An Evaluation of the Accuracy of Assess and MiniWright Peak Flowmeters*

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With the advent of small inexpensive peak flowmeters, the at-home monitoring of peak flow rates has become an invaluable aid in the treatment of asthmatic patients. In this study, we evaluated the performance of the MiniWright and Assess peak flowmeters for accuracy and reproducibility. Measurements were made at varying peak flow rates and compared with those obtained simultaneously by a calibrated pneumotachograph. When this segment of the study was completed, the peak flow devices were subjected to 200 uses and were then retested. Four MiniWright peak flowmeters that had been extensively used in our clinic were tested as well. The Assess peak flowmeter was more accurate than the MiniWright at low flow rates (<300 L/min), while the MiniWright meter was more accurate at high flow rates (>400 L/min). We also found that the accuracy of the MiniWright meter deteriorated after 200 uses and worsened further after extensive use, while the Assess meter retained its accuracy after 200 uses.

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The peak flowmeter has been used extensively in the management of asthma. Its use in the hospital and emergency department has been well described.1-4 In more recent years, the availability of inexpensive, small, portable peak flowmeters has increased. These meters have been shown to be helpful to both physicians and patients in the outpatient management of asthma. By helping to monitor the course of the disease and its response to medication, peak flowmeters allow for early intervention during exacerbations of asthma, many times avoiding the need for hospitalization.5-6

The reproducibility and accuracy of inexpensive hand-held peak flowmeters have been evaluated in the past.5-14 These qualities are essential for the accurate monitoring of the disease over time. In this study, we investigated the performance of three currently available peak flowmeters in widespread use.

Portable peak expiratory flowmeters depend on a calibrated spring mechanism for their readings, and springs may stretch and lose elasticity over time, changing the accuracy of the instrument. To evaluate this effect, we studied peak flowmeters before and after 200 uses to assess any change in accuracy that would be expected during the normal use of the instrument.

METHODS

Apparatus

A Fleisch No. 3 pneumotachometer connected to a differential pressure transducer (Validyne model MP-45) and a carrier demodulator (Validyne model CD18) equipped with a 200-Hz low-pass filter was used to measure airflow (V) (corrected to BTPS). The outputs were digitized at 800 Hz by a 12-bit analog to digital converter (Labmaster, Scientific Solutions, Inc) driven by a microcomputer (NEC Powermate 386/20) equipped with appropriate software (Labtech Notebook, Laboratory Technologies, Inc).

Each peak flowmeter tested was connected in series with the distal end of the pneumotachometer. The mouthpiece of the flowmeter was 5 cm from the site of flow measurement on the pneumotach (Fig 1).

Calibration

Two Collins rotameters, one calibrated between 0 and 90 L/min, and the other calibrated between 60 and 900 L/min, were used to calibrate the pneumotachometer. We found that the presence of a peak flowmeter in series with the pneumotachometer caused minor changes in the calibration of the instrument. For this reason, calibration was performed with the peak flowmeters in place to allow for errors due to back pressure and turbulence caused by the peak flowmeter. Regression analysis was used to mathematically derive correction factors for flow measurements between 0 and 11 L/s (0 and 660 L/min) with an average pneumotachometer flow error of less than 0.25 percent. The accuracy of this steady-state calibration during dynamic maneuvers was verified using digital integration of the flow signal in comparison with a calibrated 1-L syringe. Prior to each series of measurements, the apparatus was zeroed.

Protocol

Three models of peak flowmeters were evaluated: (1) MiniWright (Clement Clarke International), (2) New Assess peak flowmeter (Healthscan), and (3) Original Healthscan (old Assess) meter that has been out of production for the last ten years but is still distributed by various pharmaceutical companies. Ten meters from each group were tested.

