The role of peak nasal and oral inspiratory flow in the evaluation of patients with sleep-related breathing disorders*

Giancarlo Ottaviano[1], Alfonso Luca Pendolino[1], Ennio Nardello[1], Matteo Pollis[2], Bruno Scarpa[3], Rosario Marchese-Ragona[1]

[1] Department of Neurosciences DNS, Otolaryngology Section, University of Padova, Padova, Italy

[2] Department of Neurosciences DNS, Odontostomatology Institute, University of Padova, Padova, Italy

[3] Department of Statistical Sciences, University of Padova, Padova, Italy

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Abstract

Background: Sleep-related breathing disorders (SRBD) are common reported disorders in the adult population. The nose plays an important role in the development of SRBD; thus, the measurement of nasal respiratory function remains an important step in the management of these patients. Peak nasal inspiratory flow (PNIF) is a useful tool to assess nasal airflow and it has recently been studied together with peak oral inspiratory flow (POIF).

Objective: The aim of the present study was to evaluate the role of PNIF and POIF in an adult population of patients affected by SRBD.

Methodology: Seventy consecutive adult patients with SRBD were included in the present study. All patients were evaluated with home-based sleep studies (type III), PNIF, POIF, SNOT-22 questionnaire, Epworth Sleepiness Scale test and VAS for nasal obstruction.

Results: Although PNIF and POIF showed to correlate with each other, no correlations were observed between Apnea Hypopnea index (AHI) and PNIF, POIF or NPI (PNIF/POIF). A further analysis showed a marginal correlation between SNOT- 22 and AHI and between SNOT-22 and POIF. Furthermore, in a multivariate analysis, also POIF marginally correlated with some of the sleep- related SNOT-22 items.

Conclusions: In the present study neither PNIF nor POIF were found to be associated with OSAS severity. However, POIF values correlated better than PNIF with sleep related symptoms suggesting that POIF could be a more useful parameter for upper airway assessment in patients with SRBD. In addition, a correlation between OSAS severity, in terms of AHI, and SNOT-22 total score has been reported.

Key words: obstructive sleep apnoea syndrome, AHI, nasal patency index, sino-nasal outcome test-22, visual analogue scale, Epworth Sleepiness Scale test, CPAP

Introduction

Sleep-related breathing disorders (SRBD) are common disorders in the adult population ranging from simple snoring to complete collapse of the airway with cessation of airflow in obstructive sleep apnoea syndrome (OSAS) [1]. Population-based studies have shown that symptomatic OSAS affects approximately 3% to 7% of adult men and 2% to 5% of adult women [2].

The real role of the nose in SRBD patients is still debated [3,4]. Nasal breathing is the preferential breathing route in wakefulness and in sleep and nasal airway resistance is responsible for approximately two thirds of the total airway resistance in wakefulness [5]. It is well known that daily nasal obstruction results in day-to-day discomfort, frequent complaints of poor sleep quality and daytime fatigue. Intranasal obstruction can in fact markedly increase the number of obstructive apneas and hypopneas during sleep [6,7], causing a greater number of changes in sleep stage [6]. In this regard, it has been shown that patients with symptoms of rhinitis or with nasal congestion are at higher risk of developing SRBD [8,9] and a positive relationship between total nasal resistance, AHI and oxygen desaturation has been observed[10]. Interestingly, the presence of a high Mallampati score and a concomitant nasal obstruction has been found to be associated with an increased risk of OSAS [7], highlighting the importance of comprehensive study of the UA (upper airway) in these patients.

As nasal obstruction increases the risk of developing SRBD, and the oropharyngeal space is the other common site of UA collapse in SRBD patients, a functional respiratory UA evaluation in addition to the most complete UA endoscopic assessment should represent a key step in the management of these patients [11,12]. Peak nasal inspiratory flow (PNIF) is a cheap, easily available and quick method for the objective assessment of nasal airway obstruction [13] showing significant correlation with nasal obstruction symptom[14]. It has been recently used to evaluate the respiratory nasal function in a group of OSAS patients and in a control group [15]. The authors found lower PNIF values in the OSAS group than in the control group [15]. A further step in the study of SRBD patients could be represented by the use of the peak oral inspiratory flow (POIF) as measure of the oral/oropharyngeal obstruction. PNIF together with POIF values have already been studied in children undergoing tonsillectomy also for SRBD, showing that both PNIF and POIF are useful tools to measure oral and nasal obstruction [16].

