSS) version 25 software was used and PEF values were expressed in means. Correlation analysis was carried out to assess the relationship between the two methods of measurement. Computation of differences between individual PEF values and the average PEF values respectively measured by the different devices was done in SPSS, and a one-sample t-test was conducted to ascertain the statistical significance. To avoid a misleading data with correlation analysis, limits of agreement were computed and a Bland-Altman Plot was created to represent the information graphically. The information was also tested for proportional bias using linear regression analysis. Statistically significant levels considered for all relevant analyses was p-value of less than or equal to 0.05.

RESULTS

Distribution of the patients based on age and gender

A total of 100 adults PEF readings were analyzed for the study. As presented in Table 1, the mean age of the patients was 48.90 ± 19.77 years. Patients within the ages of 41 and 50 years were more. The gender distribution of the patients was comparable, though males were slightly more (51%) than females (49%) as shown in table 1.

Pearson Correlation coefficient (r) comparing the difference of PEF values measured with different devices.

The one-sample t-test analysis as seen in table shows that there is no statistical difference in the mean PEF values measured with the two devices ($p = 0.295$). There was a strong Pearson correlation between the values and is statistically significant ($p < 0.0001$).

Limits of agreement between PEF values

Figure 3 is a Bland-Altman plot showing the limits of agreement between PEF values measured with the two different devices (Mini Wright PEF meter and Spirometer). From the plot, majority of the values are clustered around the mean, though a few values are outside both the upper and lower limits.

DISCUSSION

In the current study, we tried to ascertain if the values of PEF readings obtained from a Mini wright peak flow meter and those obtained from a spirometer have some level of agreement in order to be used interchangeably, especially in our setting with limited resources where majority of health care facilities do not have access to spirometers. This index study showed that the difference between the measured values of the PEFR with the Mini wright Flow Meter and the spirometer varied slightly but it was not statistically significant.

Furthermore, the results from the one-sample t-test through correlation and Bland-Altman plot showed that there was no significant difference in PEF values measured by the two devices. This implies that the two methods are comparable. This finding was corroborated by a study done by Reshmarani et al (13) but the study was carried out among healthy adults unlike the index study which was a hospital-based study of patients. Another study done by Tiwari et al (14) among healthy subjects, chronic obstructive pulmonary disease (COPD) and bronchial asthma patients, revealed that there was no significant difference in the mean values of peak flow meter and spirometer.

Studies have shown conflicting results in terms of agreement with regards to PEF values measured by different methods. A study by Wensley and co-workers (15) found that PEF readings obtained from a peak flow meter was statistically significantly greater than that obtained from a spirometer in both healthy and asthmatic children. The overall mean difference was about 5%; and for the children with asthma, it was 3%. The study was however conducted on children with a mixture of healthy and asthmatic participants, unlike the current study which was conducted on adults with suspected pulmonary disease.

Dipti and Prem (16) showed a statistically significant difference between PEF values measured from spirometry and those from PEF meter. The current study was conducted on patients with suspected pulmonary diseases unlike theirs that was conducted on healthy volunteers. There have also been suggestions of using spirometry in place of PEF meters for monitoring adults and children with asthma at home (17,18). However, for the reasons advanced above in terms of cost and availability in resource-poor settings, we doubt the feasibility of this advocacy.

In resource-limited settings, the unavailability of functional spirometers is often greeted with the problem of inability to objectively diagnose and monitor obstructive lung diseases. This has placed a huge challenge to Pulmonologists and other physicians practicing in these settings. Patients, on the other hand have had to make huge sacrifices in order to have access to spirometry in far-away referral facilities.

With the findings of the current study, we think a lot can be done with the Mini wright peak flow meter in managing lung diseases in resource-limited settings. First, the diagnosis of Asthma can be made conveniently with variability testing (19) without having to bother about the use of spirometry in the meantime. Also, Asthma monitoring can be done effectively at home due to the reduced cost of having a peakflow meter compared to a spirometer. This would foster patient involvement in the management of their asthma thereby promoting better disease outcomes.

Furthermore, patient waiting time would be shorter as the reduced cost and better portability of the peakflow meter would mean that health facilities can acquire these instruments in relatively larger quantities, such that during patient evaluation, a larger number of patients can be evaluated at the same time.

A NICE assessment for a draft guideline on asthma diagnosis (19) cites a low and variable sensitivity but a high specificity of up to 0.99 in adults and 0.80 children for peak flow monitoring in the diagnosis of asthma. This high specificity ('negativity in health') does mean, however, that clear evidence of peak flow variability is very good for ruling asthma in as a diagnosis, while sensitivity ('positivity in disease') improves if the monitoring is repeated particularly across a period of exacerbation and remission of symptoms.

CONCLUSION

The current study shows that PEF values obtained from the MiniWright PEF meter and the Spirolab III spirometer are comparable. While we appreciate that there are conflicting results in terms of agreement of PEF values measured with different devices, our results show considerable consistency and agreement using the two devices.

We therefore, accept the null hypothesis that there is no difference between the PEF values measured with the MiniWright Peak Flowmeter and those measured with the Spirolab III Spirometer. We also reject the Alternate hypothesis that there is a difference between the PEF values measured with the MiniWright Peak Flowmeter and those measured with the Spirolab III Spirometer.

Recommendations: With the scarcity of resources in many centres in developing countries, we recommend that PEF values obtained with the Mini Wright peakflow meter should be used actively for the diagnosis and monitoring of lung diseases in resource-limited settings.

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Conflict of interest: No conflicts of interest declared.

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Table 1: Distribution of the patients based on age and gender

Variables	**Frequency**
Age range in years	
18-20	7
21-30	15
31-40	11
41-50	19
51-60	15
61-70	13
71-80	14
81-90	5
91-100	1
Mean age = 48.90±19.77	
Gender	
Male	49
Female	51

Table 2: One-sample t-test and Pearson Correlation coefficient (r) for PEF values.

