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Peak nasal inspiratory flow; normal range in adult population*

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SUMMARY

Aims: *Measurement of Peak Nasal Inspiratory Flow (PNIF) seems to be a cheap, simple, easily performed method to assess nasal patency. The purpose of this study is to establish normative PNIF data for a healthy adult population and provide charts relating PNIF normal values with age, height and sex in adults.*

Methods and results: *Repeated measurements of PNIF were performed in 170 volunteers. In total, 137 of these fulfilled the study criteria (66 females and 50 males) and all of them were non-smokers, non-asthmatic, without nose and paranasal sinuses problems, with ages ranging from 16 to 84 years.*

Data were statistically analysed and tables were produced relating PNIF to age, sex and height. There was no interaction of sex with age or height. There was considerable residual variability of PNIF between individuals not explained by any of the variables studied.

Conclusions: *We conclude that PNIF could be a useful method to study nasal patency in both primary and secondary care to aid diagnosis of nasal disease. The study provides normative data for a Caucasian population.*

Further variables need to be explored to predict expected PNIF values more accurately.

Key words: Peak Nasal Inspiratory Flow, nasal patency, nasal obstruction, normal values, age, height, sex, tables.

INTRODUCTION

Nasal airway obstruction is a common problem in ENT practice. For that reason the measurement of nasal patency has long interested rhinologists and respiratory physiologists. In 1958 modern rhinomanometry (RM) was developed [1] and since then has been used worldwide and remains one of the most recognised benchmarks in modern respiratory physiological research for the measurement of nasal airway resistance [2]. Due to the fact that the rhinomanometer is relatively expensive, complex to use and time-consuming, especially if we test children because of the degree of patient cooperation required, different techniques for assessing nasal patency have been studied, such as the peak nasal flow rate.

In 1973, Taylor et al. [3] described the peak nasal expiratory flow comparable to the method used orally for detecting pulmonary obstruction. They found a good correlation with this method compared to nasal airway resistance, as did Frölund et al.[4].

In 1980, Youlten [5] presented the peak nasal inspiratory flow meter (PNIF), which is a modification of the Wright [6] peak flow meter and consists of a face mask which the patient applies over the nose (without touching it) with the mouth closed. The patient sniffs air through the nose and the peak flow is recorded by a cursor.

Two works [7,8] have independently shown that PNIF is highly correlated with nasal airway resistance and is as good an indication of objective nasal patency as formal rhinomanometry. Another study [9] has demonstrated a good correlation between PNIF and the subjective sensation of nasal patency in adults. Cho et al.[10], in 1997, showed that PNIF is reproducible in the evaluation of nasal airway obstructions.

PNIF is a cheap, simple, easily performed method to assess nasal patency with hygienic advantages over the expiratory flow device,

Prescott CAJ and Prescott KE in 1995 [11] studied the values of PNIF in normal children but there are no reports of any normal values for PNIF in an adult population, so a study was conducted at The Royal National Throat Nose and Ear Hospital, London, UK, to establish baseline normal values in adult subjects.

The purpose of this pilot study is to provide tables relating PNIF normal values with age, height and sex in an adult population.

MATERIALS AND METHODS

Subjects

We recruited 170 subjects ranging from 16 to 84 years old. Of these, 14 women were excluded because they were taking oral

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contraceptives, 11 individuals were excluded because of β-blocker therapy, 4 because of a mean score >1 on SNOT 20 (Rhinitis Quality of Life questionnaire)[12], 2 because of poor collaboration (age of 86 and 84 respectively) which did not allow them to achieve a maximal inspiratory effort, 1 because of oral corticosteroid treatment and 1 because of systemic lupus erythematosus. In total, 137 volunteers were entered into the study and none had complaints of nasal blockage or other nasal symptom. All were non-smokers, non-asthmatic, without any previous surgery to the nose and paranasal sinuses and scored < 1 on SNOT 20.

The population was recruited at the Royal National Throat Nose and Ear Hospital in London from students, members of staff and patients coming because of problems other than the nose.

Measurements

A portable Youlten peak flow meter (Clement Clark International) was used for the measurement of peak inspiratory nasal flow. The masks attached to the spirometer were choosen to fit tightly on each subject's face without touching the nose and were cleaned with swabs saturated with alcohol (Sterets, Seton Healthcare Group pcl) and dried between every subject tested.

Upon enrolment in the study, before starting the test, each subject was asked to complete a SNOT 20 questionnaire. They were asked if they were experiencing nasal blockage or any other nasal problem, 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 SNOT 20, who were non-smokers, non-asthmatic and without any previous surgery at the nose and paranasal sinuses, were asked about age, race and medications used and their height was than measured.

All subjects were tested while sitting and were encouraged to inhale as hard and fast as they could through the mask keeping the mouth closed starting from the end of a full expiration [residual volume (RV) method]. Three satisfactory maximal inspirations were obtained and the highest of the three results was taken as the PNIF. All the assessments were made by the first author (GO).

Table 1. Mean PNIF values at each attempt in males and females.

