Comparison between unilateral PNIF and rhinomanometry in the evaluation of nasal cycle*

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Abstract

Background: Human unilateral nasal airflow shows spontaneous changes over a period of hours due to the alternating congestion and decongestion of the venous sinuses within the nasal turbinates and nasal septum.
The aim of the present study was to compare PNIF and unilateral PNIF with nasal resistances measured by means of AAR in the evaluation of the nasal cycle.

Methods: PNIF, unilateral PNIF and AAR measurements were randomly performed in 20 non-smokers, non-asthmatic volunteers, with a SNOT 22 score <1. Nasal measurements were done four times in a single day at 08.30, 11.00, 13.30 and 16.00. The correlation between PNIF, unilateral PNIF and nasal resistances was studied. The pattern of nasal airflow for each subject was also analyzed.

Results: A significant negative correlation between PNIF-lPNIF-rPNIF and respectively AAR-lAAR-rAAR was found. Only 1 subject did not show nasal cycle, while all the rest were equally distributed between a reciprocal pattern of the nasal cycle, or an in-phase changes of the nasal cycle, both at PNIF and AAR.

Conclusions: Nasal cycle can be easily assessed by means of PNIF. In fact, AAR and PNIF showed a reasonable correlation in the measurement of nasal cycle, although PNIF offered a lower variability. Reciprocal and in-phase patterns of the nasal cycle were equally distributed in our population.

Key words: peak nasal inspiratory flow, unilateral peak nasal inspiratory flow, anterior active rhinomanometry, nasal cycle

Introduction

Nasal airway obstruction is a common problem in ENT practice and the measurement of nasal flow is of considerable importance for rhinologist. Anterior active rhinomanometry (AAR) is considered the method of choice to measure nasal breathing function, but it is expensive and time-consuming. Peak nasal inspiratory flow (PNIF) is a cheap and quick method for the objective assessment of nasal airway obstruction, also unilaterally, and has been demonstrated to be reproducible in the evaluation of nasal airway obstruction and as good an indication of objective nasal patency as formal Rhinomanometry [(1-3)].

It has been demonstrated that human unilateral nasal airflow shows spontaneous changes over a period of hours. 'Nasal cycle' is present in almost 80% of the people [(4,5)] and it is due to the alternating congestion and decongestion of the venous sinuses within the nasal turbinates and nasal septum [(6)]. Nasal cycle seems to be controlled mainly by the sympathetic nerve supply to the nose [(7)] under the direction of the central nervous system [(8-10)]. Subjects with a nasal cycle could either exhibit in-phase changes of unilateral airflow or reciprocal changes, with reciprocal changes being more frequent [(11)]. Recently, in fact, it has

been demonstrated that the majority of subjects show reciprocal changes of nasal airflows [12].
The aim of the present study was to compare PNIF and unilateral PNIF with nasal resistances measured by means of AAR in the evaluation of the nasal cycle in a group of healthy subjects.

Materials and methods

A cohort of 20 healthy adult volunteers ranging from 23 to 39 years, with a mean age of 28 ± 3.9 years was recruited at the Department of Neurosciences DNS, Section of Otolaryngology of Padova University. All subjects were asked to complete a SNOT 22 questionnaire, as previously done [13]. They were also asked if they were experiencing nasal blockage or any other nasal problem and if they were smokers, asthmatic or had undergone any previous surgery on the nose and paranasal sinuses. All the subjects with a score <1 on the SNOT 22, who were non-smokers, non-asthmatic and without any previous sinonasal surgery, were enrolled in the study. None of the subjects enrolled took any form of medication. Detailed characteristics of the population are reported in Table 1.
The present investigation was conducted in accordance with the 1996 Helsinki Declaration and was approved by our Otolaryngology Section's in-house ethical committee. Informed consent was obtained from each subject before starting any study-related procedure.
A portable Youlten peak flow meter (Clement Clark International) was used for the PNIF measurement. Unilateral PNIF (lPNIF and rPNIF) was also measured as described in a previous study[2]. Nasal resistances were evaluated using AAR (Rhinolab, Rendsburg, Germany) as described elsewhere[14].
All nasal measurements were done four times in a single day, at 08.30, 11.00, 13.30 and 16.00. For PNIF and unilateral PNIF, two satisfactory maximal inspirations were obtained each time, and the higher of the two results was then considered [15].
PNIF and AAR were randomly performed in all participants after at least 10 minutes of acclimatisation in a room with constant temperature (between 19 and 22 C°) and a relative humidity of 25-35%[16]. All tests have been done by the same operator (ALP).