The aim of the present study was to evaluate for the first time PNIF and POIF in adult patients affected by SRBD.

Materials and Methods

Patients

The present investigation was conducted in accordance with the 1996 Helsinki Declaration. Data were examined in agreement with the Italian privacy and sensible data laws (D.Lgs 196/03) and the otolaryngology section internal regulation. Informed consent was obtained from each subject before starting any study-related procedure.

A population of 70 consecutive adult patients (54 men and 16 women) with SRBD referred to the Department of Neurosciences (Otolaryngology Section) of Padova University was considered for the study. Subjects younger than 18 years and patients with American Society of Anesthesiologists (ASA) Physical Status Classification System higher than III were excluded. Moreover, patients unable to provide informed consent, or without a fluent Italian language or those who refused to participate were not included in the study.

All patients were evaluated with home-based sleep studies (type III) [17]. The documented parameters were airflow, respiratory effort, oxygen saturation, body position, and ECG in order to obtain a diagnosis of simple snoring or OSAS, according to the AHI score (AHI<5, simple snoring; 5≤AHI<15, mild OSAS; 15≤AHI<30, moderate OSAS; AHI ≥30, severe OSAS). All home-based sleep studies produced technically satisfactory results.

A portable Youlten peak flow meter (Clement Clark International) was used for the PNIF measurement [18], while for the POIF measurement we used an In-Check flow meter (Alliance Tech Medical). Both PNIF and POIF measurements were performed in supine position. For PNIF and POIF, two satisfactory maximal inspirations were obtained, and the higher of the two results was then considered, as previously described [19]. Additionally, all subjects were asked to complete an Epworth Sleepiness Scale (ESS) test, a Sino-nasal outcome test-22 (SNOT-22) questionnaire and a visual analogue scale (VAS) for nasal obstruction prior to start the nasal and oral measurements. Subjects were also instructed to avoid excessive smoking and caffeine during the day before the evaluation, but none was requested to modify their usual medication intake in order to reflect the most common state that patients experience in daily life.

Statistical analysis

Spearman correlation coefficient has been used to measure the relation between POIF and PNIF and the Kruskal Wallis test to measure the significance of the association between AHI and the other variables. In order to identify the relation between NPI and POIF with the other available variables a multiple quantile regression model was performed by selecting relevant variables through backward stepwise selection based on the Akaike information criterion (AIC). A p-value ≤0.05 was considered statistically significant. Values in the range of 0.20 > p ≥ 0.05 were considered as indicating a statistical trend. All analyses were run using the R language and environment for statistical computing (R Foundation for Statistical Computing, Vienna, Austria).

Results

The detailed characteristics of the population considered in the present study are reported in Tables 1 and 2. The median AHI value of the population was 30.6±16.7. Table 3 shows the main statistical results. PNIF and POIF showed to correlate with each other (p<0.0001, ρ=0.408) (Figure 1). No correlations were found between AHI and PNIF (p=0.88), POIF (p=0.91) or NPI (PNIF/POIF)[20] (p=0.83). Anyway, although OSAS severity, in terms of AHI, was not correlated with the ESS score (p=0.30), AHI showed a marginal correlation with SNOT-22 total score (p=0.13). Furthermore, SNOT-22 total score and the SNOT-22 item "nasal blockage" showed a correlation with POIF values: a significant

Table 1. Median age, BMI, AHI, PNIF, POIF, VAS and SNOT-22 results separated for males and females.

