

Peak Expiratory Flow in Bed? A Comparison of 3 Positions

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BACKGROUND: Current guidelines for the correct peak expiratory flow (PEF) maneuver include standing. In the hospital setting, PEF values are often ordered to assess response to asthma therapy for exacerbations. We have observed that the PEF is sometimes performed with the patient in bed. **METHODS:** Healthy adults performed the PEF maneuver in random order, standing, lying back at an $\sim 45^\circ$ angle on pillows, and sitting, slumped forward $\sim 10^\circ$ with legs extended. PEF was recorded for 3 attempts in each of the 3 positions. **RESULTS:** We enrolled 94 subjects (39 male, 55 female, mean age 24 y) in 2011. Mean PEF in the standing position (669 ± 42 L/min) was significantly higher than in the lying back (621 ± 42 L/min) ($P < .001$) and sitting (615 ± 42 L/min) positions in males ($P < .001$), and, similarly, in females, standing produced a significantly higher mean PEF (462 ± 42 L/min) than the lying back (422 ± 42 L/min) ($P < .001$) and sitting (447 ± 42 L/min) positions ($P < .05$). **CONCLUSIONS:** Clinicians should ensure that PEF is obtained with patients out of bed and in the standing position. *Key words:* peak expiratory flow; asthma; correct maneuver. [Respir Care 2013;58(3):494–497. © 2013 Daedalus Enterprises]

Introduction

As part of the objective monitoring of asthma patients, peak expiratory flow (PEF) is helpful in ambulatory as well as hospitalized patients.¹ The National Institutes of Health asthma guidelines recommend assessing PEF in the emergency department and during hospitalization, including improvement to a PEF of $\geq 70\%$ of the predicted value before discharge home.¹ In addition, the Global Ini-

tiative for Asthma recommends monitoring of PEF in hospitalized patients.² Current guidelines for the correct PEF maneuver include standing.¹ In the hospital setting, PEF determinations are frequently obtained by respiratory therapists (RTs).

Although it is expected that RTs will follow recommended PEF technique, we have observed that RTs will sometimes not ask the patient to get out of bed and stand up (or at least sit up straight on the side of the bed). Rather, the PEF values are obtained with the patient lying back in the bed or sitting up slumped forward with legs extended in bed. Consequently, the validity of the recorded PEF values is in doubt. The purpose of this study was to determine if there are differences in PEF values associated with 3 different positions (standing, lying back at an $\sim 45^\circ$

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The authors have disclosed a relationship with Monaghan Medical, which donated the peak flow meters and mouthpieces for this study.

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angle on pillows, or sitting up slumped forward $\sim 10^\circ$ with legs extended). Because both national and international asthma guidelines recommend monitoring PEF in the hospital setting, and since the recommended correct technique includes standing, we believe this study has obvious clinical relevance.

Methods

This was a prospective, randomized study in which participants were recruited from the University of Tennessee Health Science Center in Memphis, Tennessee. The study was approved by the institutional review board of the University of Tennessee. First year pharmacy students, enrolled in the Basic Clinical and Communication Skills course at the University of Tennessee College of Pharmacy, were eligible to participate in the study. Subjects were ≥ 18 years of age and in good health. As part of the course, students were already required to demonstrate correct use of peak flow meters, having received a lecture and demonstrations regarding correct and incorrect PEF technique. Monaghan Medical donated the peak flow meters and the mouthpieces, but had nothing to do with the study idea, proposal, data collection, data analysis, or manuscript preparation.

The peak flow meters (TruZone, Monaghan Medical, Plattsburg, New York) used in the study are, per the product literature, designed and manufactured to meet the most recent American Thoracic Society Standards for peak flow measurements. With these new peak flow meters, study participants used disposable one way valved mouthpieces supplied by Monaghan Medical. The correct steps for PEF technique used in our study were consistent with the National Institutes of Health asthma guidelines,¹ and were as follows: (1) move the indicator to the bottom of the numbered scale, (2) stand up, (3) take a deep breath, filling your lungs completely, (4) place the mouthpiece into your mouth and close your lips around it; do not put your tongue inside the hole, (5) blow out as hard and fast as you can in a single blow: Blast! Repeat steps 1–5 two more times. The best of 3 attempts was used in the study (just as the best of 3 attempts are used in the hospital setting by the RT or at home by the patient).

Although not a component of this study's objectives, it is pertinent to point out that we have previously studied the effect of accelerating air in the mouth with the tongue during the PEF maneuver.³ Therefore, as part of correct technique in the current study, subjects were specifically observed for avoidance of accelerating air in the mouth with the tongue by having the peak flow meter mouthpiece placed well into the mouth.