Variables	**Mini wright PEF Meter**	**Spirometer**
Mean + SD	336.19+93.18	329.60 +92.87
Mean (d)	6.60	
SD (s)	62.51	
SE	6.25	
95% C I	-5.822 to 18.986	
t-test, p-value	1.053, 0.295	
Pearson Correlation coefficient (r), p-value	0.774 , < 0.0001	

Mean (d) = difference of means; SD (s) = standard deviation of the mean;
SE = standard error; 95% CI = 95% confidence interval;
Mean PEF measured in L/min

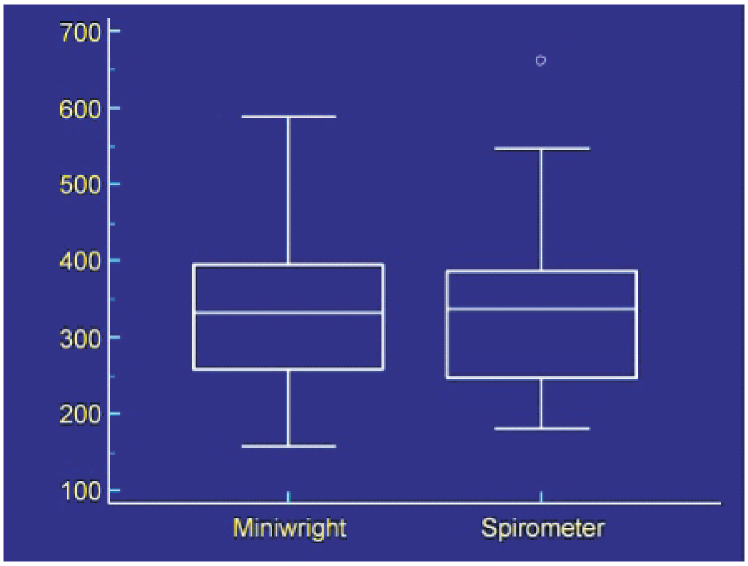

Figure 1: Box - and - Whisker plot comparing the mean PEF values measured by different instruments.

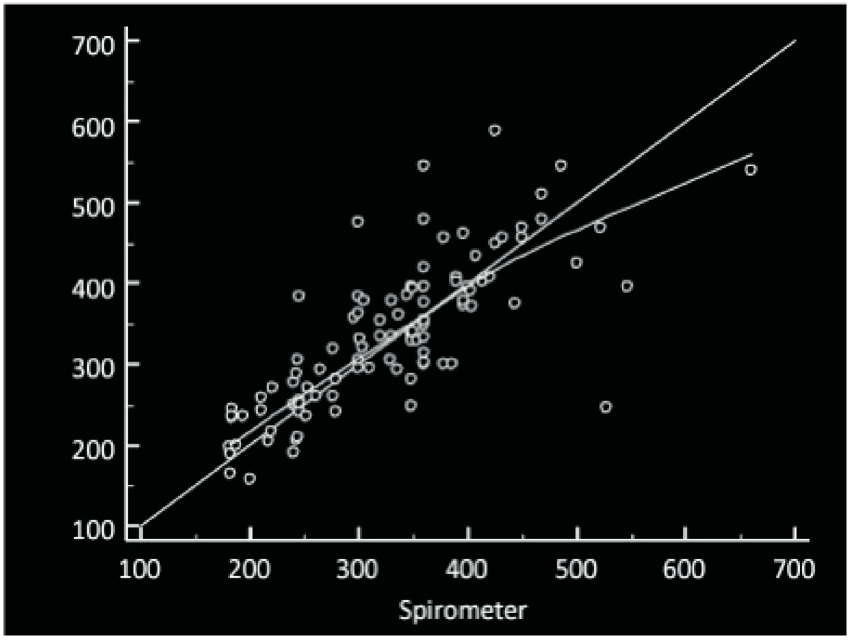

Figure 2: Scatter plot showing the correlation between PEF values measured with different devices.

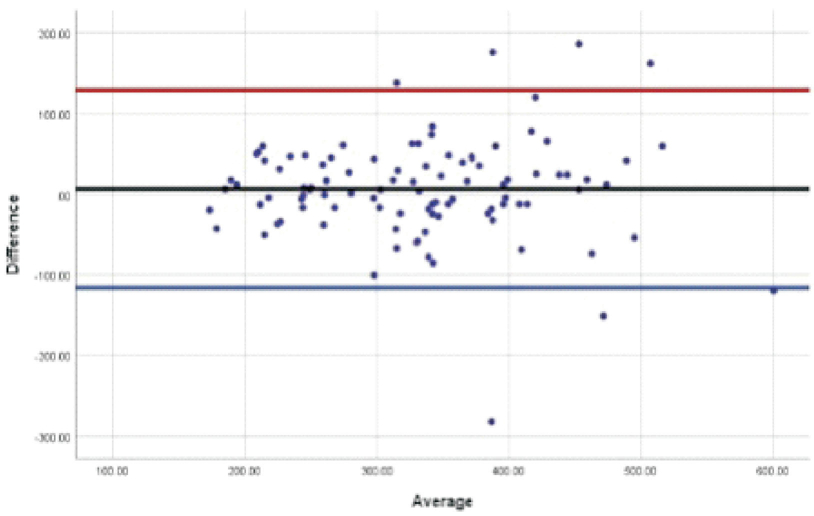

Figure 3: Bland-Altman plot showing limits of agreement of the PEF values. Mean (d)-6.6, Standard deviation (s)- 62.51, Upper limit (d + 1.96s)- 129.1, Lower limit (d – 1.96s)- 115.9.