Statistical analysis

The Pearson correlation test was used to compare PNIF, lPNIF, rPNIF and AAR, lAAR, rAAR in the evaluation of nasal airflow variations. P-values have been calculated for all tests, and 5% was considered as the critical level of significance.
The pattern of nasal airflow for each subject was expressed as a Pearson's correlation coefficient, where the +1 indicates a direct correlation of left and right airflows with the changes in-phase, and a correlation coefficient of -1 indicates a reciprocal correlation of left and right nasal airflows.
The R: a language and environment for statistical computing (R Foundation for Statistical Computing, Vienna, Austria) was used for all analyses.

Results

Mean baseline (first measurement at 8.30 a.m.) data on nasal flows and nasal resistances are reported in Table 1. These data are consistent with a healthy normal population. Figures 1 and 2 show the nasal cycle evaluated by both PNIF and AAR in a period of 7,5 hours in two of the studied volunteers.
We observed a significant negative correlation between PNIF, lPNIF, rPNIF and respectively AAR, lAAR, rAAR (Table 2, Figure 3). Considering the daily variability of nasal airflows and resistances, PNIF showed a fluctuation of 9.7 % from the mean value, unilateral PNIF of an average of 16% (mean lPNIF variation = 15.78%; mean rPNIF variation = 16.49%) from its mean value, AAR of 24%, unilateral AAR of an average of 33% (mean lAAR variation = 26.38%; mean rAAR variation = 39.52%). Considering the effects of nasal cycle in relation to the time of measurement, we

Table 1. Mean age, height and baseline (first measurement at 8.30 a.m.) nasal breathing function results in males and females of the studied group.

	Males (n=9)			Females (n=11)		
Variable	Mean	SD	Range	Mean	SD	Range
Age (yr)	28.8	4.9	23-39	28.0	3.2	26-36
Height (cm)	177.3	4.2	170-186	166.2	4.3	158-173
BMI (kg/m^2)	23.7	1.8	20.8-26.8	20.7	1.7	17.9-22.6
lPNIF(L/min)	163	34	130-220	125	41	80-200
rPNIF (L/min)	144	61	70-250	106	36	65-180
PNIF (L/min)	237	45	190-335	181	33	120-230
lAAR (Pa*sec/ml)	0.09	0.04	0.05-0.17	0.10	0.05	0.05-0.22
rAAR (Pa*sec/ml)	0.15	0.3	0.03-0.85	0.10	0.06	0.04-0.21
AAR (Pa*sec/ml)	0.03	0.01	0.02-0.06	0.05	0.02	0.02-0.07

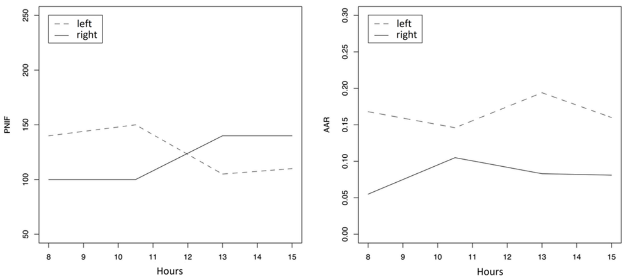

Figure 1. Changes in unilateral nasal airflows and resistances in one of the studied volunteers showing reciprocal changes.

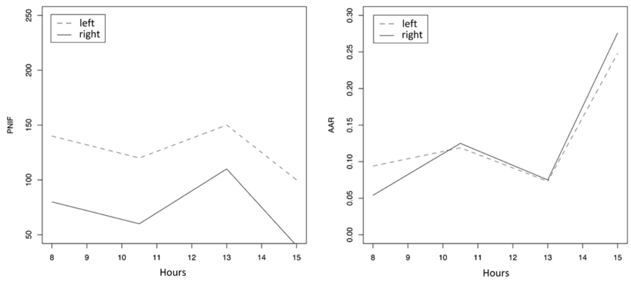

Figure 2. Changes in unilateral nasal airflows and resistances in one of the studied volunteers showing in-phase changes.

found that both PNIF and AAR had their highest variability with respect to the mean value at 8.30 and at 16.00 (Table 3).
By evaluating the correlation coefficient r of PNIF and AAR measurements, which describes the relationship between the changes in nasal airflow/resistances on each side of the nose, we observed that only 1 subject did not show any modification during the day ($r \approx 1$), while all the rest were equally distributed between a reciprocal pattern of the nasal cycle ($r<1$), or an in-phase changes of the nasal cycle ($r>1$) both at PNIF or AAR (Figure 4).

