A PCRS consensus on how to calculate and interpret peak expiratory flow rate variability and reversibility for asthma diagnosis





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In this article, the authors provide a pragmatic consensus approach to calculating and interpreting peak expiratory flow rate (PEFR) variability and reversibility from peak flow diary recordings for asthma diagnosis. This guide is intended for healthcare professionals working in primary care. Please see the links in the references for more information on the evidence and value of peak flow monitoring

Background

This PEFR calculation and interpretation consensus has been developed as a response to queries from Primary Care Respiratory Society (PCRS) members. They have told us that they have been taught more than one way of making a calculation, how they have observed other asthma diagnosticians using varying methods, and that there is no consistent approach recommended from national and international asthma guidelines. In addition, some methods suggested are too onerous and time-consuming for time-pressured clinicians.

The role of PEFR in asthma diagnosis: summary of national and international clinical guidelines

There is no single gold standard test that can rule in or rule out an asthma diagnosis. To arrive at a diagnosis requires the accumulation of evidence from many sources over time. This paper does not cover the entirety of how to make a diagnosis, but PCRS has primary care-focused resources that we encourage you to explore further[1].

Two key features that should be assessed to confirm an asthma diagnosis are ***reversibility*** and *variability* (Table 1).

Table 1. Global Initiative for Asthma (GINA)[2] definitions of reversibility and variability.

Reversibility	Variability
Generally, refers to rapid improvements in Forced Expiratory Volume (FEV_1) or PEFR measured within minutes after inhalation of a rapid-acting bronchodilator such as 200-400mcg of salbutamol or more sustained improvement over days or weeks after the introduction of treatment such as inhaled corticosteroids (ICS)	Refers to improvement and /or deterioration in symptoms and lung function. Excessive variability may be identified over the course of one day (diurnal variability), from day to day, from visit to visit, or seasonally.

Table 2. NICE and GINA recommendations on the use of PEFR variability and reversibility for diagnosis

	2017 NICE guidelines (Last updated 2021)[3]	2023 GINA guidance[2]
General principles	Diurnal variability of 20% should be demonstrated.	Diurnal variability of >10% in adults and >13% in children should be demonstrated. Use the highest of 3 readings. Use the same PEFR meter each time as a 20% variation has been shown from meter to meter[2,4,6]. Use of PEFR is possible from age 5 years.
In relation to an acute asthma attack	Use PEFR to assess variability. The use of PEFR to demonstrate reversibility is not described. (NICE recommend using FEV_1 to measure reversibility)	PEFR reversibility (response to 200-400mcg salbutamol after 15 minutes) of 20% is consistent with asthma
Peak flow diary (adults)	Monitor PEFR variability for 2 to 4 weeks (aged 17 and over) if diagnostic uncertainty after initial assessment and a FeNO test and they have either: **Scenario 1:** • normal spirometry or • obstructive spirometry with reversible airways obstruction but a FeNO level of 39 ppb or less. **Scenario 2:** • obstructive spirometry with • irreversible airways obstruction and • a FeNO level between 25 ppb and 39 ppb.	Gather daily data over 1-2 weeks in order to make a diagnosis of asthma.
Peak flow diary (5 to16)	Monitor peak flow variability for 2 to 4 weeks if diagnostic uncertainty after initial assessment and a FeNO test and they have either: • normal spirometry or • obstructive spirometry with irreversible airways obstruction and a FeNO level of 35 ppb or more.	Gather daily data over 1-2 weeks in order to make a diagnosis of asthma.

History, examination, and review of what has previously been recorded in a patient's notes can all be used to consider whether variability and reversibility have been demonstrated. However, all guidance now also recommends at least one more objective measure to support any subjective findings.

PEFR recordings taken during the management of acute asthma attacks (that can show reversibility) and diary readings taken over a number of days or weeks (that can show both reversibility and variability) can be used to provide data to aid in the diagnosis of asthma. Using PEFR to demonstrate ***variability*** is considered to be a suitable objective test by both the National Institute for Health and Care Excellence (NICE)[3] and the Global Initiative for Asthma (GINA)[2] (Table 2).