	Males (n=54)			Females (n=16)		
Variable	**Median**	**IQR**	**Range**	**Median**	**IQR**	**Range**
Age (years)	52.50	15.75	26-75	58.50	12.00	47-77
BMI (kg/m^2)	26.80	3.92	22.8-48.9	25.85	3.22	22-36.3
AHI (events/hour)	30.9	17	4.8-81	30.4	18.35	5.9-59
PNIF (L/min)	130.00	50.00	60-240	115.00	38.75	90-140
POIF (L/min)	290.00	100.00	100-430	185.00	82.50	110-300
VAS	5.00	5.00	0-9	5.50	5.25	0-10
SNOT-22	31.50	33.50	1-94	30.00	27.50	4-67
Epworth	4.00	7.75	1-17	8.00	4.00	3-16

IQR: InterQuartile Range; BMI: Body Mass Index; AHI: Apnea Hypopnea index; PNIF: Peak Nasal Inspiratory Flow; POIF: Peak Oral Inspiratory Flow; VAS: Visual Analogue Scale; SNOT-22: Sino-Nasal Outcome Test-22; Epworth: Epworth Sleepiness Scale test.

Table 2. Sex distribution, PNIF and POIF values according to OSA severity.

Variable	**Sex**		**PNIF (L/min)**			**POIF (L/min)**		
	Male (n=54)	**Female (n=16)**	**Median**	**IQR**	**Range**	**Median**	**IQR**	**Range**
Mild OSAS (5≥AHI<15)	10	2	130	60	60-230	260	140	110-430
Moderate OSAS (15≥AHI<30)	18	6	120	45	70-240	260	95	110-400
Severe OSAS (AHI≥30)	26	8	120	40	70-230	270	105	100-410

OSAS: Obstructive sleep apnoea syndrome; AHI: Apnea Hypopnea index; IQR: InterQuartile Range; PNIF: Peak Nasal Inspiratory Flow; POIF: Peak Oral Inspiratory Flow.

Table 3. Main statistical results.

Variable	**p-value**
PNIF-POIF	**<0.0001**
AHI-PNIF	0.88
AHI-POIF	0.91
AHI-NPI	0.83
AHI-Epworth	0.30
AHI-SNOT-22	0.13
AHI-SNOT-22 (reduced concentration)	**0.04**
AHI-SNOT-22 (reduced productivity)	**0.04**
POIF-SNOT-22	**0.05**
POIF-SNOT-22 (nasal blockage)	0.10
PNIF-SNOT-22 (nasal blockage)	0.53
PNIF-VAS (nasal obstruction)	0.62
POIF-VAS (nasal obstruction)	0.44

AHI: Apnea Hypopnea index; NPI (PNIF/POIF): Nasal Patency Index; PNIF: Peak Nasal Inspiratory Flow; POIF: Peak Oral Inspiratory Flow; VAS: Visual Analogue Scale; SNOT-22: Sino-Nasal Outcome Test-22; Epworth: Epworth Sleepiness Scale test.

correlation the former (p=0.05) and a marginal correlation the latter (p=0.10) (Figure 2a, 2b). Conversely, VAS score for nasal obstruction did not correlate neither with PNIF nor with POIF (p=0.62 and p=0.44, respectively).

In a quantile multiple regression analysis to predict the relation between NPI and the other variables available, the AIC criterium led us to a model that included age (p=0.03), sex (p=0.04) and the following SNOT-22 symptoms [reduced concentration (p=0.06) and waking up at night (p=0.11)] (Table 4). Similarly, a quantile multiple regression analysis was used to predict the relation between POIF and the other available variables. The AIC criterium led us to a model included age (p=0.07), sex (p=0.03) and the following SNOT-22 symptoms [blockage of the nose (p=0.06), fatigue (p=0.07) and waking up tired (p=0.20) (Table 5). Furthermore, considering also the drugs assumed by the patients, five took antidepressant/antiepileptic drugs and seven beta-blockers. These drugs are well-known for influencing the AHI and causing nasal obstruction, respectively [21-23]. Calculations were repeated excluding the above-mentioned twelve patients. Statistical analysis on the remaining 58 subjects ruled out any relevant differences in the obtained results.

