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Mini-Wright peak flow meters are reliable after 5 years use

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ABSTRACT: In studies with a long-term follow-up, peak expiratory flow (PEF) meters are often used to assess bronchial obstruction. The question arises whether data obtained with these frequently used meters are still reliable after several years of use, and whether the old meters should be renewed after a certain period.

In the present study, we tested the reliability of PEF values measured with mini-Wright PEF meters that had been used frequently for 5 yrs. The values obtained with these meters were compared with values measured with identical but new meters, in 50 patients with obstructive airways disease. Though statistically significant, there was no clinically significant difference in mean PEF measured with the old and new meters in most patients (mean difference 10.2 L·min^{-1}). However, on an individual basis, the differences between old and new meters could be large (upper and lower limits of agreement (mean±2 SD) being 63.6 and -43.2 L·min^{-1}, respectively).

We conclude that mean peak expiratory flow values measured with frequently used mini-Wright peak expiratory flow meters are still reliable after 5 yrs. In long-term studies, renewal of peak expiratory flow meters should be restricted to cases of obvious malfunction.

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Peak expiratory flow (PEF) meters are frequently used for many years, both for research purposes and in routine clinical care [1–3]. Whereas several studies have been published reporting the technical standards of portable PEF meters [4–6], little is known about the reliability of the readings over a period of several years [4, 7]. SHAPIRO *et al.* [4] showed that the accuracy of the mini-Wright peak flow meters deteriorates after use. SIERSTED and OXHØJ [7] showed that the long-term within-PEF meter reproducibility varies in an unpredictable way. When designing studies with a long follow-up, in particular, the question arises whether PEF meters should be renewed after a certain period.

The aim of this study was to test the reliability of PEF values measured with peak flow meters that had been used more than 2,000 times over 5 yrs. Therefore, we compared the values of these (old) meters to values measured with new ones. We hypothesized that the use of old PEF meters instead of new meters would lead to clinically relevant differences in PEF values. In addition, the accuracy both of old and new meters was assessed by pneumotachography.

Methods

This study was part of a long-term multicentre study in patients with obstructive airways disease and bronchial hyperresponsiveness (asthma and chronic obstructive pulmonary disease (COPD)). During the first 2.5 yrs of the study, three different inhalation regimens (β_2-agonists in combination with corticosteroids (n=91), anticholinergics (n=92) or placebo (n=91)) were analyzed in 274 patients [8]. Additionally, all three groups were treated with β_2-agonists in combination with corticosteroids for another period of six months. Sixty eight out of 91 patients with inhaled corticosteroids from the start of the study completed the first 3 yrs. Fifty eight of them were willing to participate in another 2.5 yrs of follow-up; the main goal was to investigate the effects of treatment with inhaled β_2-agonists and corticosteroids on the long-term course and outcome of obstructive airways disease. Four patients dropped out, none for pulmonary reasons.

At the start of the long-term study, all patients received a standardized instruction on the use and cleaning procedures of a mini-Wright peak flow meter (Clement Clarke International Ltd, London, UK). During a period of 5 yrs, they had used their PEF meters at home (nine blows a day for 2 weeks, every 3–6 months). Thus, an old meter had been used more than 2,000 times by each participant. Fifty of the 54 participants still had their PEF meter from the start of the study and participated in this study. In these patients (36 males and 14 females), three PEF measurements were made both with the old meters and identical but new ones, in random order, and additionally two PEF rates were assessed with a pneumotachograph. All measurements were supervised and were performed at the hospital. The best value per instrument was used for analysis. The values obtained with

the old meters were compared to readings from the newly produced PEF meters. Additionally, the readings from the old and new meters were compared to PEF rates assessed with a pneumotachograph. A Lilly-type pneumotachograph was used in four centres and a Fleisch-type pneumotachograph in one centre. One centre used a dry rolling-seal spirometer, Mijnhardt Volugraph 2000 (Bunnik, the Netherlands), instead of a pneumotachograph. Calibration of these devices was performed using a calibration syringe.

