Original article

Peak nasal inspiratory flow: normal values in a healthy vietnamese adult population

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Abstract

Background: Peak nasal inspiratory flow (PNIF) is an objective measurement of nasal patency. However, standard reference values specific to the Vietnamese population have not been established. **Materials and methods**: In a cross-sectional study, PNIF was measured three times in 300 healthy Vietnamese participants aged 17 to 88. Normal PNIF values for males and females were determined through multiple regression analysis, adjusting for age and height. **Results**: Males showed significantly higher PNIF values than females (158.78 ± 40.97 vs. 113.40 ± 31.93 L/min, $p < 0.001$). Both age and height were found to significantly influence PNIF ($p < 0.001$). After adjusting for these variables, the average difference between genders was 33.82 ± 33.71 L/min. The reference range for males was 121.93 (95% CI: 119.16 - 124.69) to 181.68 (95% CI: 178.92 - 184.45) L/min, and for females, it was 92.53 (95% CI: 90.62 - 94.43) to 143.44 (95% CI: 141.54 - 145.34) L/min. The third PNIF measurement yielded the highest average, which was statistically significantly different from the first and second attempts. **Conclusions**: PNIF is influenced by gender, age, and height. This study provides reference PNIF values for healthy Vietnamese adults, adjusted for these factors.

***Keywords**: peak nasal inspiratory flow, nasal patency, objective measurement, nasal obstruction, age, height, gender.*

1. INTRODUCTION

Nasal obstruction is a frequently encountered symptom in otolaryngology. It can be categorized into two primary etiological groups: mucosal and structural. Evaluation of its severity may involve both subjective assessments and objective measurement techniques. Objective assessment of nasal obstruction can be achieved through rhinomanometry (RMM) and acoustic rhinometry (ARM), which measure the minimum cross-sectional area and nasal volume [1]. Previous research has shown that both RMM and ARM are valuable for monitoring treatment response; however, they do not always correlate well with symptoms associated with nasal obstruction [2]. A notable advantage of RMM is its ability to provide both unilateral nasal airflow and nasal airway resistance (NAR) measurements, as well as total NAR through mathematical integration [3]. Nonetheless, RMM and ARM are relatively costly, technically demanding, time-intensive, and require skilled operators and significant patient cooperation.

First introduced by Youlten in 1980 as a modification of the Wright peak flowmeter, the peak nasal inspiratory flowmeter (PNIF) offers a practical method for assessing nasal patency [4]. PNIF involves forceful nasal inhalation, with the highest airflow recorded, and is a useful tool for evaluating nasal obstruction and rhinitis severity [5]. While normative PNIF values exist for adult Caucasians [6-8], no such data have been reported for the Vietnamese population, despite available reference values for RMM and ARM. This study aimed to establish PNIF reference values for Vietnamese adults and compare them with findings from other populations, while also identifying factors that influence these values.

2. MATERIALS AND METHODS

This prospective cross-sectional study included 300 healthy Vietnamese adults aged 18-88. Participants had no nasal symptoms, no history of asthma or rhinitis, and a SNOT-22 score below 1. Those with prior nasal surgery, recent PNIF was measured using the portable Youlten flowmeter (Clement Clark International, Harlow, UK). Properly fitting masks were used to avoid contact with the nasal alae and were disinfected with 70% alcohol before each use. Participants were seated and instructed to inhale forcefully through the nose after full exhalation, keeping their mouths closed (Figure 1). Three successful attempts were recorded, and

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the highest value was taken as PNIF. The procedure followed standard PNIF measurement protocols [6].

Figure 1. PNIF application

The study was approved by the ethics committee of Hue University of Medicine and Pharmacy (IRB number: H2023/457), adhered to the Declaration of Helsinki, and obtained written informed consent from all participants.

Statistical analysis

Statistical analysis was performed using Stata version 18 (StataCorp, College Station, TX, USA). Age and height were summarized as mean ± standard deviation (SD). Regression analysis was used to evaluate their influence on PNIF. Significant sex-based differences in PNIF, even after adjusting for age and height, led to the development of separate reference ranges for males and females using sex-specific general linear models. These models included age and height to predict PNIF, and reference ranges (mean ± 1.96 SD) with 95% confidence intervals were calculated assuming a normal distribution. Both adjusted and unadjusted reference ranges were reported. Overall PNIF values were also expressed as mean ± SD. A paired t-test was used to compare repeated PNIF measurements, with $p < 0.05$ considered statistically significant.