NICE does not make a recommendation about the use of PEFR for measuring ***reversibility***. The preferred test for reversibility recommended by NICE and GINA is spirometry which is defined as bronchodilator reversibility of 12% (children and adults) including a 200ml improvement in volume (in adults). GINA, however, also suggests that a reversibility of 20% using PEFR is consistent with asthma provided a good effort is made on each blow.

PEFR variability assessment sits in a secondary (GINA) and tertiary (NICE) position in relation to the other preferred objective measures which are spirometry and Fractional Exhaled Nitric Oxide (FeNO) testing. Timely access to spirometry and FeNO, however, varies between services across the UK and peak flow can add useful information, particularly if one of the other two tests is normal or shows borderline results. PEFR diaries are also particularly useful where FeNO and spirometry will not be usually available such as in occupational or other situationally triggered asthma situations.

When considering the relative benefits of a spirometry or peak flow test, it is important to remember that asthma, by its nature, is a variable disease, and so spirometry undertaken at a snapshot in time without symptoms may well be normal (and therefore no airway obstruction to reverse) whereas PEFR monitoring captures a longer period over which symptoms may present. In an ideal world with no resource limitation, data from all

Table 3. NICE and GINA recommendations on calculating diurnal PEF variability

	2017 NICE guidelines (Last updated 2021)[3]	2023 GINA guidance[2]
Diurnal (within a day) PEFR variability	No guidance on calculation method No guidance on frequency or timing of daily measures.	• Twice per day readings (Best of 3) • Calculate daily score using: (Highest - Lowest) / mean of (highest +lowest) x 100 • Add up each daily score (1-2 weeks) and calculate the mean.

three sources should be sought as they each provide different information.

The use of peak flow meters that can be issued on an NHS prescription is well established, low cost, and readily available within primary care and can be used outside the clinic setting. However, these portable meters results are susceptible to error and are not calibrated as with spirometry and FeNO. Therefore, it is important to coach the user to get the best readings. This can be done by checking that the patient uses the device consistently and correctly; and ensuring the same measurements are all from one device[4]. More information about how to obtain an accurate recording is detailed in a resource published in the Primary Care Respiratory Update in May 2023[5].

Calculating the diurnal variability score: summary of guidance (NICE/GINA)

The focus of this paper is to describe how to calculate peak expiratory flow rate variability for asthma diagnosis once the patient has returned with their completed diary. We have looked at both NICE and GINA and the evidence each used for their approaches and this is summarised in Table 3.

The 2017 NICE guideline does not provide a method to calculate a variability score. However, within Appendix C of the underlying guidance evidence[7], the criteria used to explore accuracy and cost-effectiveness of PEFR variability in the diagnosis of asthma described the calculation as: "*usually expressed as amplitude (highest – lowest reading) as a percentage of the mean or the highest reading. PEFR variability values should be recorded as the mean over at least 3 days*".

GINA recommends a diurnal variability calculation also known as 'within-day' variability and the method selected is described as the 'daily amplitude percent mean'. GINA notes that there are multiple ways of making the diurnal variability calculation[4]. The scoring approach recommended by GINA has been used by researchers to describe normal ranges of diurnal variability and from this, agreed cut-off levels for abnormal variation have been decided. The GINA approach describes abnormal variability as >10% in adults and >13% in children which differs from that described by NICE where >20% is considered to be consistent with asthma.

The other common method of calculating PEFR variability is the 'between-day' method. Here, the lowest recorded PEFR recorded over a 1 to 2-week episode is divided by the highest PEFR in the same period. This is not recommended for use in diagnosis by either authority. Elsewhere it is suggested as an easier method to use once diagnosis has been established for the purposes of monitoring[8]. However, whilst the 'between day' method is a much faster calculation to perform, it is not considered the best method for diagnosis.

When comparing the two approaches, though, NICE does not recommend a calculation method for diurnal variation it seems the studies reviewed for the guideline were included if they used the 'daily amplitude percent mean' method and therefore aligns with GINA. However, despite suggesting the same method there is a question as to why NICE suggests a higher threshold of 20% variability as indicative of asthma. A review of the underlying literature used by NICE reveals that a range of values, most between 15% and 20% could be used as indicative of asthma but the final figure selected depends on the levels of sensitivity and specificity that could be tolerated[9,10]. The underlying literature used by both also generally notes that four times a day testing, with an attempt to capture an early morning (when PEFR is usually lowest) and late afternoon reading (when PEFR is usually highest) will provide a significantly more reliable result, though GINA finally recommends twice per day readings.

