



# Peak expiratory flow meter scale changes: implications for patients and health professionals

A change in the scale on peak expiratory flow meters in the UK will be initiated by the Department of Health later this year. Martin Miller discusses the reasons behind the revision and how this will contribute to improved asthma management.

**Martin R. Miller** BSc MD FRCP  
Senior Lecturer in Respiratory Medicine, University of Birmingham, Selly Oak Hospital, Birmingham

**Correspondence:** Dr Martin Miller, University of Birmingham, Selly Oak Hospital, Raddlebarn Road, Selly Oak, Birmingham B29 6JD; tel: 0121 627 1627; email: martin.miller@uhb.nhs.uk

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Peak expiratory flow meters have made a major contribution to the management of asthma. Courtesy of the National Respiratory Training Centre.

The definition and diagnosis of asthma is a clinical one made from symptoms, signs and simple tests of lung function.<sup>1</sup> However, the cellular and inflammatory aspects of asthma are now also being included in the definition of asthma.<sup>2</sup> Peak expiratory flow (PEF) meters have made a major contribution to the management of asthma.<sup>3,4</sup> They can help in making the diagnosis of asthma by allowing patients to record their within-day variability of PEF, which would be typical of asthma if it exceeds 20% of the mean value for the day.<sup>5</sup> The most widely used guidelines for managing asthma recommend PEF measurement for diagnosing asthma, stratifying for severity, determining response to therapy, determining when to admit and when to discharge from hospital.<sup>1</sup>

Over 10 years ago calibration errors were first demonstrated for PEF meters<sup>6,7</sup> and a decision was made then not to change the meters until a fuller understanding of all aspects of testing the meters was available.<sup>8</sup>

## The Wright scale or the right scale?

The PEF meters available under the drug tariff for prescription follow a design and calibration of these instruments that dates back to the very first type of meter that was available.<sup>9</sup> Improvements in calibration methods for flow, by using computerised pump systems, have led to the ability to produce very accurate flow profiles.<sup>6,7</sup> These systems demonstrated in 1991 that the original flow calibration was inaccurate with an over-reading in the middle of the range of these meters (Figure 1).

Two points were raised over these findings. Firstly could the pump flows be inaccurate? For any flow to occur in a tube system a pressure upstream leads to the flow downstream. Initially this pressure in a pump system was interpreted as if it was a static compression<sup>10</sup> and the application of Boyle's law would suggest that the output flow would be reduced. However in a pump system this is an open, and not closed, compression and the air behaves as an incompressible fluid. For the air to behave as a compressible fluid in an open pump system, such that dynamic compression occurs, the velocity of the air in the system must exceed three-tenths of the speed of sound, about 110 m/s, which is not the case.<sup>11</sup> A flow of about twice that which a human can blow through a variable orifice meter like the mini-Wright meter would be needed to meet this criterion.

For flow profiles with a relatively long dwell time for PEF, i.e. the duration of flow above 90% of peak, the output flow from a pump system is very accurate. For more demanding profiles with short dwell times, and to a lesser extent for fast rise times to PEF (the time taken from 10% of PEF to 90% of PEF), pump systems are less accurate. Corrections to overcome this problem have been proposed,<sup>12</sup> but an

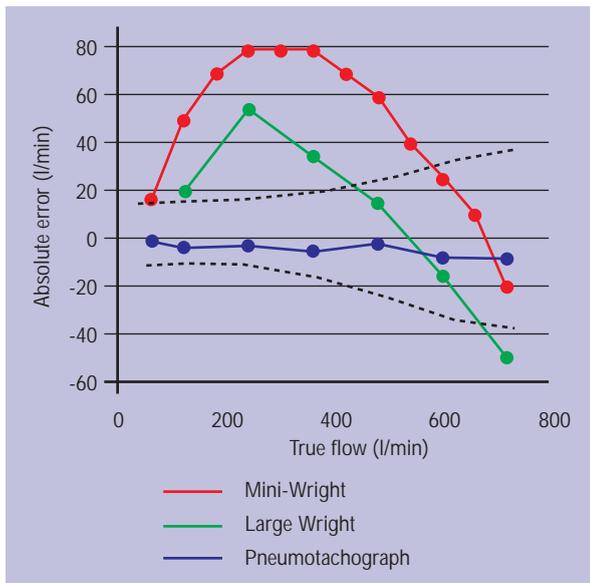


Figure 1. Plot of the absolute error in recording for a mini-Wright meter, a large Wright meter and a Fleisch pneumotachograph, with the American Thoracic Society accuracy limits shown by two dotted lines.

