# Office spirometry – indications and limitations

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## Abstract

Spirometry is the simplest test with which to evaluate respiratory function. Factors limiting the clinical usefulness of office spirometry relate mainly to the quality of the test. Accurate and reliable results depend on accurate equipment, a competent operator, a cooperative patient, a good quality control programme and appropriately selected reference values. Poorly performed spirometry increases the risk of misinterpreting the results.

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## Introduction

Spirometry is a simple, non-invasive, inexpensive tool for assessing and managing common respiratory diseases that provides an objective, quantifiable measure of lung function.[1] Spirometry measures air flow and volume as a function of time. The values obtained can be graphically expressed as volume against time or more usefully as flow against volume. When expressed as flow against volume it produces the flow-volume loop, which is invaluable in interpreting results and providing clues to a specific diagnosis. The main values obtained are the forced vital capacity (FVC), forced expiratory volume in one second ($FEV_1$) and $FEV_1$/FVC ratio. These are vital for the diagnosis of obstructive lung diseases, such as asthma and chronic obstructive pulmonary disease (COPD). Spirometry is also used to assess the severity of obstruction, based on the percentage of predicted $FEV_1$, and to determine whether there is significant reversibility in response to a bronchodilator (helps differentiate asthma from COPD). Spirometry is also useful in monitoring disease progression and response to therapy.

## Indications

The main use of spirometry in the primary care setting is in the evaluation of patients presenting with respiratory symptoms and screening for COPD.

Indications for spirometry include:

- Evaluation of individuals presenting with respiratory symptoms or abnormal findings on physical examination and/or laboratory investigations, e.g. abnormal chest radiograph
- Screening individuals at risk for having pulmonary disease
  - Current (or former) cigarette smokers over 45 years of age
  - Occupational exposure to substances known to cause pulmonary disease
- Monitoring changes in lung function due to
  - Disease progression, e.g. COPD
  - Response to therapeutic interventions, e.g. steroid therapy in asthma
  - Adverse reactions to drugs or occupational agents known to cause pulmonary disease
- Pre-operative risk assessment
- Assessment of impairment and disability

An important indication is the screening (case finding) of all adults over the age of 45 years who are current or former cigarette smokers to identify those at risk for undergoing accelerated decline in lung function and those who already have airflow obstruction.[2] This recommendation is supported by evidence that early identification and intervention (smoking cessation) can alter the natural history of COPD.[3] There is also evidence that abnormal spirometry results can add to the efficacy of smoking cessation programmes.[4]

There are well-established guidelines for the classification of respiratory impairment based on spirometry for general respiratory disorders, and specifically for asthma.[5,6]

## Limitations in clinical practice

Spirometry helps to classify functional abnormalities due to various diseases into restrictive and obstructive defects (see Table I). It does not provide a specific aetiological diagnosis.

A reduced FVC and $FEV_1$ with a normal $FEV_1$/FVC ratio suggest the

**Table I:** Interpretation of spirometry

| | FVC % predicted* | $FEV_1$ % predicted* | $FEV_1$/FVC ratio |
|---|---|---|---|
| **Restrictive pattern** | < 80 | < 80 | > 70 |
| **Obstructive pattern** | < 80 | < 80 | < 70 |

* Normal range 80-120%

presence of a restrictive lung disease. The diagnosis is confirmed by measuring the total lung capacity (TLC) on advanced lung function testing. The severity is then graded on the percentage predicted TLC. A reduced $FEV_1$/FVC ratio and $FEV_1$ are diagnostic of obstructive lung disease. The FVC is initially normal, but declines as the disease progresses. A mixed obstructive-restrictive defect cannot be diagnosed on spirometry. Further advanced lung function testing is required for this.

