Are measurements of peak nasal flow useful for evaluating nasal obstruction in patients with allergic rhinitis?*

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Abstract
Background: Nasal obstruction is one of the most bothering allergic rhinitis (AR) symptoms and there is a need for objective parameters to complement clinical evaluation due to blunted perception in many patients. In this study we compare measures of peak nasal inspiratory flow (PNIF) and peak nasal expiratory flow (PNEF) in patients with AR and in individuals without nasal symptoms and correlate them with the perception of nasal obstruction.

Methods: A comparative cross-sectional study was conducted in 64 AR patients and 67 individuals without nasal symptoms aged between 16 and 50 years. All subjects had PNIF and PNEF measures and subjective evaluations of nasal obstruction were done through a visual analogue scale (VAS) and a symptoms questionnaire.

Results: The results show a lower PNIF and PNEF in AR patients compared to controls. There was no correlation between VAS score and PNIF and PNEF. There was a weak inverse correlation between PNIF and symptoms score.

Conclusion: Objective measures of nasal obstruction, especially PNIF, can give useful informations on aspects of the disease different from those obtained from the patient's perception.

Keywords: Peak nasal inspiratory flow, peak oral expiratory flow, allergic rhinitis, nasal peak expiratory flow, nasal obstruction

Introduction
Nasal congestion is a common complaint among patients with allergic rhinitis (AR)[(1)]. In an investigation carried out in Europe in more than three thousand AR patients, 99% of them reported that nasal congestion was a cardinal symptom[(2)]. Patou et al., studying the pathogenesis of nasal congestion, reported that mucosal inflammation and mucus secretion are the main causes of obstruction[(3)]. Patients with persistent and more intense forms of AR, even in asymptomatic phases, can feel constant nasal annoyance and chronic nasal congestion, although with difficulties in realizing its presence and intensity[(4,5)].

It is challenging to objectively quantify nasal congestion in clinical practice[(6)]. Initial and subsequent evaluations are usually carried out exclusively on patient's subjective complaints[(7)]. However, considering the variability and complexity of subjective perception, some authors argue that patient's perception should be associated with objective measures of nasal congestion to improve the clinical evaluation of nasal obstruction symptoms[(7-9)].

Rhinomanometry (RM), acoustic rhinometry (RMA) and peak nasal inspiratory flow (PNIF) are the most commonly used methods[(6-8)]. RM measures nasal resistance to air flow. RMA measures the area at predetermined points of the nasal cavity and PNIF measures the maximum inspiratory flow in liters per minute[(6,7,9)].

Studies have shown that both RM and PNIF are accurate in detecting obstruction[10,11]. Sensitivity values varied from 66% to 77%, specificity and diagnostic accuracy for both methods of 80% and 77%, respectively[11]. Spronsen et al.[12], using the GRADE (Grading recommendations Assessment, development and Evaluation System) approach and based on high quality evidence advocate RM, RA and PNIF for evaluation and treatment follow-up of nasal obstruction. Mendes et al.[13] emphasize the fact that, although RM and RMA are the most validated methods, PNIF has been more widely used due to its low cost and easy handling.

The growing adoption of objective methods in clinical research has raised questions about the significance of those measures to clinical evaluation, as well as about how they relate to the patient's subjective perception[9,14].

The objective of this study was to compare PNIF and PNEF measures in patients with allergic rhinitis with those in individuals with no nasal symptoms complaints and to correlate them with the perception of nasal obstruction.

Materials and methods

Study design, population, period and site

This is a cross-sectional study with a control group conducted on 131 individuals aged between 16 and 50 years, separated in two groups: 64 patients with allergic rhinitis symptoms recruited consecutively from an ENT clinic for a regular visit and 67 control individuals without nasal complaints enrolled from our university community. Data collection was done between July and October 2011. The study was approved by the University Ethics Committee (nº 063/11) and all volunteers gave a signed informed consent.

