Peak Nasal Inspiratory Flow: Reference Values for Thais

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ABSTRACT

Objective: Nasal obstruction can be measured objectively by rhinomanometry and acoustic rhinometry, both complex techniques. Peak nasal inspiratory flow (PNIF) is also a tool for evaluating nasal obstruction. This study aimed to establish normal PNIF ranges for an Asian population accounting for sex, age, weight, and height.
Methods: Using a portable Youlten peak flowmeter, PNIF was measured in 180 healthy Thais (ages 15-70 years). Normal ranges for male and female subjects, adjusted for weight and height, were determined using multiple regression analysis.
Results: Body mass index values (mean ± S.D.) of the 82 male and 98 female subjects were 24.9 ± 4.5 and 21.7 ± 4.3 kg/m^2, respectively. PNIF was significantly higher in males than in females (139 ± 37.6 vs. 97.1 ± 27.1 l/min, $p<0.001$). After adjusting for weight and height, PNIF reference ranges (lower and upper limits with 95% confidence intervals, respectively) were 126.8 (124.5 to 129.1) and 151.2 (148.9 to 153.5) l/min for males and 82.5 (80.0 to 85.0) and 111.7 (109.2 to 114.3) l/min for females.
Conclusion: Sex, height, and weight affected the PNIF rate. This study has provided normal PNIF ranges for healthy male and female Thai population that account for weight and height.

Keywords: Peak nasal inspiratory flow, nasal airflow, nasal obstruction, normal value, reference range

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INTRODUCTION

Nasal obstruction is one of the most common complaints in clinical practice. It can be categorized into two etiologic groups: mucosal and structural. The mucosal etiology is more common because of the high prevalence of upper respiratory tract infections and allergic inflammation.

Because of the “chronic” nature of allergic diseases and their high prevalence worldwide, physicians must treat and monitor patients for long periods of time.[1] Along with diseases such as hypertension or heart disease, allergic diseases affect quality of life (QoL).[2] Among allergy-induced symptoms, nasal obstruction is the most common and leads to consequences such as sinusitis, chronic mouth breathing, and sleep-disorder problems.[3]

It is therefore important that nasal obstruction is evaluated objectively and then monitored to confirm its severity. The objective evaluation can be accomplished by applying rhinomanometry (RMM) to measure nasal airflow (NAF) and nasal airway resistance (NAR). The minimum cross-sectional area (MCA) and

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nasal volume (NV) can be measured by acoustic rhinometry (ARM).[4,5]

Previous studies of RMM and ARM demonstrated good correlation with nasal obstruction-related symptoms.[6] These methods have been used, not only to monitor response to treatment, but can also contribute to fulfilling one of the criteria for diagnosing allergic rhinitis using the nasal provocation test.[7] The advantage of RMM is its ability to provide NAF and NAR values for each side of the nose and total NAR as a single value by mathematical calculation. However, RMM and ARM are relatively expensive, complex to use, time-consuming, and require experienced operators as well as a considerable degree of patient cooperation.

In 1980, Youlten introduced the peak nasal inspiratory flowmeter, which was a modification of the Wright peak flowmeter.[8] With peak nasal inspiratory flowmetry (PNIF), the patient sniffs air through the nose, and the peak flow is recorded. PNIF can be used as a screening tool for evaluating nasal obstruction or determining rhinitis severity.[9,10]

A study estimating normal values for peak nasal inspiration by adult Caucasians using PNIF was conducted by Ottaviano et al.[11] Normal values for pediatric and adolescent Greek and African populations have also been established.[12,13] Others have published RMM and ARM normal values for Asian populations.[5,14] The purpose of this study was to use PNIF to estimate the reference range for peak nasal inspiration in Thais. It is possible that the results could also be applied to other Asian populations.

MATERIALS AND METHODS

This cross-sectional, prospective study included 180 healthy Thai volunteers. They were eligible if they were 15-70 years of age, had no symptoms of nasal congestion, no history of asthma or rhinitis, and no structural abnormalities in their nasal cavities. They were excluded if they had previously undergone surgery of the nose or paranasal sinuses, had inhaled nasal corticosteroid within the last 2 weeks or had ingested oral corticosteroid within the last 4 weeks, had used oral or nasal decongestant within 1 day prior to testing, or were habitual smokers.

The PNIF measurements were done using the portable Youlten flowmeter (Clement Clark International, Harlow, UK). The masks attached to the meter were chosen to fit tightly on each subject's face without touching the alar of the nose (Fig 1). They were cleaned with 70% alcohol solution and left to dry before each use. All subjects were tested while sitting. They were encouraged to inhale through the nose as hard and fast as they could while keeping the mouth closed starting from the end of a full expiration. Three satisfactory maximum inspirations were obtained, and the highest of the three values was taken as the maximum PNIF (PNIFmax). Our procedure was consistent with established protocols for PNIF measurement.[11]

The study was approved by the institutional review board of the ethics committee of Siriraj Hospital (COA number Si.339/2007). The study complied with the Declaration of Helsinki. All patients included in the study provided written informed consent.