Various other variables can be derived from the FVC manoeuvre, e.g. forced expiratory flow between 25% and 75% of the FVC ($FEF_{25-75\%}$). Many of these additional variables have been suggested as being more sensitive tests for the detection of airflow limitation. However, they add little to the FVC and $FEV_1$ in the interpretation of results and should not be included in office spirometry reports.[7]

The subject's results are evaluated for abnormalities against predicted values for age, height and gender. The predicted values are calculated from reference equations derived from population studies. Normal predicted values will vary for a specific individual depending on which study the reference equation is derived from and therefore will influence the interpretation of the results as normal or abnormal. Office spirometers are typically programmed with prediction equations derived from Caucasians such as the European Community for steel and coal (ECSC). Non-Caucasians have slightly lower FVC and $FEV_1$ values. A correction factor therefore needs to be applied to give approximated predicted values for non-Caucasians. Which reference values and if any correction factors are used must be stated in the results.

The clinical usefulness of spirometry is dependent on the quality of the results. The first step in interpreting the results is ensuring that the test is performed correctly and meets the currently recommended acceptability and reproducibility criteria (see Table II and table III). If these are not met, the results need to be interpreted with caution.

The FVC manoeuvre is an effort-dependent process that involves three phases: 1) rapid maximal inspiration, 2) forceful rapid exhalation and 3) continued maximal exhalation. Suboptimal performance in any or all of these phases will result in erroneous results. The operator plays an important role in coaching the subject to perform the manoeuvre as best as possible, and needs to place equal emphasis on all three phases, particularly the initial maximal inspiration. Failure to take a rapid full inspiration and/or hesitation before starting exhalation will result in lower peak expiratory flow (PEF) and $FEV_1$ values. A variable inspiratory effort between repeated manoeuvres is a common cause of poor reproducibility.

The contour of the flow-volume curve is invaluable in the interpretation of results. It allows the clinician to assess the quality of the test and provides clues to large airway obstruction (see Figures 1 and 2).

**Table 2:** Acceptability and reproducibility criteria

**At least 3 acceptable tests**
- Full inhalation before start of test
- Satisfactory start of exhalation
  - Evidence of maximal effort
  - No hesitation
- No cough or glottal closure during the first second
- Satisfactory duration of test
  - At least 6 seconds
  - Up to 15 seconds in patients with airflow obstruction
- No evidence of leak
- No evidence of obstruction of the mouthpiece

**Reproducible results**
- For FVC and $FEV_1$, the two largest values should be within five percent (5%) or 0.1 liter (whichever is larger) of each other
  - If these criteria are not met, continue testing
  - If these criteria are not met after 8 trials, stop testing and proceed with the interpretation, using the three best acceptable tests.

**Selection of test values for interpretation**
- Select from tests of acceptable quality
- Select the largest values for FVC and FEV1, regardless of the test used
- For indexes of average or instantaneous flow, use values from the test with the largest value for FVC and $FEV_1$ combined

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**Table 3:** Prerequisites for optimal spirometry results

Adequately trained technician
Accurate equipment (must comply with current ATS recommendations)
Daily volume calibration (using a 3L syringe)
Appropriate infection control
- Hand washing
- Disposable or sterilised reusable mouthpieces
- In line filters (if manoeuvre involves inhalation)
- Regular cleaning / decontamination (as per manufacturer)
- Avoid performing spirometry in patients with inter-current respiratory infections, in cases of suspected tuberculosis or with oral sores/infection

Cooperative patient
Explain and demonstrate procedure to patient
Measure and document weight and height (do not use stated values)
Patient should be seated with the chin lifted and neck slightly extended
Printed results must include the flow-volume traces