Inclusion and exclusion criteria

Included were patients with clinical diagnosis of persistent allergic rhinitis by an ENT specialist according to the ARIA (Allergic Rhinitis and its Impact on Asthma) initiative[15] and positive cutaneous tests for airborne allergens. Those excluded were patients with diagnosed or a suggestive history of asthma or other respiratory diseases that compromise lung or nose functions, patients under medication for nasal symptoms including topic steroids, systemic vasoconstrictors and antihistamines at or during the four weeks before the study, patients with marked septum deviation at anterior rhinoscopy and patients with altered cognitive level that compromised the conduction of research.

The control group was recruited at the university and comprised people without clinical diagnosis of allergic rhinitis, without nasal symptoms at the clinical score of nasal symptoms (see ahead) and no nasal congestion at the visual analogue scale (VAS). Excluded were smokers, asthmatics or individuals with upper respiratory tract infection at the moment or 15 days before exams.

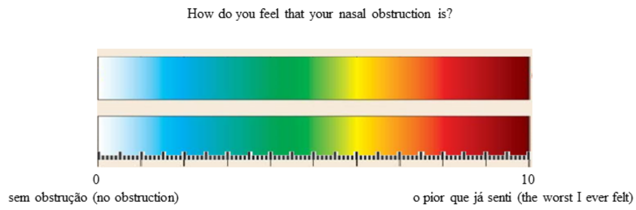

Figure 1. Visual analogue scale.

Clinical evaluations

AR patients and controls were asked to mark on the colour VAS (Figure 1) the level of nasal obstruction symptom and to answer the allergic clinical questionnaire of nasal symptoms adapted from Gomes et al.[16] to ascertain nasal symptoms level (see further). VAS was presented also in a colour gradation, taking zero and white color as a reference for no congestion symptoms at the extreme left of the scale and, at the extreme right, the number 10 and the dark red color represented a completely obstructed nose.

Individuals were asked to mark a point on the scale that seemed to better correspond to their nasal congestion feeling (Figure 1). The answers to symptoms questionnaire (pharyngeal pruritus, sneezing, watery rhinorrhea, itchy nose, itchy eyes and nasal obstruction) were rated from zero to three (Table 1). A categorization of mild, moderate or severe was attributed to the total sum of 1-6, 7-12 and 13-18 points, respectively[16].

PNIF and PNEF measurements

All the AR patients and the control group had peak nasal flow determinations after they answered the symptoms questionnaire and marked the VAS.

Patients with allergic rhinitis were asked to perform nasal hygiene, blowing their noses to eliminate secretion before PNIF and PNEF. PNIF measuring was done with an inspiratory flow meter, In-Check Nasal (Clement Clark, Harlow, UK). Individuals

Table 1. Clinical score rating.

Classification	Definiton
0	No symptoms
1	Mild symptoms, well tolerated, not interfering with daily activities or sleep
2	Well defined symptoms, discomforting, interfering only with activities that demanded a higher degree of concentration
3	High intensity symptoms, very bothersome, hindering daily activities and sleep

Table 2. Demographical and clinical characteristics of recruited individuals.

Variable	AR* Patients		Controls	
Gender	**n**	**%**	**n**	**%**
Male	12	18,8	28	41,8
Female	52	81,2	39	58,2
Total	64	100	67	100
Age				
16-19	6	9,4	8	12
20-29	28	43,7	51	76,1
30-39	19	29,7	7	10,4
40-49	7	10,9	1	1,5
50	4	6,3	-	-
Total	64	100	67	100
Symptom score				
None	0	0	67	100
Mild	13	20,3	-	-
Moderate	42	65,6	-	-
Severe	9	14	-	-
Total	64	100	67	100
VAS (mean ± SD)	5,47 ± 2,05		0,02 ± 0,12	

*AR = Allergic Rhinitis

were seated in a comfortable position and wore a facial mask adjusted by one of the researchers to avoid leaks and then instructed to make maximum inspiratory effort through the nose from expiratory reserve volume, with their lips closed. This procedure was repeated until three measurements with a maximum variation of 10% between them were obtained and the higher value selected.
PNEF measures were obtained using the Assess peak flow meter (Respironics, Parsippany, NJ, USA), with a facial mask adapted to the mouthpiece. The patients were instructed to make maximum expiratory effort through the nose, with their lips closed, after a maximum inspiration from tidal volume. The highest value was chosen from three measurements with < 10% variation between them.
Individuals in both groups were submitted to subjective evaluation (visual analogue scale and clinical score) and to PNIF and PNEF evaluations by independent examiners.