Statistical analysis

All statistical data were analyzed using Stata version 13 (StataCorp, College Station, TX, USA). Baseline demographic data, including age, height, and weight, were reported as the mean ± standard deviation (S.D.). Initially, regression analysis was performed to assess the effects of these factors on peak nasal inspiration. The large difference in the peak nasal inspiration between male and female subjects, even after being

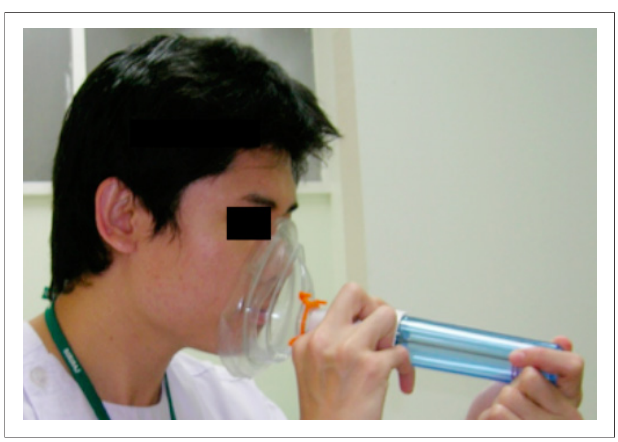

Fig 1. Portable Youlten flowmeter.

adjusted for the effects of weight and height, led to the decision that the reference range needed to be estimated separately for males and females. It was also essential to adjust for the effects of weight and height. Therefore, the reference range was estimated from the predicted PNIF obtained from two regression models where weight and height were included—one for males and the other for females. The reference range comprised the lower and upper limits obtained and the mean ± 1.96 S.D. The 95% confidence interval (95%CI) was estimated based on the normal distribution assumption and comprised the adjusted reference range. This estimation was also provided for the raw data and is reported as the unadjusted reference range for exploratory purposes. The PNIF values were also described as the mean ± S.D. for the overall group and for the 5^{th}, 50^{th}, and 95^{th} percentiles separately for males and females. P values were two-sided, with the significance level at p<0.05.

RESULTS

Among the 180 healthy subjects, 82 were male and 98 were female. Their mean ± S.D. body mass indexes were 24.9 ± 4.5 and 21.7 ± 4.3 kg/m^2, respectively (Table 1).

PNIF values for both sexes were higher during their second and third inhalation efforts, compared with their first effort. PNIFmax values (mean ± SD) were 139 ± 37.6 l/sec in males and 97.1 ± 27.1 l/sec in females. The difference in PNIFmax between male and female subjects was statistically significant (p<0.001). After adjusting for weight and height, the reference PNIF ranges (mean ± 1.96 S.D.) were 126.8 (124.5 to 129.1) and 151.2 (148.9 to 153.5) l/min, respectively, for males and 82.5 (80.0 to 85.0) and 111.7 (109.2 to 114.3) l/min, respectively, for females (Table 2). PNIF values were significantly influenced by sex, weight, and height (p<0.001). Age did not influence the PNIF value (p=0.5) (Table 3).

DISCUSSION

The PNIF values in our study were 139.0 ± 37.6 l/min for the male subjects and 97.1 ± 27.1 l/min for the female subjects. Four studies (from the United Kingdom, Finland, France, and Brazil) have also reported normal PNIF values (Table 4). Ottaviano et al. (UK study) reported that the PNIF values were 143 ± 48.6 l/min in males and 121.9 ± 36 l/min in females.[11] Teixeira et al. (Brazilian study) reported that the PNIF values were 134.7 ± 43.0 l/min in male subjects and 139 ± 31.8 l/min

TABLE 1. Demographic and anthropometric data of the subjects.

Parameter	Male subjects (N = 82)	Female subjects (N = 98)	Total (N = 180)
Age (years)	39.2 ± 14.1	38.7 ± 13.5	38.9 ± 13.7
Height (cm)	169.2 ± 6.1	157.7 ± 5.7	162.9 ± 8.2
Weight (kg)	71.3 ± 13.5	53.9 ± 10.6	61.9 ± 14.8
Body mass index (kg/m^2)	24.9 ± 4.5	21.7 ± 4.3	23.2 ± 4.7

Results are given as the mean ± standard deviation.

TABLE 2. Peak nasal inspiratory flow rate adjusted for weight and height using multiple linear regression analysis.

Parameter	No.	Mean (S.D.)	Mean difference	95%CI	P
Male sex	82	139.0 (37.6)			
Female sex	98	97.1 (27.1)			
Unadjusted			41.9	32.4 to 51.5	<0.001
Adjusted for weight			34.2	22.6 to 45.9	<0.001
Adjusted for height			31.3	18.1 to 44.6	<0.001
Adjusted for weight and height			27.2	13.3 to 41.2	<0.001

Results are given as liters per minute. CI: confidence interval.