Data analysis

The paired Student's t-test was used to test the differences in PEF values, after checking for normality (Kolmogorov-Smirnov test; $p>0.05$). Significance level was set at 5%. Means are presented ±SD for descriptive purposes and ±SE for evaluative purposes. Measure of agreement between the old and new peak flow meters was assessed using the method of BLAND and ALTMAN [9].

Results

Mean (SD) age of the participants was 47 (11 yrs), mean (SD) PEF measured with the old meters was 493 (130) L·min^{-1} and with the new meters 483 (132) L·min^{-1}.

Fifty of the 91 patients who were treated with inhaled β_2-agonists and inhaled corticosteroids from the start of the follow-up study could participate in this study. There were no significant differences in baseline characteristics between those patients who could participate and those who did not, especially not in age, sex, lung function and bronchial hyperresponsiveness.

Mean PEF value obtained with the old meters was 10.2 (SE 3.8) L·min^{-1} higher than the mean PEF value obtained by the new meters ($p=0.009$). Figure 1 shows the differences in PEF values between the old and new meters plotted against their mean. The upper and lower limits of agreement (mean±2 SD) are 63.6 and -43.2 L·min^{-1}, respectively (table 1). The differences between the old and new meters were not flow-dependent.

Table 1. – Differences in PEF values obtained with the old and new PEF meters and with the pnuemotachograph and upper and lower limits of agreement for the old *vs* new meters

Difference	PEF# L·min^{-1}	p-value (paired t-test)
Old meter - new meter	10.2 (3.8)	0.009
Old meter - pnuemotachograph	15.0 (14.5)	0.30
New meter - pneumotachograph	4.8 (14.3)	0.74
Limits of agreement (old *vs* new meter)**	**PEF L·min^{-1} (95% CI)**	
Upper limit	63.6 (50.3, 76.8)	
Lower limit	-43.2 (-29.9, -56.4)	

#: mean value, and SE in parenthesis; ** BLAND and ALTMAN [9]. PEF: peak expiratory flow; 95% CI: 95% confidence interval.

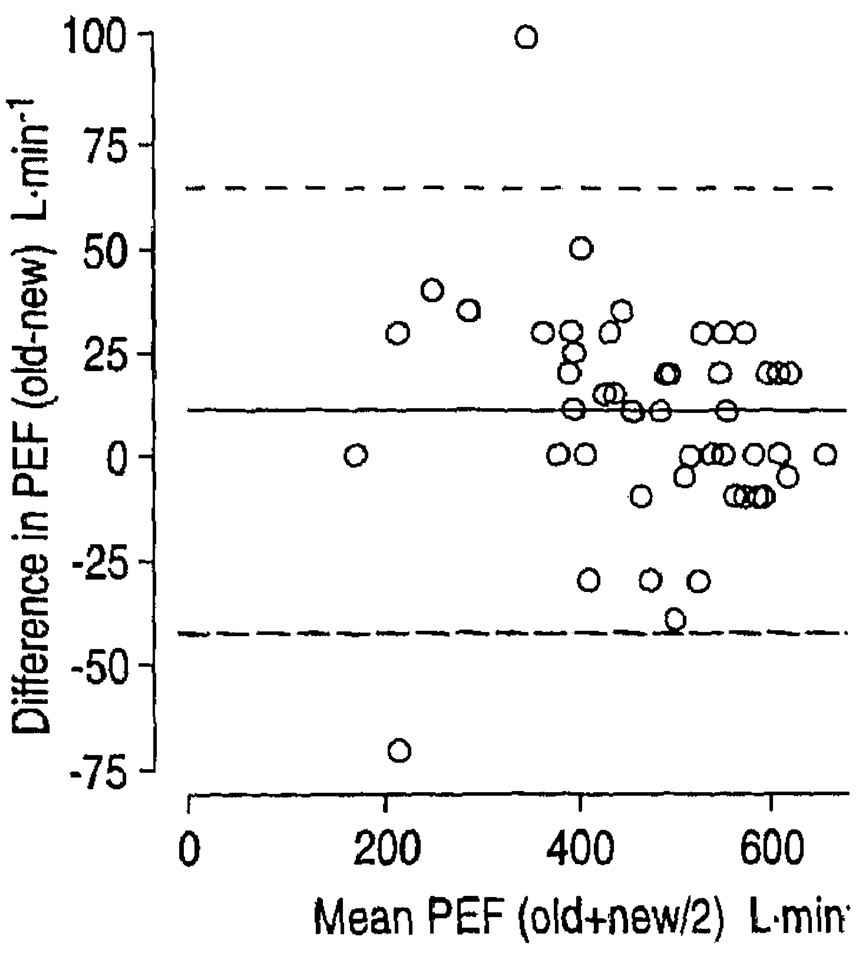

Fig. 1. – Differences in peak expiratory flow (PEF) values between the old and new meters plotted against their mean.