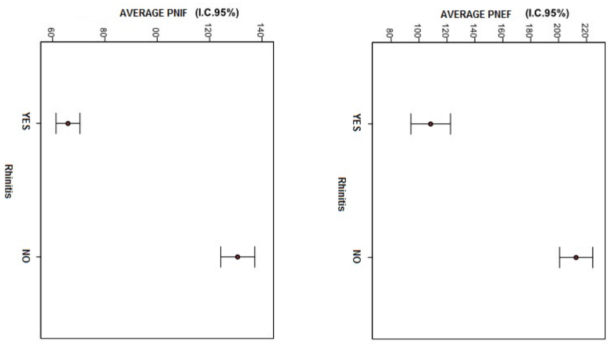

Figure 2. Average PNIF and PNEF in patients with and without allergic rhinitis considering a 95% confidence interval.

Statistical analysis

A descriptive analysis for the characterization of the samples was carried out as well as an inferential analysis for the comparison of the quantitative variables between groups with and without allergic rhinitis, wherein an unpaired student T-test was applied. The Pearson correlation coefficient was calculated for the analysis of the correlation between variables. Data were analyzed using SPSS (Statistical Package for the Social Sciences) for Windows, version 18.0. The significance level assumed was 5%.

Results

Table 2 summarizes the demographical and clinical characteristics of the enrolled individuals.The mean clinical nasal symptoms score (10.14 ± 3.03) for RA patients indicates a population with moderate persistent allergic rhinitis. Table 3 shows the comparison between PNIF and PNEF according to gender in each group.
Average PNIF and PNEF values were lower among patients with allergic rhinitis when compared to individuals without rhinitis, and this difference was statistically significant; mean PFIN 65,94 (± 18.3) L/min. versus 130,73 (± 26.60) L/min. and mean PNEF 108.36 (± 56.9) L/min. versus 212,54 (± 48.9) L/min with $p < 0,01$ (Figure 2).

VAS and symptoms scale correlations with the PNIF and PNEF were conducted only in AR patients. Results show that there was neither a significant correlation between VAS with PNIF ($r = -0,072$; $p = 0,571$) nor with PNEF ($r = -0,221$; $p = 0,079$). Regarding the clinical nasal symptoms score and PNIF, the results show that there was a low negative, although statistically significant correlation with PNIF ($r = -0,26$; $p = 0,03$) that was not found with PNEF (Figure 3).

When we analysed the correlation between PNIF and PNEF in patients with and without allergic rhinitis, there is a significant and positive correlation between them (Figure 4) . Still, the value $r^2 = 0,551$ indicates that PNEF variation can explain only 55,1% of PNIF variation.

Table 3. Mean descriptive statistics and standard deviation of the parameters under study as a function of gender and presence/absence of rhinitis.

Indicator	Gender	Rhinitis		Without rhinitis	
		Mean ± SD	Min-Max	Mean ± SD	Min-Max
PNIF	General	65.94 ± 18.32 [a]	30-120	130.73 ± 26.64 [a]	90-200
	Male	70.0 ± 15.95 [b]	50-100	145.0 ± 29.75 [b g]	90-200
	Female	65.0 ± 18.84 [c]	30-120	120.5 ± 18.63 [c g]	100-160
PNEF	General	108.36 ± 56.87 [d]	0-230	212.54 ± 48.88 [d]	100-340
	Male	130.8 ± 71.54 [e]	0-220	232.9 ± 50.47 [e h]	120-340
	Female	103.2 ± 52.39 [f]	0-230	198.0 ± 42.62 [f h]	100-310

SD= Standard Deviation // Min-Max = minimum and maximum values.

Same letters indicated statistically significant differences between pairs, considering p < 0,01 from t - test onwards for independent samples.