3. RESULTS

Out of the 300 healthy participants, 119 were males and 181 were females. The average age and height (mean ± SD) for males were 33.42 ± 16.43 years and 167.78 ± 5.84 cm, while for females, they were 37.15 ± 18.50 years and 156.51 ± 5.63 cm, respectively (Table 1). The distribution of PNIF by gender is shown in Figure 2.

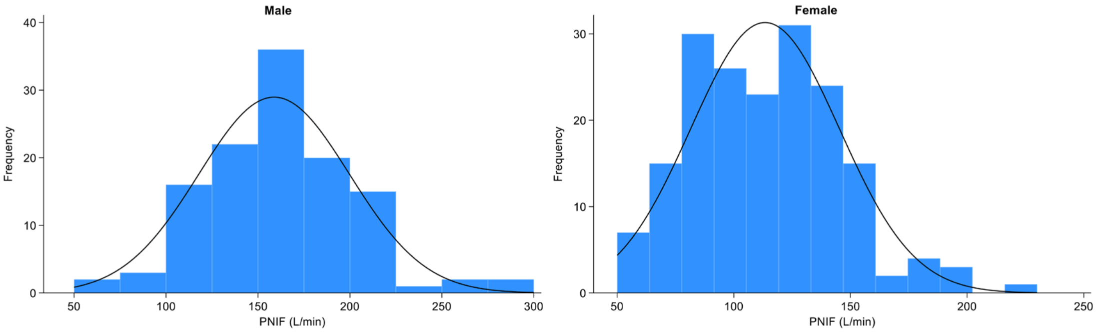

Figure 2. Distribution of peak nasal inspiratory flow by gender

PNIF values increased with repeated attempts, especially after the initial trial. The mean PNIF on the third attempt (PNIF3) was the highest and showed a statistically significant difference compared to both the first (PNIF1) and second (PNIF2) attempts ($p < 0.01$) (Table 1).

Table 1. Demographic and anthropometric data and mean PNIF values

Variable	Male (n = 119)	Female (n = 181)	Total (n = 300)
Age (years)	33.42 ± 16.43	37.15 ± 18.50	35.67 ± 17.78
Height (cm)	167.78 ± 5.84	156.51 ± 5.63	160.98 ± 7.94
PNIF1 (L/min)	147.48 ± 39.03	103.81 ± 30.18	121.13 (40.06)
PNIF2 (L/min)	152.35 ± 39.76	107.96 ± 31.02	125.57 ± 40.94
PNIF3 (L/min)	155.71 ± 41.69	110.99 ± 32.30	128.73 ± 42.36
PNIF (L/min)	158.78 ± 40.97	113.40 ± 31.93	131.40 ± 42.08

Results are given as the mean ± standard deviation

PNIF maximum values (mean ± SD) were 158.78 ± 40.97 L/min in males and 113.40 ± 31.93 L/min in females. The difference in PNIF between male and female subjects was statistically significant ($p < 0.01$). After adjusting for age and height, the average difference between genders was 33.82 ± 33.71 L/min (Table 2).

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

Gender	Mean (SD)	Mean difference	95% CI	P
Male	158.78 (40.97)			
Female	113.40 (31.93)			
Unadjusted		45.38	42.64 to 48.13	< 0.01
Adjusted for age		42.31	39.55 to 45.06	< 0.01
Adjusted for height		28.87	25.06 to 32.69	< 0.01
Adjusted for age and height		33.82	30.00 to 37.63	< 0.01

Results are given as the mean ± standard deviation

For males, the reference range for PNIF was 121.93 to 181.68 L/min, with 95% confidence intervals (CIs) of 119.16 - 124.69 and 178.92 - 184.45 L/min, respectively. For females, the range was 92.53 to 143.44 L/min, with corresponding 95% CIs of 90.62 - 94.43 and 141.54 - 145.34 L/min. Gender, age, and height had a significant impact on PNIF values (Tables 1 and 2). Figure 3 illustrates the estimated PNIF values along with 95% CIs for each gender, based on specific age and height parameters.