TABLE 3. Peak nasal inspiratory flow rates in male and female healthy individuals.

Parameter	Male subjects (N = 82)	Female subjects (N = 98)
1st PNIF	119.3 ± 33.1	82.9 ± 23.9
2nd PNIF	129.4 ± 36.1	85.4 ± 27.8
3rd PNIF	132.1 ± 37.9	91.6 ± 30.4
PNIFmax	139.0 ± 37.6	97.1 ± 27.1
5th percentile	90.0	50.0
50th percentile	140.0	97.5
95th percentile	200.0	150.0
Mean ± S.D.	139.0 ± 37.6	97.1 ± 27.1
Reference range unadjusted		
Lower limit (mean - 1.96 S.D.)	65.3	43.9
95% CI	51.6 to 79.2	34.8 to 53.1
Upper limit (mean + 1.96 S.D.)	212.8	150.3
95% CI	198.9 to 226.7	141.1 to 159.5
Reference range adjusted for weight and height		
Lower limit (mean - 1.96 S.D.)	126.8	82.5
95% CI	124.5 to 129.1	80.0 to 85.0
Upper limit (mean + 1.96 S.D.)	151.2	111.7
95% CI	148.9 to 153.5	109.2 to 114.3

Results are given as liters per minute. PNIF = peak nasal inspiratory flow.

in female subjects.[15] Our mean values are comparable to theirs even though there were differences in the races. There was another report of normal PNIF values. In the French population, the PNIF values were 100.3 ± 43.6 in males and 79.3 ± 32.2 in females.[16] Their mean PNIF values were markedly lower than ours. The authors noted that there was no obvious explanation for the relatively low values compared with those in other reports.

Similar to the other studies, our mean PNIF values showed differences between sexes.[11,16,17] PNIF values in male subjects were significantly

TABLE 4. Comparison of PNIF values among nationalities in previous studies.

Blomgren[17] (Finland)	Ottaviano[11] (UK)	Klossek[16] (France)	Teixeira[15] (Brazil)	Tantilipikorn Present study (Thailand)
No. of subjects				
100	137	151	74	180
Sex				
Male (n=50)	Male (n = 60)	Male (n = 59)	Male (n = 47)	Male (n = 82)
Female (n=50)	Female (n = 77)	Female (n = 92)	Female (n = 31)	Female (n = 98)
Mean age (years)				
Global (21-60)	-	46 ± 15	36.8	38.9 ± 13.7
Mean: 39	Male: 43.3 ± 22.1	Male: 49.6 ± 16.1	Male: 39.2 ± 14.1	Male: 39.2 ± 14.1
	Female 40.2 ± 18.6	Female 43.7 ± 14	Female 38.7 ± 13.5	Female 38.7 ± 13.5
Mean PNIF				
Male: 145 (58-233)	Male: 142 ± 46.8	Male: 104.6 ± 54.8	Male: 134.7 ± 43.0	Male: 139.0 ± 37.6
Female: 128 (44-211)	Female: 119.2 ± 36.6	Female: 80.8 ± 33.4	Female: 139.0 ± 31.8	Female: 97.1 ± 27.1

higher than those of female subjects. The Brazilian study, however, found that the mean PNIF value in males was lower than that of females (134.7 ± 43.0 vs. 139.0 ± 31.8 l/min), although the difference did not reach statistical significance.[15]

The reference values can be presented as the mean ± 1.96 S.D. or the 95% reference interval.[18] The reference values from the UK and French studies were presented as the mean ± S.D.[11,16] The studies from Finland and Brazil both presented their reference values as the mean ± S.D. and the 95% reference interval, as we did.[15,17]

Some PNIF studies in children showed that age influenced the PNIF values.[12,13,19] The values increased from a young age until they stabilized at the age of 8 years in South Africa and 12 years in Greece.[12,13] Our findings, which showed no influence of age on PNIF, were in agreement with the reports from Finland and France, because both studies were conducted in adult populations similar to ours.[16,17] Ottaviano et al. showed that age influenced PNIF results.[11] In their study, the discrepancies were explained by MODPNIF, which was derived from the modeling transformed variable of PNIF.

Putting age aside, the subjects' weight, height, and sex affected the PNIF values, although our study showed that only height and sex significantly affected the values. Ottaviano et al. reported that age was the strongest and most significant determination of the PNIF results, with sex and height making a less significant contribution.[11]

CONCLUSION

The PNIF values (mean ± S.D.) in this study were 139.0 ± 37.6 for the male subjects and 97.1 ± 27.1 for the female subjects. These PNIF values can be used as the reference values for Thais and possibly other populations in Southeast Asia. They can be used clinically to evaluate nasal obstruction and the efficacy of a medical or surgical treatment of nasal obstruction as well as in research as objective parameters. In our study, we wanted simply to establish the norms for PNIF. Therefore, we did not measure PNIF in patients with severely blocked nasal passages.

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