**Figure 1:** Examples of flow-volume loops

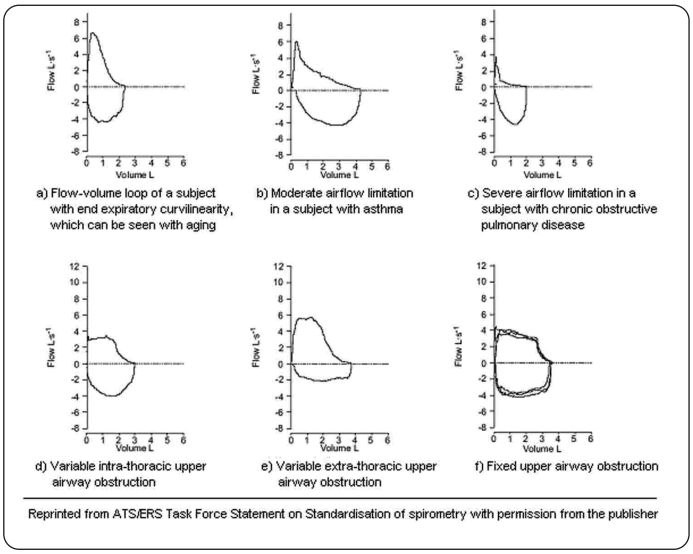
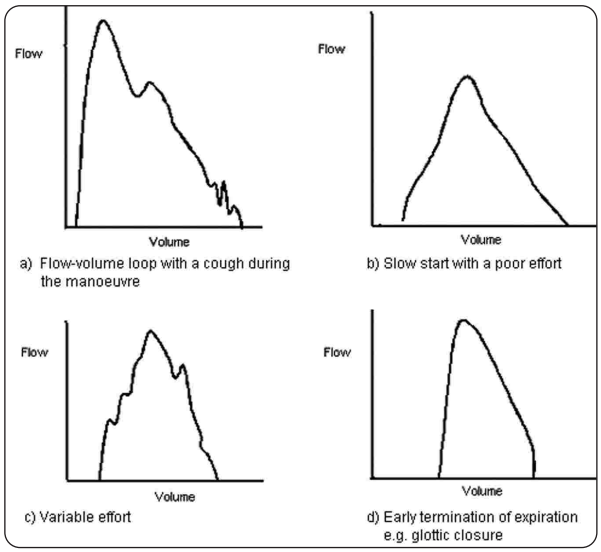



**Figure 2:** Examples of unacceptable flow-volume loops




The $FEV_1$/FVC ratio is the most sensitive and specific measure of airflow limitation and a ratio of 70% is the currently accepted lower limit of normal (LLN).[8] A $FEV_1$/FVC ratio below 70% confirms the presence of airflow obstruction. The $FEV_1$/FVC ratio decreases with age as a result of the normal age-related decline in lung function. This can be seen as a slight concave contour towards the latter part of the expiratory limb on the flow-volume loop. Using a fixed 70% threshold for the diagnosis of airflow obstruction may result in the over diagnosis of obstructive lung disease in the elderly.[9]

Another problem with interpreting lung function in the elderly is that the predicted normal values are less reliable, especially if the subject's age is greater than that of the study population from which the reference equations have been derived. For these reasons, results in the elderly need to be interpreted with caution.

The diagnosis of asthma is confirmed by demonstrating reversibility in the $FEV_1$ and/or FVC defined as a 12% and at least 200ml increase in the $FEV_1$ and/or FVC in response to a bronchodilator. Patients with COPD may have an element of reversibility, but the FVC and $FEV_1$ do not normalise as in asthma. In untreated or poorly controlled asthmatics one may not be able to demonstrate reversibility in response to a bronchodilator due to uncontrolled airway inflammation with oedema. If one strongly suspects asthma on clinical features reversibility should be reassessed following a short course of oral corticosteroids. In addition normal spirometry in subjects with a history suggestive of asthma does not exclude the diagnosis. Bronchoprovocation testing is then indicated. This can be done in the office by simple exercise testing demonstrating a drop in the $FEV_1$ of 15% or more.

## Conclusion

The majority of patients afflicted by asthma and COPD are cared for by primary care physicians and spirometry plays an essential role in diagnosing, assessing the severity and the management of these two conditions.[10,11] It is therefore essential that all primary care physicians have access to spirometry. The biggest limitation to office spirometry is the interpretation of results from poorly performed tests. Detailed guidelines are available on the standardisation of office spirometry [8,12,13] and every doctor offering spirometry should familiarise themselves with the South African Thoracic Society's Guidelines on office spirometry.[8]

**See CPD Questionnaire, page 52**

Ⓟ This article has been peer reviewed

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