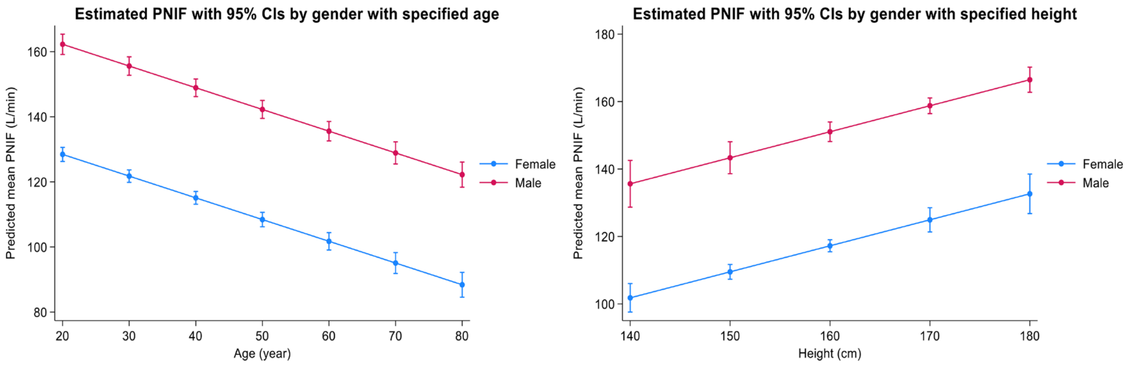

Figure 3. Mean estimates of PNIF for males and females with specified age and height.

4. DISCUSSION

The PNIF values in our study were 158.78 ± 40.97 L/min in males and 113.40 ± 31.93 L/min in females. When compared to international data, our PNIF values were broadly comparable despite demographic and racial differences. A Western study by Ottaviano et al. [6] reported PNIF values of 143 ± 48.6 L/min for males and 121.9 ± 36 L/min for females, showing slightly lower male and slightly higher female values relative to our findings. In contrast, Teixeira et al. [9], in a South American population, observed values of 134.7 ± 43.0 L/min for males and 139 ± 31.8 L/min for females. Interestingly, their female subjects had higher mean PNIF values than males, which diverges from most other reported trends. A study from Thailand reported PNIF values of 139.0 ± 37.6 L/min for males and 97.1 ± 27.1 L/min for females [10], aligning more closely with our gender-based differences but showing overall lower values, particularly among females.

A recent meta-analysis reported a mean PNIF value of 138.4 L/min among individuals without nasal obstruction [5]. In our study, the overall mean PNIF for healthy subjects was 131.40 ± 42.08 L/min (Table 1), which is comparable to the meta-analysis findings. This similarity supports the reliability and validity of our measurements within the broader context of existing literature.

Significant differences in PNIF between males and females were observed, aligning with previous research [6-10]. These discrepancies are plausibly attributable to inherent anatomical and physiological distinctions, including the relatively larger nasal passages and increased pulmonary capacity observed in males. Prior investigations have demonstrated that males typically exhibit greater nasal airway volumes and surface areas, which contribute to diminished nasal resistance and elevated airflow rates [11].

Age and height were also identified as influencing factors in PNIF values. Ottaviano et al. [6] reported age as the most significant determinant, with sex and height contributing to a lesser extent. On the contrary, reports from France showed no influence of age on PNIF [7]. This discrepancy may be attributed to ethnic differences between study populations and the different techniques and number of measurements. Some PNIF studies in children showed that age influenced the PNIF values [12-14].

The results of our study confirm that PNIF is a valuable parameter for assessing the severity of nasal obstruction. Although rhinomanometry is a well-established and validated method for evaluating nasal airway resistance, it has notable limitations. Despite its reliability and safety, the technique is time-intensive, demands specialized expertise, lacks portability, and requires expensive equipment [15]. Consequently, the implementation of a reliable, cost-effective, and easy-to-use alternative, such as PNIF, could provide meaningful clinical advantages.

A major strength of our study is the large sample size, which exceeds those of prior studies conducted in Western and Southeast Asian populations. Furthermore, participants were screened using the SNOT-22 questionnaire to exclude individuals with potential rhinosinusitis, thereby enhancing the reliability of our findings. We also developed multiple predictive models for PNIF values, accounting for potential confounding variables. Finally, we established reference values using both the mean ± 1.96 standard deviations and the 95% reference interval, providing a robust framework for clinical interpretation.

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5. CONCLUSION

In our study, PNIF values were found to be 158.78 ± 40.97 L/min for males and 113.40 ± 31.93 L/min for females, with an overall mean of 131.40 ± 42.08 L/min in healthy Vietnamese adults. These findings may serve as reference standards for the Vietnamese population and, potentially, for other Southeast Asian populations. Clinically, these reference values can aid in assessing the severity of nasal obstruction and in evaluating the efficacy of both medical and surgical treatments. Nevertheless, further studies are necessary to establish the validity and reliability of PNIF as an outcome measure in the management of rhinologic conditions, including nasal obstruction, within the Vietnamese population.

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