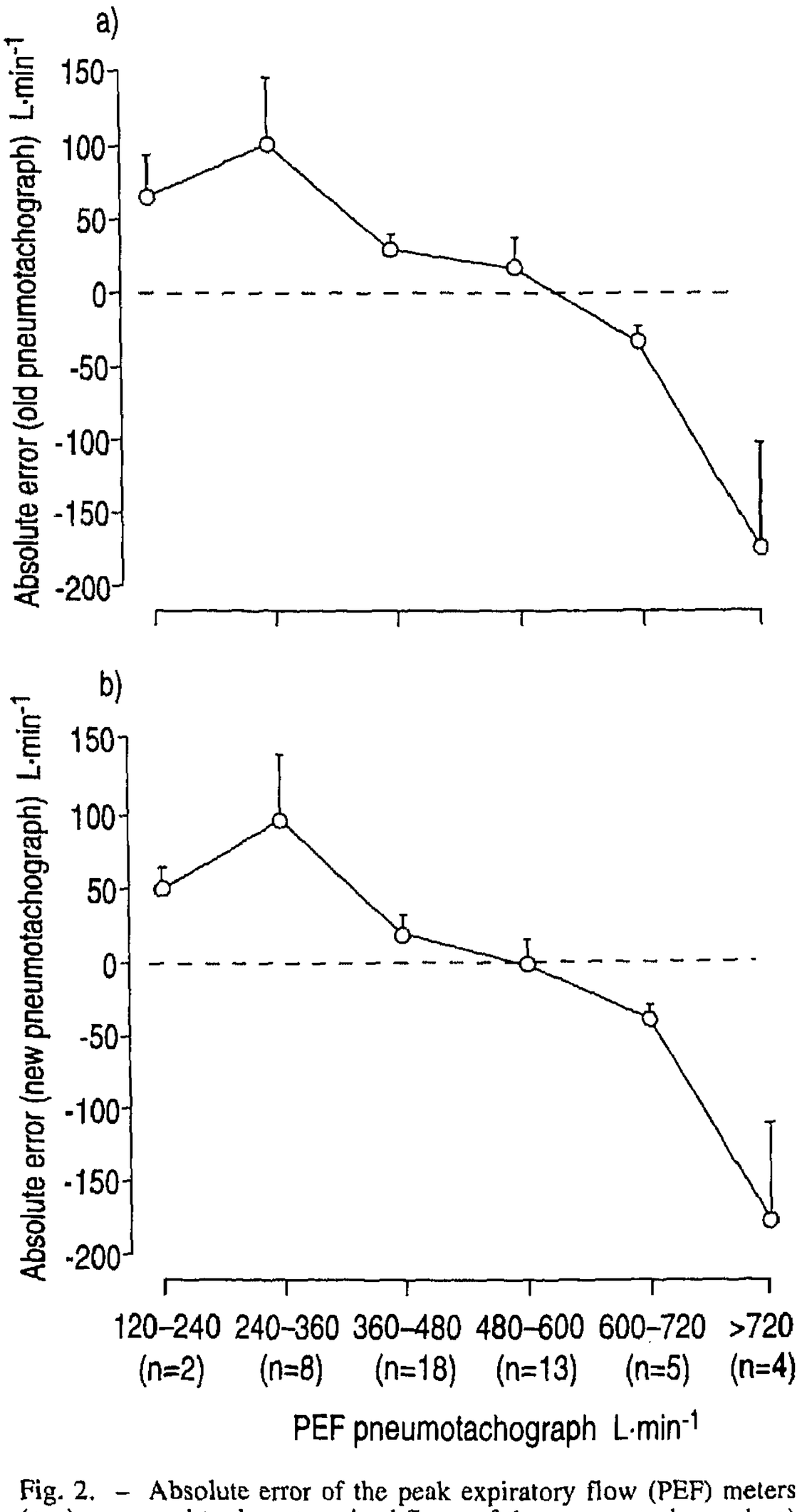

Fig. 2. – Absolute error of the peak expiratory flow (PEF) meters (±SE) compared to the catagorized flows of the pneumotachograph. a) Data on old PEF meters; and b) data on new PEF meters.

To assess accuracy, the flow obtained by the pneumotachograph was accepted as the true flow. MILLER *et al.* [6] showed only a small error between the flow of a pneumotachograph (Fleisch) and the true flow obtained by a computer-driven pump at different flow levels (120–720 L·min^{-1}). There were no statistically significant differences in mean PEF values between both the old and the new mini-Wright peak flow meters and the pneumotachograph, mean (SE) being 15.0 (14.5) and 4.8 (14.3) L·min^{-1}, respectively (table 1.).

Figure 2a shows the absolute error of the old PEF meters compared to the pneumotachograph on the y-axis and the categorized flows of the pneumotachograph on the x-axis. There were flow-dependent differences with notable overestimated flow rates in the mid-flow range and underestimated flow rates at values greater than 600 L·min^{-1}. A comparable shape of the curve was found when using the new PEF meters (fig. 2b).

Discussion

This study shows a statistically significant, but for most patients clinically irrelevant, difference in mean PEF value between old mini-Wright PEF meters (after 5 yrs of regular usage) and identical but new meters. However, differences on an individual basis can be large. DEKKER *et al.* [10] showed that an increase in PEF of 60 L·min^{-1} after administration of a bronchodilator drug indicates a clinically significant improvement, based on the optimal relationship between sensitivity and specificity of absolute flow improvement after bronchodilation. In the present study, a mean difference of 10.2 L·min^{-1} was found between PEF values obtained with old and new meters. However, figure 1 shows that readings from an old meter may be 64 L·min^{-1} above or 43 L·min^{-1} below those from a new meter, which thus indicates a clinically relevant lack of agreement between old and new meters. The level of agreement is not flow-dependent, as is shown by the homogeneous distribution of the differences around the mean at different flow levels (fig. 1).