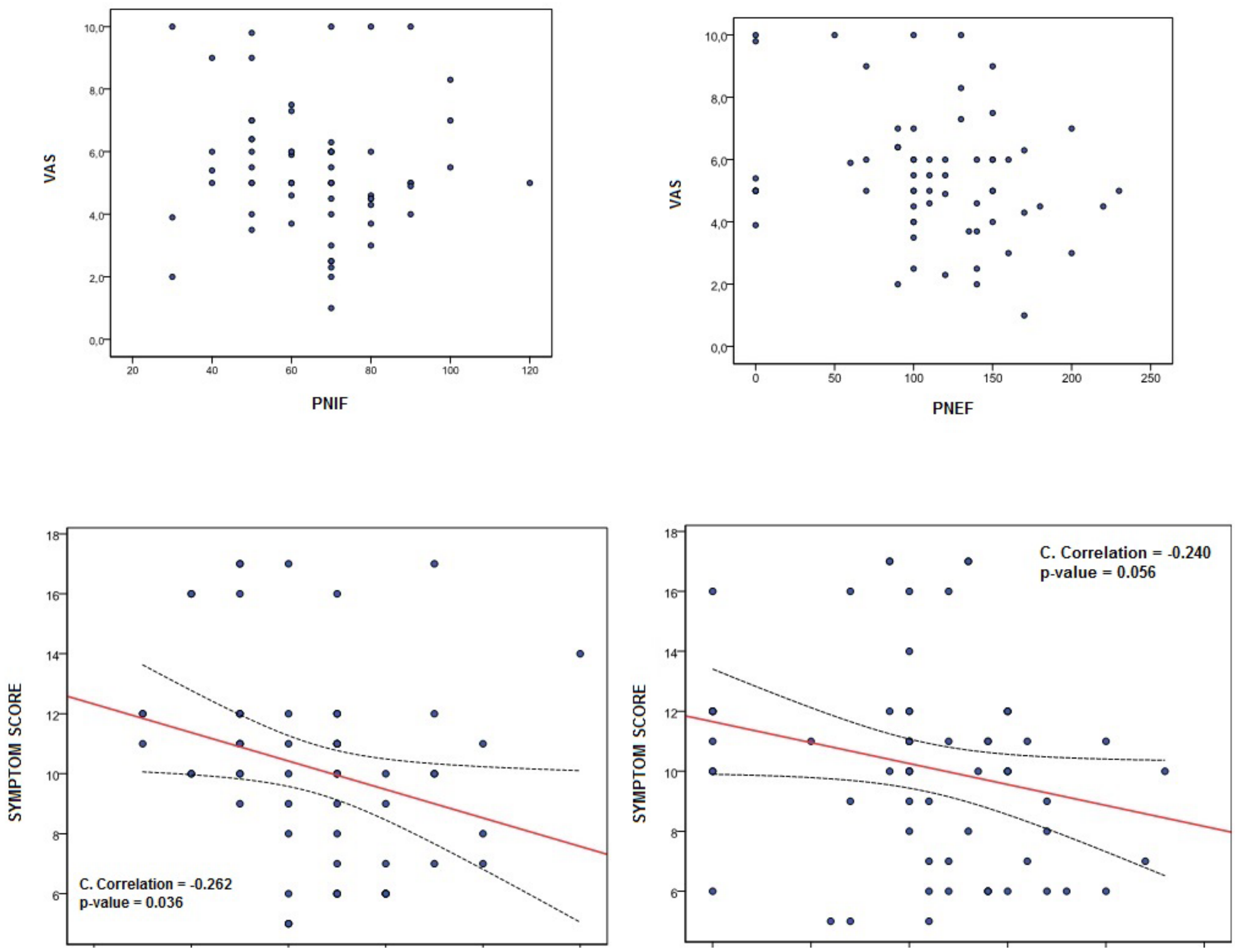

Figure 3. Scattergram for VAS, Symptom Score, PNIF and PNEF.