Discussion

Nasal cycle is the spontaneous, reciprocal congestion and decongestion of the nasal mucosa during the day, where congestion of one side is generally accompanied by reciprocal decongestion of the contralateral side due the dilation and constriction of the venous cavernous tissue in the submucosa of the turbinates and septum [17]. This physiological phenomenon has been suggested to be present in almost 70% to 80% of healthy adults, according to different authors [16,18], although a true periodicity and reciprocity exists in only about 21%-39% of the subjects [11]. When present, nasal cycle can show a phase length that ranges from 30 minutes to 6 hours [19]. It has been found that nasal cycle can show either in-phase or reciprocal changes in unilateral airflow [11,20]. Very recently, Williams and Eccles, evaluating the effects of nasal cycle on 30 subjects by means of AAR measurement over a period of 7 hours, concluded that the majority of subjects exhibited reciprocal changes in unilateral airflow [12]. Interestingly, up to four patterns of fluctuation in nasal patency during the day have been described which eventually may transform from one to another, suggesting that the airflow pattern is not fixed and can be influenced by external factors[21]. In the present study, all but one volunteers were shown to have a clearly demonstrable nasal cycle with two different nasal airflow change patterns being observed. In particular, both PNIF and AAR showed that roughly half of the subjects presented an in-phase pattern while the other half a reciprocal pattern. A control model involving a hypothalamic center and two brainstem half centres has been proposed to explain both the in phase and reciprocal changes in airflow associated with nasal cycle [12]. From the results of the present study it seems that the in-phase changes in nasal airflow, probably driven by the dominant control of the nasal cycle from the hypothalamus, may be even more frequent than previously reported [12]. In this regard, it has been demonstrated that the unilateral blocking of the stellate ganglion produces bilateral swelling of nasal mucosa [22]. In the case of the volunteer who did not show a nasal cycle, it is possible they have a 'non-cycling' nose, as has already been demonstrated by other authors [12,21,23].
The nasal cycle can be assessed with several tools [24]. Rhinomanometry is a well-established technique in the evaluation of nasal resistance to airflow and has also been standardized to describe the nasal cycle [25]. The use of a reliable, cheap and simple method for assessing nasal airway obstruction is highly desirable [26]. PNIF validity to measure various degrees of single nostril patency has been demonstrated both in healthy and obstructed noses [27] and in the evaluation of nasal cycle, although the latter involved a very limited number of subjects [28]. In the present paper, for the first time, PNIF and AAR were

Table 2. Correlations between AAR, rAAR, lAAR and PNIF, rPNIF, lPNIF.

	Correlation (r)	p value
PNIF vs AAR	-0.376	p=0.0006
lPNIF vs lAAR	-0.353	0.0013
rPNIF vs rAAR	-0.348	p=0.0016

Table 3. Variability of PNIF and AAR in the measurement of nasal cycle.

Test time	PNIF coefficent of variation	AAR coefficent of variation
8.30	0.23	0.37
11.00	0.2	0.33
13.30	0.16	0.34
16.00	0.23	0.45