These results suggest that mean peak flow values obtained by meters that have been used frequently during 5 yrs are still comparable with mean values obtained by new PEF meters, and can be used for analyses. There does not seem to be a need for replacement in long-term studies when using the mean PEF values in the analyses. On an individual basis renewal of peak flow meters may result in large changes in PEF levels. Therefore, replacement is not advised when using within-patient analyses. This is the case in disease monitoring or when serial PEF values are being related to different kinds and levels of exposure. Meters should be replaced in case of malfunction or deterioration. Optimal assessment of deterioration includes physical calibration of the PEF meters with the pneumotachograph at different flows, both at the beginning and at regular intervals throughout a long-term study.

There were no statistically significant differences between the (old and new) mini-Wright peak flow meters and the pneumotachograph. It is well-known that there are flow-dependent differences between the flow of mini-Wright peak flow meters and the true flow [5, 6]. MILLER *et al.* [6] and GARDNER *et al.* [5] found overreadings in PEF values in the mid-flow range and underreadings at the higher flow levels. We have also found flow-dependent differences between the flows measured with both the old and new meters and the flow recorded by a pneumotachograph. These differences are reflected in the large standard error of 14.5 and 14.3 L·min^{-1}, respectively (table 1). After categorizing the pneumotachograph flows, the shape of the curve was similar to the curves obtained by MILLER *et al.* [6] and GARDNER *et al.* [5] (fig. 2).

We conclude from this study that: 1) intensive and prolonged use of peak expiratory flow meters does not lead to unreliable mean peak expiratory flow values in long-term studies; 2) Replacement of peak expiratory flow meters in disease monitoring or in long-term studies (clinical and epidemiological) should be avoided, given the wide limits of agreement, except in case of obvious malfunction.

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