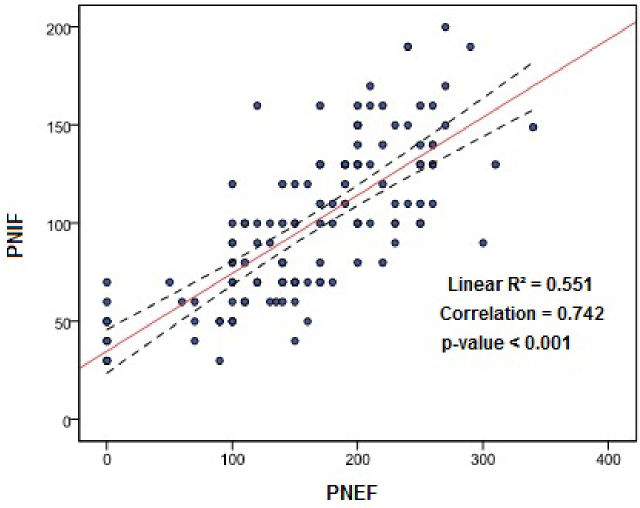

Figure 4. Scattergram for PNIF and PNEF (general sample).

Discussion

Our results show lower PNIF and PNEF average values for AR patients than for non AR subjects. It has been shown that the nasal flow of these patients is lower in relation to the values described in other studies for normal individuals[18-20] and those found in our control group. Normal values for unilateral PNIF in healthy adults have recently been published, which could favor research in situations in which each nostril needs to be individually evaluated[20].

Findings by Teixeira et al.[21], studying PNIF as an evaluation tool for nasal patency in 78 individuals aged between 19 and 67 years, with and without allergic rhinitis, are similar to our results, showing lower PNIF values (114L/min) in individuals with allergic rhinitis compared to individuals without allergic rhinitis (154.31L/min). This reinforces the recommendation for the PNIF as a tool capable of recording changes in nasal patency.
Starling et al.[22], comparing patients with allergic rhinitis and without nasal symptoms proposed a cut-point of 115 L/min, with good specificity and negative predictive value for moderate and severe signs of rhinitis, suggesting that PNIF measures can be useful for screening studies among the general population to diagnose nasal congestion as a cause of the symptoms of rhinitis. Our mean values are in accordance with this established cut-off. It is worth stressing that when we analyze the correlation of PNIF and PNEF behaviour in individuals with and without allergic rhinitis, a strong positive correlation was found between the variables (r = 0.74). This suggests that it is possible for PNEF to predict PNIF, although, despite this correlation, PNEF has little explanatory power (R^2 = 0,551) over PFIN and, due to the greater variability of PNEF, it would not be recommendable to substitute PNIF measures for PNEF measures.
Blomgren et al.[23], evaluating the clinical utility of PNIF and PNEF measures in 100 healthy volunteers aged between 21 and 60 years, observed that PNEF showed a higher coefficient of variability compared to PNIF, and like us, they have found a greater difficulty with measurements execution due to nasal secretion in the mask and oral airflow leakage[23]. PNIF thus seems to be more suitable for use in clinical daily practice as it is better validated than PNEF and because it is more practical and reproducible.

A more thorough investigation with AR patients comparing to reference values for PNIF, as well as determining the level of flow reduction that effectively causes a clinical impact could significantly contribute to the clinical evaluation and follow-up of these patients before, during and after treatment[9,17,18].
Timperley et al.[14], studying the clinical importance of PNIF measures in patients submitted to nasal septoplasty observed a 20% improvement in PNIF in the postoperative period among patients who complained of obstruction, suggesting an early clinical impact in the obstruction perception reported by the patient.
In the interpretation of these measures it is important to consider some variables that can interfere with the results. Lower airway obstruction has been considered in several studies. Ottaviano et al.[24], evaluating the influence of the oral peak expiratory flow (PEF) using a portable peak flow over the PNIF in normal subjects aged from 15 to 71 years, observed a statistically significant correlation between measurements of PEF and PNIF, even greater than those found for weight, gender and height. Studies that include measures of lung function in patients with allergic rhinitis can refine the assessment of PNIF. In fact, Kirtsreesakul et al.[25] propose the ratio between PNIF and peak oral expiratory flow as a better tool than PNIF alone for the objective assessment of nasal patency.