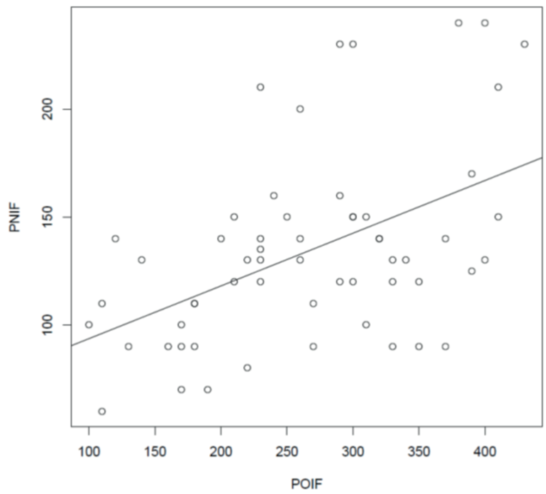

Figure 1. Correlation between PNIF and POIF.

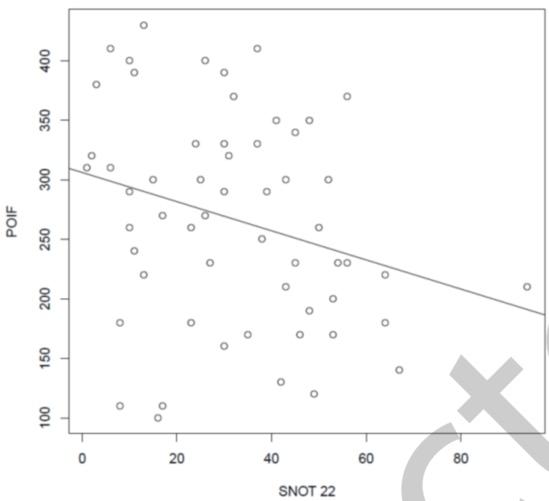

Figure 2a. Correlation between POIF and SNOT-22.

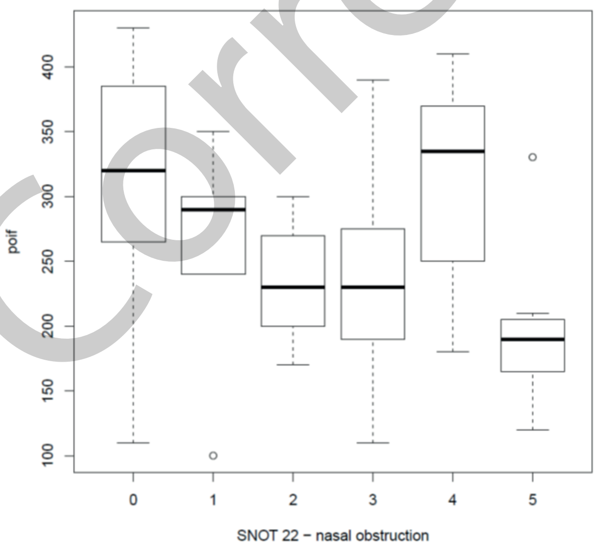

Figure 2b. Correlation between POIF and the SNOT-22 item "nasal blockage".

Table 4. Multivariate regression model: correlations between NPI and the other variables available.

Coefficients	Estimate	Std. Error	t value	p-value
(Intercept)	0.37372	0.15152	2.46643	**0.01634**
age	0.00462	0.00209	2.21022	**0.03**
sex	-0.14405	0.06755	-2.13251	**0.04**
SNOT-22 (reduced concentration)	0.03410	0.01786	1.90952	0.06
SNOT-22 (waking up at night)	-0.02536	0.01557	-1.62857	0.11

NPI (PNIF/POIF): Nasal Patency Index; SNOT-22: Sino-Nasal Outcome Test-22.

Table 5. Multivariate regression model: correlations between POIF and the other variables available.

Coefficients	Estimate	Std. Error	t value	p-value
(Intercept)	385.15982	79.37980	4.85211	**0.00001**
age	-2.19178	1.21239	-1.80781	0.07
sex	57.57991	26.71828	2.15508	**0.03**
SNOT-22 (blockage of the nose)	-11.96347	6.37086	-1.87784	0.06
SNOT-22 (fatigue)	-27.54566	15.20812	-1.81125	0.07
SNOT-22 (waking up tired)	18.40183	14.22716	1.29343	0.20

NPI (PNIF/POIF): Nasal Patency Index; SNOT-22: Sino-Nasal Outcome Test-22.