The PCRS approach to calculating and interpreting PEFR variability and bronchodilator reversibility for diagnosis of asthma

Calculating PEFR bronchodilator reversibility

To calculate % increase i.e. the bronchodilator reversibility %. The equation is:

(Post-bronchodilator best of 3 – Pre-bronchodilator best of 3) / pre-bronchodilator best of 3 x 100

E.g.

Pre-bronchodilator 3 readings (best): 210, 210, (220)

Post-bronchodilator 3 readings (best): 270,280, (290)

(290-220)/220 x 100 = **32%**

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Figure 1. Patient peak flow diary record and patient instructions

MY PEAK FLOW DIARY

It is important for us to see these results to help us access your breathing.

Please complete this for 2 weeks and then either send us the charts or bring it to your next appointment.

To send us your peak flow results:

- Please take a photograph of your peak flow diary and email the photograph to (INSERT E-MAIL)
- Please include your name and date of birth in the email.
- If you are unable to email us, please either drop it into (INSERT

What is Peak Flow?

- Peak Flow is a measurement of how quickly you can blow air out of your lungs.
- If you manage to blow out quickly and forcefully you should get a high score.
- If your airways are tight and inflamed you won't be able to blow out so quickly and your score will be low.

You need to check your peak flow:

- ✓ Every day, twice a day for 2 weeks to get a useful pattern
- ✓ At the same times of day, in the morning and in the evening
- ✓ Before you take your asthma medicine
- ✓ Using your best effort each time you blow into the meter so you are comparing like for like
- ✓ Using the same peak flow meter each time

How to use your peak flow meter and diary:

- Put the pointer back to the first line on the scale
- Stand, or sit upright (choose what's easiest for you and always do it the same way)
- Take a deep breath
- Make sure your mouth makes a tight seal around the mouthpiece
- Blow as hard and as fast as you can into the meter
- Write down your score
- Do this 3 times in a row so you get 3 scores, and use the highest of these scores to fill in your diary

Name: .....

Date of birth: .....

Date		Am	Pm	Extra readings	Comments
	Day 1				
	Day 2				
	Day 3				
	Day 4				
	Day 5				
	Day 6				
	Day 7				

Date		Am	Pm	Extra readings	Comments
	Day 1				
	Day 2				
	Day 3				
	Day 4				
	Day 5				
	Day 6				
	Day 7				

This Word document can be downloaded and edited so that you can add your practice details

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Figure 2. Excel Table variability calculator and a graph showing diurnal variation