Nasal obstruction is a complex perception that can involve anatomical, subjective and physiological components[9,24]. Physiological measures obtained by PNIF have shown good correlation with those obtained by RM and RMA[24,26,27], but the correlation studies between subjective and objective measures are not conclusive.
Chaaban [29], in a recent review, emphasizes that objective measures of nasal patency cannot predict the subjective feeling reported by patients. A simple example is the application of camphor or eucalyptus on the nose or palate mucosa that can cause a perception of improvement of nasal flow without any change in resistance being detected by rhinomanometry.
Jose et al.[30], investigating the association between PNIF measures and subjective perception of nasal obstruction using a 5-point Likert scale, ranging from no obstruction to total obstruction, obtained a good correlation between these measures in a population of subjects without nasal symptoms. Similar

findings were described by Teixeira et al. when they examined the visual analogue scale and PNIF in healthy subjects before and after the use of a nasal vasoconstrictor[31]. However, when these same authors compared in another study the correlation between PNIF and VAS in patinets with rhinitis, there was a low correlation.

Starling et al.[22], evaluating the correlation between PNIF measures and the signs and symptoms of rhinitis obtained by physical examination and a clinical score in 283 young adults with and without allergic rhinitis, found no significant correlation (p = 0.057) between PNIF and clinical symptom scores. Thus, PNIF measurements were more associated with the isolated obstructive symptom, indicating that the information obtained by PNIF is qualitatively different from that obtained by the general symptoms of rhinitis.

Gomes et al.[16] evaluated the correlation between PNIF and a clinical score of symptoms in children and adolescents aged from 6 to 16 years diagnosed with allergic rhinitis. The results obtained showed a weak negative correlation (r = - 0.29, p < 0.001) between such measures. Wilson et al.[32], investigating the correlation between PNIF and clinical symptom scores in patients with seasonal allergic rhinitis undergoing different therapeutic regimens found similar results.

Ottaviano et al., in a recent study[33], observed a low correlation between subjective measures obtained by the questionnaire Sino-Nasal Outcome Test (SNOT 22) with PNIF and nasal resistance obtained by anterior active rhinomanometry in healthy and obstructed individuals. In our study, we found similar results when we evaluated the correlation between clinical score and PNIF, however, there was no correlation between VAS, PNIF and PNEF. Such findings can be related to the complexity of subjective perceptions that can be influenced by the patients' experience with their symptoms in the context of their lives and may lead patients to under- or overestimate their symptoms. Clinical characteristics of patients with persistent allergic rhinitis who live with persistent obstruction may favour this blunted perception by adapting to their chronic symptoms and they often do not have a comparative standard of satisfactory nasal breathing. It should be noted that the standardization of subjective instruments of evaluation adopted in our study may have been important to refine this analysis. Furthermore, PNIF also showed limited ability to assess all the symptoms of rhinitis, although adequately evaluating the symptom of nasal obstruction, confirming the findings of Gomes et al.[16]. In fact, two recent clinical trials to evaluate AR treatment showed the need to associate a clinical score to PNIF to improve treatment response assessement[34,35].

On the basis of our results, we can speculate that the use of PNIF does not exclude the need for a subjective evaluation as these tools can be complementary in symptoms evaluation. PNIF may provide a standardized objective measure for the nasal obstruction symptoms, especially for those patients more adapted to their chronic symptoms.

Conclusions

PNIF and PNEF measurements can aid the clinician to better evaluate the symptom of nasal obstruction in patients with allergic rhinitis, being especially useful for those with difficulties in their symptoms perception.

PNIF is more suitable for the clinical practice and research than PNEF due to its lower variability and better correlation with patient's subjective perception of symptoms. Further studies may propose standardized reference values for various populations that could help in the interpretation and the adoption of these measures to the clinical evaluation.

Author contributions

GMMdO: Principal investigator, study design, data collection, manuscript writing;
JÂR: Study design and analysis, manuscript writing.
PAMC: Study design and analysis, manuscript writing.
ESCS: Supervisor and tutor of the study

Conflict of interest

There are no financial conflicts of interest.

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