Discussion

Sleep related breathing disorder are prevalent diseases in the adult population often associated with a low quality of life [24,25]. Early recognition of SRBD is important to treat the symptoms and to avoid the occurrence of the typical comorbidities. Inability to breathe through the nose is thought to cause SRBD, such as snoring and/or OSAS [4,26], to influence SRDB symptoms [27,28], causing reduced quality of sleep[29].

The availability of quick, simple, cost-effective and reliable tools for the evaluation of nasal obstruction, such as PNIF, could be of help for the evaluation of SRBD patients. Furthermore, the use of POIF, together with PNIF, could give more information on the UA patency in these patients. In the present study PNIF and POIF together with nasal and SRBD symptoms have been evaluated in a group of 70 adult patients with OSAS or snoring. In line with previous findings [16,20], PNIF and POIF were found to be correlated with each other highlighting that both of them can give an important contribute to study the UA patency. However, neither PNIF, nor POIF or NPI showed a correlation with OSAS severity, in terms of AHI, meaning that they cannot be considered good markers of OSAS severity, at least in adults. The present results seem to be in line with those reported in the literature. Meng et al., studying a group of patients affected by allergic rhinitis and a control group by means of a sleep study and PNIF, observed a significant difference between the study group and the control group in most of the sleep parameters, but not in AHI [30]. Similarly, De Aguiar and co-workers found that PNIF was not able to differentiate between OSAS and healthy subjects [31].

Questionnaires play an important role in medical daily practice allowing a quick screening of patients' symptoms. Given that SRBD causes non-restorative sleep, the presence of an increased sleepiness at specific questionnaires could be considered a good way to detect patients who may need further evaluation. It has been suggested that questionnaires alone are not accurate enough for the early diagnosis of OSAS, but they could be useful if combined with other parameters, such as history and simple clinical findings [32]. Therefore, a good diagnostic accuracy can be achieved only if many parameters are combined [32]. SNOT-22 is a disease-specific questionnaire involving 22 items combining rhinologic issues with general health issues, including sleep related problems. Interestingly, in the present study although AHI and ESS score did not correlate, as already reported by other authors [32-34], AHI marginally correlated with SNOT-22 total score. Moreover, SNOT-22 showed a significant correlation with POIF. Finally, in the multiple regression analysis, POIF and NPI showed a marginal correlation with the SNOT-22 items "reduced concentration", "wake up at night" and "wake up tired", showing that POIF and NPI more than the simple PNIF seem to be related to sleep related symptoms.

These interesting results seem to confirm the existence of a connection between the nose and the SRBD, in particular with the symptoms. So far, the SNOT-22 questionnaire can be considered a valid instrument for a quick screening of SRBD patients and it could be proposed that in future SNOT-22 should be administered together with the ESS in these patients.

Conclusions

In conclusion, although neither PNIF nor POIF showed association with OSAS severity, the objective measurement of UA obstruction should still be considered important in the assessment of SRBD patients, as it can detect patients who might have troubles tolerating CPAP. On this regard, PNIF and POIF, being easy and portable devices, could be useful to achieve this purpose. More studies with a higher number of patients and possibly using polysomnography (type I) instead than home sleep study (type III) are welcome to deep the knowledge on this important topic.

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Authorship contribution

GO: concept drafting, discussion, review; ALP: data collection, drafting, review; EN: data collection, drafting; MP: data collection; BS: statistics; RMR: data collection, data analysis, discussion.

Conflict of interest

None.

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Giancarlo Ottaviano, MD, PhD.
Department of Neurosciences
Otolaryngology Section
University of Padova
Via Giustiniani 2
35128 Padova
Italy

Tel. +39 (0)49 8214470
Fax: +39 (0)49 8213113
E-mail: giancarlo.ottaviano@unipd.it