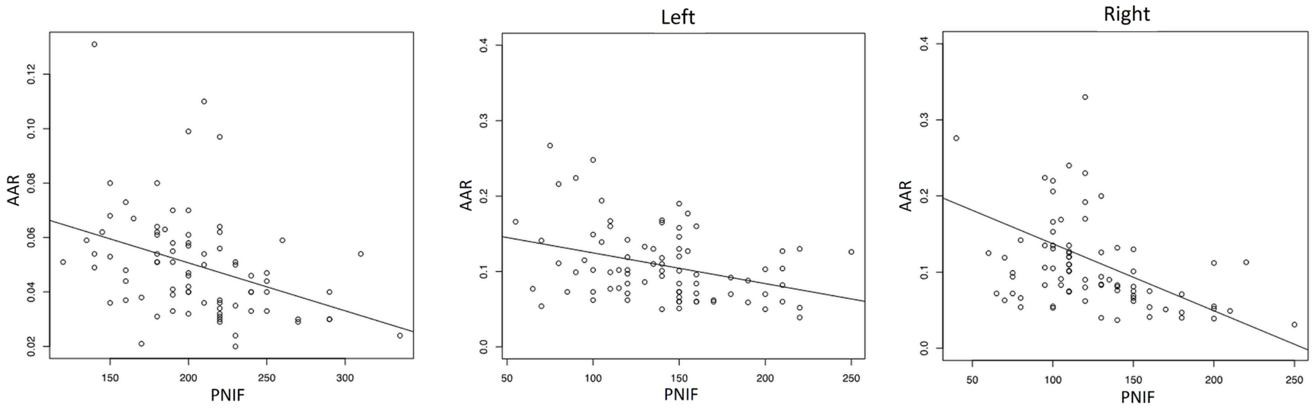

Figure 3. PNIF against AAR, respectively for bilateral and unilateral values.

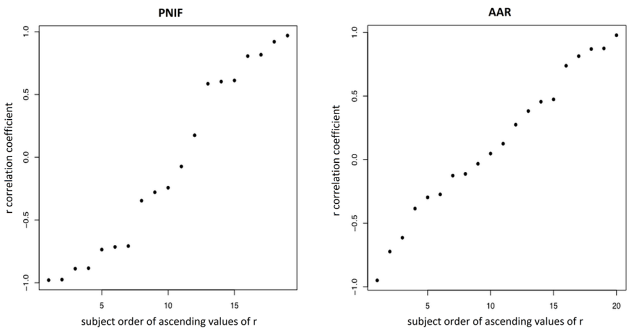

Figure 4. Correlation coefficient r of PNIF and AAR measurements, describing the relationship between the changes in nasal airflows and resistances on each side of the nose. A r<1 means reciprocal pattern of the nasal cycle, while a r>1 means in-phase pattern of nasal cycle.

both adopted for the evaluation of nasal cycle. A reasonably significant negative correlation between both AAR and PNIF and unilateral nasal resistances and unilateral PNIF was found. These results, which mean that when PNIF increases, nasal resistance measured by AAR decreases, are mostly in line with those findings previously observed in a group of 70 healthy subjects, where a significant correlation between PNIF and AAR (r=-0.299, p=0.001) and unilateral PNIF and AAR (r=-0.373, p<0.001 for the left side; r=-0.416, p<0.001 for the right side) was found [27]. Interestingly, looking at the results of the present study, PNIF seems to be more useful than AAR to show both in-phase and reciprocal changes of nasal patency due to nasal cycle. This particular result could also be due to the difficult protocol used for rhinomanometry [28].

Considering the variability of both methods in the measurement of nasal cycle, in the present study we found AAR showing a much higher variability than PNIF. In particular, the latter showed a coefficient of variation of about 10%, while AAR showed a coefficient of variation of 24%. Considering only unilateral measurements, this picture becomes even clearer with rAAR showing a 39,5 % of variability and rPNIF a variability of 16,5 %. The results for PNIF variability are similar to that proposed by Soane and co-worker who demonstrated in a group of 5 volunteers that unilateral PNIF provided a much lower coefficient of variation that AAR [28]. The reason why PNIF seems to show less variability could be once again either due to the difficult protocol used for AAR or for the higher sensibility of rhinomanometry.

Conclusion

From the data of the present study, it seems that the nasal cycle can be assessed by using a complex and expensive procedure such as rhinomanometry. However, it can also be clearly identified by means of an inexpensive and reliable instrument, such as PNIF. Although these methods showed a reasonable correlation in the measurement on nasal cycle, PNIF offered a lower variability if compared to AAR. Finally, both PNIF and AAR showed that in-phase changes in nasal airflow were more frequent than previously reported, with reciprocal and in-phase patterns of the nasal cycle being equally distributed in our study population.

Authorship contribution

ALP: data collection, drafting and review of manuscript; EN: data collection, data analysis, review of manuscript; VJL: review of manuscript, editing of manuscript; PM: data collection, review of manuscript; BS: statistics; AM: discussion, review of manuscript; GO: concept, data analysis, drafting, discussion, review and editing of manuscript

Conflict of interest

None

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