Insert Name and Hospital Number

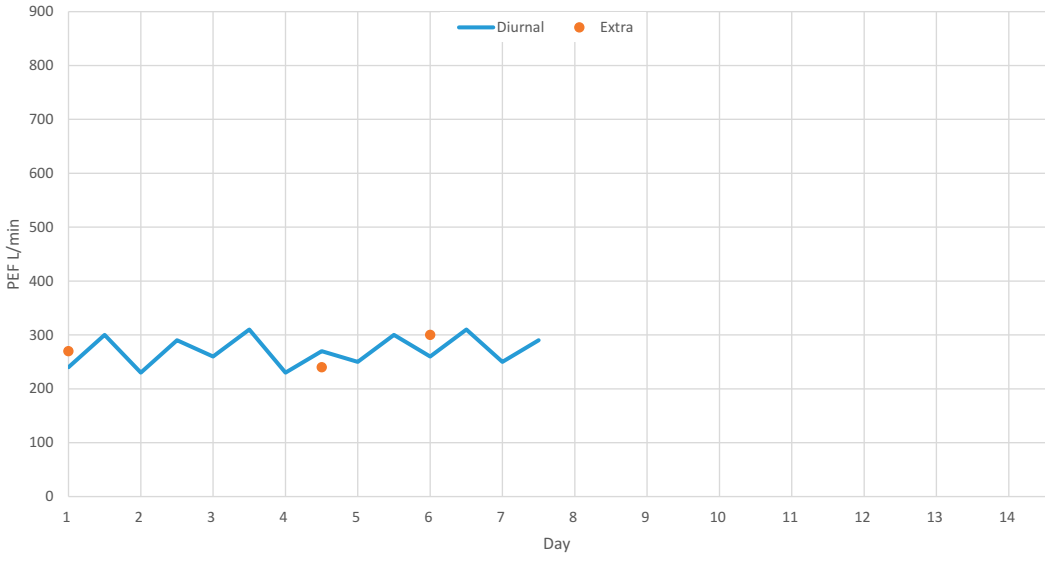
Portsmouth Severe Asthma Service

Diurnal PEF Variability

	Morning	Evening	Extra 1	Extra 2
Day 1	240	300	270	
Day 2	230	290		
Day 3	260	310		
Day 4	230	270		240
Day 5	250	300		
Day 6	260	310	300	
Day 7	250	290		
Day 8				
Day 9				
Day 10				
Day 11				
Day 12				
Day 13				
Day 14				

Daily PEF Variability
22%
23%
18%
16%
18%
18%
15%

Overall PEF Variability	18%



This Excel file for you to download provides a table for your patient's results to be entered. It automatically calculates the variability score and creates a graph for you to visualise any diurnal variation. It will work as long as at least 7 days of data overall is provided. It will account for any extra readings but these are plotted separately in the graph as the main value is to demonstrate the diurnal variation. It will accept values over 50 – 1000 inclusive but will otherwise flag a potential error in data entry.

Calculating PEFR variability

Evidence and guidance point towards the use of the 'daily amplitude percent mean' method as the best to calculate diurnal variation when collating information to make an asthma diagnosis. This method can be onerous and is more likely to include data entry errors when more tests per day are required and a longer the period of data collection is requested. Taking these factors into consideration PCRS recommends:

- A 14-day collection period as the basic standard to have sufficient data points.
- Two data points per day as a basic standard with early morning and late afternoon measures being optimal.

To calculate PEFR variability using the daily amplitude percent mean method, you work out the variability for each day and then use that to find the average over the recording period.

Daily variability = Difference between highest and lowest peak flows / Average of highest and lowest
Overall variability = Total of daily variabilities / Number of days
E.g. Using the data from Figure 2 and using the equation:
[(Highest - Lowest) / (Highest + Lowest) / 2] x 100 = Percentage variability
Day 1 - (300-240) / (540/2) x 100 = 22%
Day 2 - (290-230) / (520/2) x 100 = 23%
Day 3 - (310-260) / (570/2) x 100 = 18%
Day 4 - (270-230) / (500/2) x 100 = 16%
Day 5 - (300-250) / (540/2) x 100 = 18%
Day 6 - (310-260) / (540/2) x 100 = 18%
Day 7 - (290-250) / (540/2) x 100 = 15%
Diurnal variability score for 1 week of data -
(22+23+18+16+18+18+15) / 7 = **18%**

To make the process easier, we recommend material developed by the Portsmouth severe asthma service that is available to download from the PCRS website. See Figures 1 and 2.

Smartphone Apps

There are also several smartphone apps available that allow patients to enter their peak flow readings and can generate a pdf of results to share with a healthcare professional, and this method may suit some patients. Digital peak flow meters have also been developed which output results directly to a smartphone app and these are commercially available for purchase, but NICE has advised that further evidence is needed before they can be widely recommended[11].

What is the right cut-off for diurnal variability?

As was described at the outset of this paper, there is no gold standard test for asthma. Every piece of evidence gathered whether subjective or objective has a 'cut-off' that is determined by what is considered to be an acceptable level of:

- Sensitivity – a higher sensitivity score gives more confidence in ruling out a diagnosis if the test finding is negative
- Specificity – a higher specificity score gives more confidence in ruling in a diagnosis if the test finding is positive

The PCRS consensus is that significant variability lies in a range between 10% (13% for children) and 20% based on available guidance and review of current evidence. The closer the value is to 20% and the greater number of data points used to make the calculation, the more confident you can be in using this information to support a diagnosis of asthma.

PEFR variability should never be used alone to make a diagnosis but analysed along with other subjective and objective evidence that accumulates over time.

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