A normal subject was asked to blow through the pneumotachometer/peak flowmeter assembly. With each effort, the meter reading was recorded by the subject without knowledge of the pneumotachometer reading that was saved in an individual computer file. The subject then varied his effort to yield peak flow readings over the entire range of the meter being tested. In some cases, resistors were placed proximal to the pneumotachometer to obtain submaximal peak flow rates with maximal efforts. There was no difference in accuracy between submaximal efforts and maximal efforts with

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Each meter was first tested as new and then distributed to either patients or normal subjects. All were instructed to use the peak flow meter 200 times. The meters were then reevaluated as described above and their accuracy was compared with that obtained when new.

Four MiniWright peak flowmeters were obtained from our outpatient clinics. Each of these meters had been used extensively by many different patients over the preceding one to two years.

Calculations

The filtered peak flow data were displayed on a spreadsheet (Lotus 123) for analysis. The data were graphed and inspected for evidence of spurious data (i.e. "noise spikes") created by electrical transients. An example is shown in Figure 2, which plots pneumotachometer flow vs time for 0.4 s. The actual peak flow was determined to be the maximum flow value (as measured by the pneumotachometer) and compared with the peak flow obtained from the meter being tested. The percentage of error in peak flowmeter measurements was expressed as 100 percent times the absolute value of (meter-actual)/actual peak flow readings.

Statistics

Linear regression and the unpaired Student's t test were used for statistical analysis.

RESULTS

The old Healthscan meters were found to be extremely unreliable and were consistently nonfunctional. This problem was also noticed by our patients who quickly returned the meters believing that they were inaccurate. As they have been out of production for more than ten years, we will not present further data on these meters.

One each of both the Assess and the MiniWright meters were nonfunctional. Both were replaced. A second Assess peak flowmeter became nonfunctional after approximately 30 uses. This was replaced with a meter previously given to another patient. With both

FIGURE 1. Schematic of peak flow measuring apparatus.

FIGURE 2. Output of pneumotachometer showing flow digitized at 800 Hz vs time. Peak flow occurs at approximately 0.125 s.
nonfunctioning Assess meters, the spring had become disconnected from the butterfly. This problem was brought to the attention of Healthscan, who stated that a newer design had corrected the weak attachment (personal communication).

Figure 3 shows the data collected for the Assess peak flowmeter and for the MiniWright meter when new. The Assess meter generally underestimated peak flow at values less than 350 L/min and generally overestimated peak flow at values greater than 350 L/min. The MiniWright meter consistently overestimated flow rates below 400 L/min but was reasonably accurate at peak flows above that range.

Figure 4 shows the data collected after 200 uses of each peak flowmeter. Figure 5 shows the data from the four MiniWright peak flowmeters used in our outpatient clinics over the last one or two years. There was a dramatic reduction in the accuracy of the MiniWright peak flowmeters with progressive overestimation of peak flow. Table 1 summarizes the data comparing average percentage of errors of the two peak flowmeters at varying flow rates, both when new

![Figure 3](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21624/)

**Figure 3.** Peak expiratory flow rates determined with portable peak flowmeters as compared with a calibrated pneumotachometer. Top: Assess. Bottom: MiniWright. The solid line is the line of identity.

![Figure 4](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21624/)

**Figure 4.** Peak expiratory flow rates determined on used peak flowmeters as compared with a calibrated pneumotachometer. Top: Used Assess. Bottom: Used MiniWright. The solid line is the line of identity.

![Figure 5](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21624/)

**Figure 5.** Peak expiratory flow rates determined on extensively used (from outpatient clinic) MiniWright meter as compared with a calibrated pneumotachometer. The solid line is the line of identity.
has played an important role in the management of asthma. It is the most useful device available to monitor asthma treatment at home. Routinely used medical instruments should be accurate and over time should be able to produce consistent results.

For this report, we evaluated the accuracy of three commonly used, inexpensive, hand-held peak flowmeters. The performance of these peak flowmeters was then reevaluated after being used 200 times. In the treatment and monitoring of asthma, accuracy in the ranges below 300 L/min can be considered most important. It is in this range that decisions regarding short- and long-term therapies will be made. At flows higher than this, the patient will most likely be well. The Assess peak flowmeter outperformed the MiniWright peak flowmeter at peak flows less than 300 L/min. With use, the accuracy of the MiniWright peak flowmeter diminished while that of the Assess peak flowmeter remained relatively unchanged. Peak flow measurements are also used to follow trends over the course of weeks or longer. Therefore, for an individual using the same meter at all times, absolute accuracy may not always be necessary. However, it is important to allow valid comparison with office or hospital equipment.