explosive decompression device is able to deliver very reproducible flows with very short rise and dwell times and this test method allows the frequency response characteristics of these meters to be accurately tested.<sup>13</sup>

A second aspect raised was that using pump systems might not be a fair test of these meters, since a pump can deliver sufficient power to overcome any resistance from the meters which may not be true for patients. However this second point is not a substantive argument, since a device must accurately record whatever flow is passing through it, irrespective of how it was produced. If the device inhibits a subject's ability to deliver a true PEF then this is a separate issue and may mean that such a meter is not an acceptable device. The European Respiratory Society<sup>14</sup> and the American Thoracic Society<sup>15</sup> have specified acceptable limits for the resistance of these meters. Tests of the effect of the resistance of the meters on PEF have shown that when compared to a very low-resistance pneumotachograph the PEF recorded with a mini-Wright meter was about 5% lower but was more reproducible.<sup>16</sup>

Following the initial discovery in the early 1990s of the inadvertent inaccuracy of these meters, discussions were held between the Department of Health and representatives from the British Thoracic Society and European Respiratory Society. It was then agreed that no change to the scales could be undertaken until a full understanding of the science behind these observations was complete.<sup>8</sup> Now that this work has been completed<sup>11, 13</sup> and an EC standard for these meters has been established,<sup>17</sup> it is appropriate to change the scales and calibration of these meters.

### Will a change in scales be clinically important?

The problem with the inaccuracy is that it is not systematic, but rather varies across the range of the meters. Within-day variation in PEF is a characteristic of asthma, which means that as a patient's PEF varies so the amount of error on the reading changes and this can distort the recording of the true

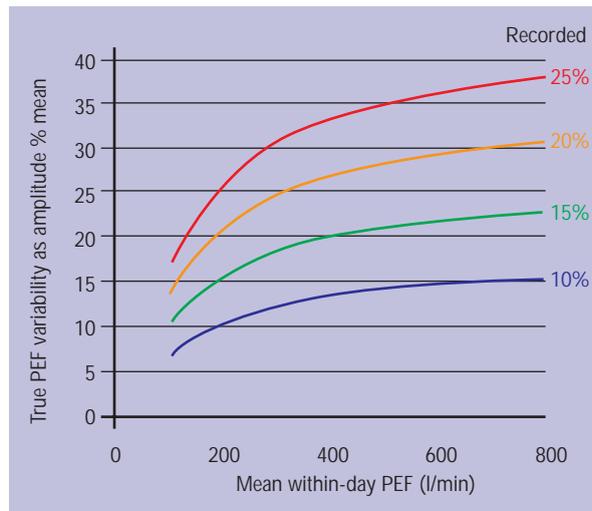


Figure 2. Isoleths of recorded PEF variability recorded with a mini-Wright meter, after PEF values have been corrected for the non-linear errors in the mini-Wright scale.

level of variability. A within-day variability of PEF of greater than 20% is highly suggestive of asthma.<sup>5</sup> However the recording of this variability with an inaccurate meter may reduce or enhance the apparent level of variability depending on where in the range of the meter the subject's PEF is placed. Figure 2 shows that if the mean within-day PEF is around 200 l/min the variability is recorded reasonably faithfully.

However, when below this level the recorded PEF variability is an overestimate of the true value (i.e. more subjects would have been thought to have a level of variability suggesting asthma than was truly the case). Above a mean within-day PEF of 200 l/min the recorded variability was in fact underestimating the true variability, such that levels of variability suggesting asthma were being missed. One study looked at this effect<sup>18</sup> and confirmed that in a group of patients with moderate to severe asthma the level of variability and asthma severity was being underestimated in about 30% of asthmatic patients. By following self-management plans for asthma these patients were therefore not increasing their treatment appropriately and about 20% more courses of prednisolone would have been started if the PEF values and the assessment of asthma severity have been correct. Thus the error of meter scale leads to asthma being underdiagnosed and undertreated, so moving to the new scales should improve patient care and correctly identify more patients with asthma. The management of asthma patients also uses symptom-related guidance to treatment, so the greatest change in patient management might be seen for poor perceivers of their asthma symptoms who rely more on the readings from their meter. The proposed change in meters should improve self-management of asthma, and this should mean a fall in the number of clinic attendances at the expense of the use of slightly more treatment.