After obtaining informed consent, subjects were randomized to perform the PEF maneuver standing, lying, and sitting. Participants were then divided into 9 groups of

QUICK LOOK

Current knowledge

Monitoring peak expiratory flow provides an objective measure of dysfunction in patients with asthma in the home, emergency department, and hospital. The ideal patient posture for peak expiratory flow measurement is standing upright, but in hospitalized patients, it is often measured with the patient semi-recumbent.

What this paper contributes to our knowledge

Peak expiratory flow in hospitalized subjects was significantly higher in the standing than in the sitting or lying back position. Posture during the measurement should be recorded. If standing is not possible, the changes created by posture should be taken into account.

8–12 (6 groups on one day, 3 groups on a second day), and an investigator was assigned to each group. PEF values were recorded for 3 attempts in each of the 3 positions. Of the 3 attempts, the highest PEF value attained by each subject in each position was used for the analyses. To ensure that the subjects were utilizing correct technique with maximal effort, the subjects were observed by the investigators or course lab assistants (2 third year pharmacy students). All investigators and teaching assistants had received the same training in correct PEF technique. To simulate a hospital bed, the procedures were performed on laboratory benches (with egg crate cushions/pillows) on the campus of the University of Tennessee Health Science Center.

Subject data collected included age, sex, height, the presence or absence of any pulmonary disease, current smoking status, and any medications that could affect pulmonary function. To ensure privacy of each individual, the data collection forms were assigned a study number rather than a personal identifier.

Statistical Analysis

For demographic variables, descriptive statistics such as means, standard deviations, and frequencies were computed. The primary variable of interest was the highest individually obtained PEF (L/min) obtained in the 3 different positions. These results were then analyzed using repeated measures analysis of variance, with the subject included as a random (block) variable and position as a fixed effect. Additional analyses were conducted using a nested factorial design with the following effects in the model: sex (fixed effect), subject nested within sex (random), position (fixed effect), and the interaction of sex and

Table 1. Baseline Characteristics

Subjects, <i>n</i>	94
Female, no. (%)	55 (58.5)
Male, no. (%)	39 (41.5)
Age, mean \pm SD y	23.9 \pm 3.7
Male	25 \pm 5.0
Female	23.1 \pm 2.0
Height, mean \pm SD cm	171 \pm 10
Female	164 \pm 7
Male	180 \pm 7
Asthma, no.	14
Other lung disease, no.	0
Nonsmoker, no. (%)	85 (90.4)
Current smoker, no. (%)	3 (3.2)
Previous smoker, no. (%)	6 (6.4)

Table 2. Peak Expiratory Flow in 3 Positions

Position	PEF, mean \pm SD	
	Male (<i>n</i> = 39)	Female (<i>n</i> = 55)
Standing	669 \pm 42*	462 \pm 42*‡
Sitting	615 \pm 42*	447 \pm 42‡
Lying Back	621 \pm 42*	422 \pm 42†
Mean	635 \pm 76*	444 \pm 76*

Standing is the recommended position for assessing peak expiratory flow (PEF). Sitting = sitting, slumped forward at \sim 10° angle with legs straight out. Lying = lying back at 45° angle.

The standard deviations depicted in this table are all the same and were estimated from the square root of the mean square error from analysis of variance, which was used to test hypotheses about differences between specific pairs of means, and are not the SDs of each subgroup.

* $P < .001$
† $P < .002$
‡ $P < .05$

position (fixed effect). All contrasts were preplanned and made with an alpha of .05. All statistical analyses were preformed with statistical software (SAS 9.1.3, SAS Institute, Cary, North Carolina).

Results

A total of 94 healthy subjects (39 males, 55 females), ranging from 21 to 44 years of age, completed the study (Table 1). Fourteen (14.8%) participants reported a history of asthma, with 7 subjects currently using medications to treat asthma symptoms. A total of 9 subjects (9.5%) reported history of tobacco use, including 3 current smokers and 6 previous smokers.

Averaged over all positions, mean PEF was higher in the males, compared with the females ($P < .001$). Position significantly affected PEF in both sexes, but the extent of this effect depended on sex (Table 2). In males the standing position was associated with the highest mean PEF,

compared with either of the other 2 positions (ie, lying back or sitting, both $P < .001$). Mean PEF values recorded for the other 2 positions were not statistically different from each other. In the females, mean PEF was highest when the participants were standing, compared to lying back ($P < .001$) or sitting ($P < .05$). Unlike the males, the mean PEF values for the females were higher when they were sitting, compared with lying back ($P = .002$). Although we had smokers and subjects with asthma in our study, the numbers of these subjects were too small to perform a sub-analysis.