Many studies have been undertaken in the past to evaluate peak flowmeter performance. Many of these have used the Wright peak flowmeter as the standard of accuracy. Other have compared the peak flow measurements obtained with one model with that of others. Only one study used a calibrated pneumotachometer as the standard of accuracy. Eichenhorn et al examined three models of peak flowmeters (including the MiniWright and the original Healthscan meters) using a calibrated pneumotachometer. They did not correct their pneumotachometer readings for turbulence due to the altered direction of flow when a peak flowmeter is placed in series with a pneumotachometer, a problem that, in our experience, can alter the performance of any pneumotachometer. In addition, the range of flow tested in this study was somewhat limited. Eichenhorn et al believed that the original Healthscan meters, acting more as rotameters, were more accurate than those meters based on springs (MiniWright and Vitalograph), which were subject to varying length tension relationships.

Our data suggest that despite using a spring, the Assess peak flowmeter is linear, accurate, and retains its accuracy with use. Our results confirm the data of others and show that the response of the MiniWright peak flowmeter is a function of the square root of actual flow through the meter. Flow rate measurements from such a meter could be easily corrected by altering the scale on the meter itself to reflect this relationship.

**Table 1—Average Percentage of Error of New and Used Peak Flowmeters at Varying Flow Rates**

<table>
<thead>
<tr>
<th>Flow Rate, L/min</th>
<th>&lt;150</th>
<th>151-300</th>
<th>301-450</th>
<th>451-600</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assess</td>
<td>18.4</td>
<td>10.2</td>
<td>12.3*</td>
<td>13.3*</td>
</tr>
<tr>
<td>MiniWright</td>
<td>30.7*</td>
<td>25.7*</td>
<td>8.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Used</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assess</td>
<td>13.2</td>
<td>7.3</td>
<td>13.6</td>
<td>13.0*</td>
</tr>
<tr>
<td>MiniWright</td>
<td>27.8*</td>
<td>32.0*</td>
<td>20.0*</td>
<td>8.7</td>
</tr>
</tbody>
</table>

*Significantly higher values (p<.002).

and after 200 uses.

Figure 6 shows data regression lines from the above and after 200 uses. Data from all efforts for each type of meter were correlated using linear and nonlinear regression models. We found that the data for Assess meters was best described as a linear function of the actual peak flow in both the new and used meters. The graph also demonstrates the accuracy of the meter, especially in the important range below 300 L/min. There is no significant change in accuracy after the 200 uses. In contrast, the peak flows measured by the MiniWright are better described as a function of the square root of actual flow. In the important range below 300 L/min, the new meters mildly overestimate flow, and with use, the accuracy of the readings diminishes further.

**DISCUSSION**

Since its introduction in 1959, the peak flowmeter

![Figure 6. Best fit regression equations of new and used Assess data (top) and MiniWright data (bottom) are shown as dashed lines and the line of identity is shown as a solid line. For the Assess meters, a linear regression model was optimal; for the MiniWright meters, a regression model based on the square root of flow was optimal.](image-url)
With use, the MiniWright meters become less accurate and begin to significantly overestimate actual flow. This problem is not seen with the Assess meters after 200 uses, but it might be expected after extended periods of active use.

CONCLUSIONS

The Assess peak flowmeter is more accurate than the MiniWright peak flowmeter over clinically relevant peak flow ranges. After limited use, the accuracy of the MiniWright peak flowmeter is markedly diminished. We were unable to show any significant difference in durability between the Assess and MiniWright peak flowmeters. The old Healthscan meters are unreliable, out of production, and should not be used. Mechanical portable peak flowmeters do not necessarily retain accuracy over time and usage. We therefore recommend that the accuracy of such devices be checked by comparison to a reliable standard periodically. The optimal interval for rechecking remains to be determined.

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