**Computerised pump systems demonstrated that the original flow calibration was inaccurate with an over-reading in the middle of the range**



### Revised prediction equations for PEF

The reference values derived by Nunn and Gregg in 1973 were all obtained using the original large Wright peak expiratory flow (PEF) meters, so will need to be revised in the light of the forthcoming PEF meter scale changes.

Our previous work<sup>6</sup> demonstrated the error profile for the large Wright meter, and that level of error can be corrected for by using the following equation for PEF in l/min:

$$\text{PEF}_{\text{corrected}} = 0.00075 \times (\text{PEF}_{\text{recorded}})^2 + 0.585 \times \text{PEF}_{\text{recorded}} + 53.2$$

with a Residual Standard Deviation (RSD) for this correction of 6 l/min.

For the mini-Wright meter the correction equation was:

$$\text{PEF}_{\text{corrected}} = 0.00090 \times (\text{PEF}_{\text{recorded}})^2 + 0.373 \times \text{PEF}_{\text{recorded}} + 47.4$$

with an RSD of 7 l/min.

### New revised prediction equations for PEF

Applying the correction for the large Wright meter to the revised Nunn and Gregg equations<sup>20</sup> yields the following new revised prediction equations for PEF:

Men:

New  $\ln(\text{PEF}) = 0.755 \ln(\text{age}) - 0.021 \text{ age} - 104.1/\text{ht} + 5.16$

Old  $\ln(\text{PEF}) = 0.544 \ln(\text{age}) - 0.015 \text{ age} - 74.7/\text{ht} + 5.48$

Women:

New  $\ln(\text{PEF}) = 0.486 \ln(\text{age}) - 0.016 \text{ age} - 76.8/\text{ht} + 5.43$

Old  $\ln(\text{PEF}) = 0.376 \ln(\text{age}) - 0.012 \text{ age} - 58.8/\text{ht} + 5.63$

where  $\ln(x)$  is the natural logarithm of  $x$ , age is in years and ht is height (cm). Similar corrections could be made for other reference equations derived from large or mini-Wright meters.

### What needs to happen now?

Since the EC standard for PEF meters<sup>17</sup> is now in force, only meters meeting this standard can be sold in the UK with a CE mark. Therefore it is essential that there is a plan to move over to the meters with the correct scales. Patients and clinicians have been working for some years with the inconvenience that PEF readings for their patients will vary depending on the equipment used for the recording. A move to meters meeting the new standard will eliminate this problem, reduce confusion and lead to an improved and more consistent management of asthma.

To ensure a smooth transition to the new meters, all parties must be adequately informed why this is happening and what it will mean. There is no reason for panic. In practice most patients and clinicians will find it difficult to see the difference in the scales. However, the new meters will need to be clearly marked. We have previously shown that a PEF meter may give reliable readings for over 10 years<sup>19</sup> if properly cared for, but any unusual readings should alert a patient to the possibility that their meter needs replacing. Because of their low unit cost, if a PEF meter needed changing after 3 years this would be a trivial expense when compared to the cost of treatments being taken by patients with asthma. In order to harmonise the use of PEF meters relatively quickly, all patient meters should be changed over to the new scale within a year. This will allow the change to be made without panic and within a timeframe that PEF meter manufacturers can achieve.

### Conclusion

Later this year the Department of Health will be initiating a change of PEF meters available under the drug tariff to those that meet the new EC standard. The reliability of these devices is unchanged and remains excellent if properly cared for according to manufacturer's instruction. Patients and healthcare workers need to understand that changes in meter scale will improve the clinical information derived from these devices and that the indications for their use and the way they are used are unchanged.

The importance of a full explanation to patients about when to use their PEF meter, the correct technique for recording PEF and how to act on the results cannot be overstated and is key to their successful use. The new meters will give a better assessment of asthma severity for an important number of patients and this should lead to improved asthma care. ■

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