Discussion

National and international asthma guidelines recommend PEF monitoring in the hospital setting.^{1,2} In addition, these guidelines recommend the standing position when performing the PEF maneuver.^{1,2} Therefore, this study offers clinically relevant information.

Although studies in asthma patients are needed, we have recently demonstrated that PEF values in young, healthy subjects are no different in the standing position versus sitting straight up in a chair.⁴ Over the past several years we have also studied and subsequently identified sex differences in correct use of peak flow meters in our pharmacy students and in patients.⁴⁻⁶ Women need more coaching to ensure maximum effort when performing the PEF maneuver.⁵⁻⁷

Attention to these variables to ensure correct technique is clinically relevant. Badr et al⁸ studied the effect of body position on maximal expiratory pressure and flow as related to adequate clearance of airway secretions as a component of defenses against respiratory-tract infections. Among 25 healthy subjects (16 male), the standing position resulted in the highest PEF versus 6 other positions ($P < .04$). Our study, with a larger subject population, is consistent with the investigation by Badr et al.⁸ Standing is associated with the highest lung volumes, and increased lung volume leads to enhanced elastic recoil.^{9,10} Standing during the PEF maneuver results in increased recoil of the lung and chest wall combined with higher pressures generated by abdominal contraction. These combined actions force air at higher velocity through narrowing airways, producing increased PEF.⁹ Also predicted PEF values for the general population are based on subjects standing.¹¹

Our study adds further evidence that healthcare professionals need to be diligent in observing patients perform the PEF maneuver. For physicians ordering PEF in patients hospitalized with asthma, it seems prudent that the order specify that the patient should be standing. In patients who cannot stand, sitting up straight with legs off the side of the bed may be acceptable, but studies are needed to verify that this position is acceptable.⁴ In the interim, it is suggested that the RT measuring the PEF should state in

the medical record which position was used when the PEF is determined. A limitation of this study is that our participants were young and healthy. Studies in the general in-patient population are needed.

Conclusions

Among healthy subjects ≥ 18 years of age, mean PEF values obtained in the standing position were significantly higher, as compared to PEF values obtained in positions reflective of patients in a hospital bed, including lying back and sitting. All healthcare providers should encourage patients when performing the PEF maneuver to use the standing position if able.

REFERENCES

1. Expert Panel Report 3. Guidelines for the diagnosis and management of asthma. Bethesda: National Institutes of Health; 2007:NIH Publication No. 07-4051.
2. Global Initiative for Asthma. Global strategy for asthma management and prevention. Updated December 2012. <http://www.ginasthma.org/guidelines-gina-report-global-strategy-for-asthma.html>. Accessed January 8, 2013.
3. Strayhorn V, Leeper K, Tolley E, Self T. Elevation in peak expiratory flow by a 'spitting maneuver': measured with five peak flow meters. *Chest* 1998;113(4):1134-1136.
4. McCoy EK, Thomas JL, Sowell RS, George C, Finch CK, Tolley EA, Self TH. An evaluation of peak expiratory flow monitoring: a comparison of sitting versus standing measurements. *J Am Board Fam Med* 2010;23(2):166-170.
5. Self TH, Cross LB, Nolan SE, Weibel JB, Hilaire M, Franks AR, et al. Gender differences in the use of peak flow meters and their effect on peak expiratory flow. *Pharmacotherapy* 2005;25(4):526-530.
6. Chafin CC, Tolley E, George C, Demirkan K, Kuhl D, Pugazhenth M, Self TH. Are there gender differences in the use of peak flow meters? *J Asthma* 2001;38(7):541-543.
7. Finch CK, Tolley E, James A, Fisher K, Self TH. Gender differences in peak flow meter technique in patients. *Nurse Pract* 2007;32(5):46-48.
8. Badr C, Elkins MR, Ellis ER. The effect of body position on maximal expiratory pressure and flow. *Australian J Physiother* 2002;48(2):95-102.
9. Wade OL, Gilson JC. The effect of posture on diaphragmatic movement and vital capacity in normal subjects with a note on spirometry as an aid in determining radiological chest volumes. *Thorax* 1951;6(2):103-126.
10. Leith DE. Cough. *Phys Ther* 1968;48(5):439-447.
11. Nunn AJ, Gregg I. New regression equation for predicting peak expiratory flow in adults. *BMJ* 1989;298(6680):1068-1070.