	Males (n=60)		*Female (n=77)*	
Variable	*Mean*	*SD*	*Mean*	*SD*
Age	43.3	22.1	40.2	18.6
Height	172.6	7.4	161.5	8.7
PNIF1	126.3	46.5	104.5	35.2
PNIF2	142	46.8	119.5	36.6
PNIF3	143	48.6	121.9	36

Statistics

Statistical analysis was undertaken with the objective of obtaining a model relating the variable PNIF to the various explanatory variables available. All of our analyses are based on standard analysis of variance tests. In the simplest case, these are equivalent to standard 2-sided t tests; more generally, the tests comprise comparisons of the ratio of mean regression and mean residual sums of squares to an F distribution with appropriate degress of freedom. Generally, we adopted 5% as the critical level of significance in our tests. We also used standard residual and probability plots to verify the adequacy of the Normality assumption in our models.

RESULTS

PNIF increased with practice, particularly after the first attempt, the mean for PNIF 3 was larger than that for PNIF 1, but was not significantly different from PNIF 2. Table 1 summarises the results of each attempt in males and females.

Figure 1 shows PNIF against age on separate axes for male and female patients. This suggested a general diminution of PNIF with age, and a slight difference between the two sexes, albeit with a large residual variability. This suggests that a straightforward linear regression of PNIF on age, sex and possibly other variables may be inappropriate, or at least inefficient.

To try to reduce this problem of heterogeneity in variability we tried a range of transformations. The most successful was:

$$MODPNIF=(PNIF)^{1/2} \quad (1)$$

i.e a square-root transformation on the response variable

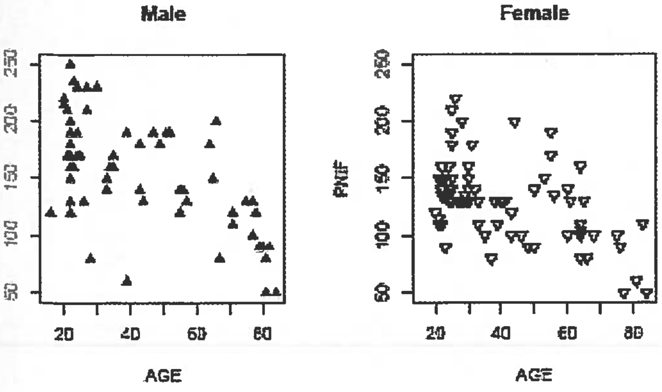

Figure 1. PNIF against age, for male and female subjects.

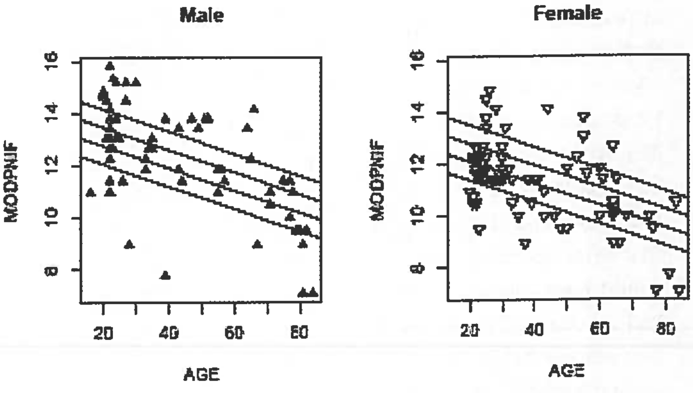

Figure 2. MODPNIF against age, for male and female subjects.

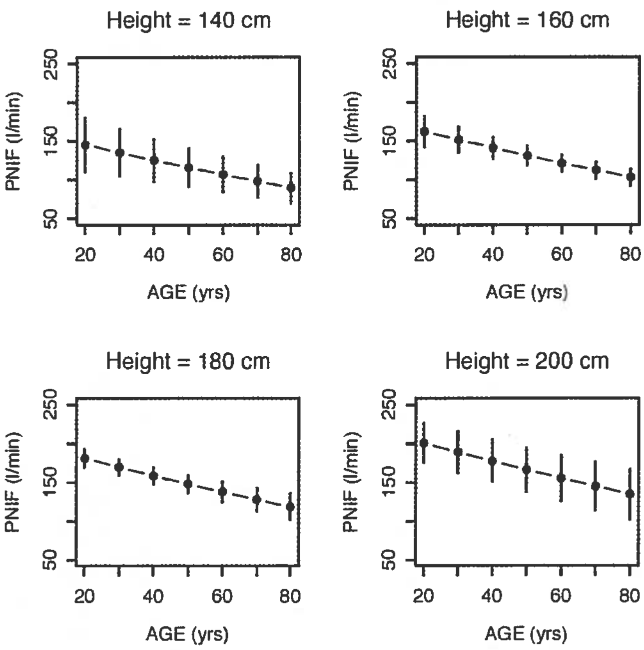

Figure 3a. Mean estimates of PNIF for males with specified age (years) and height (cm).

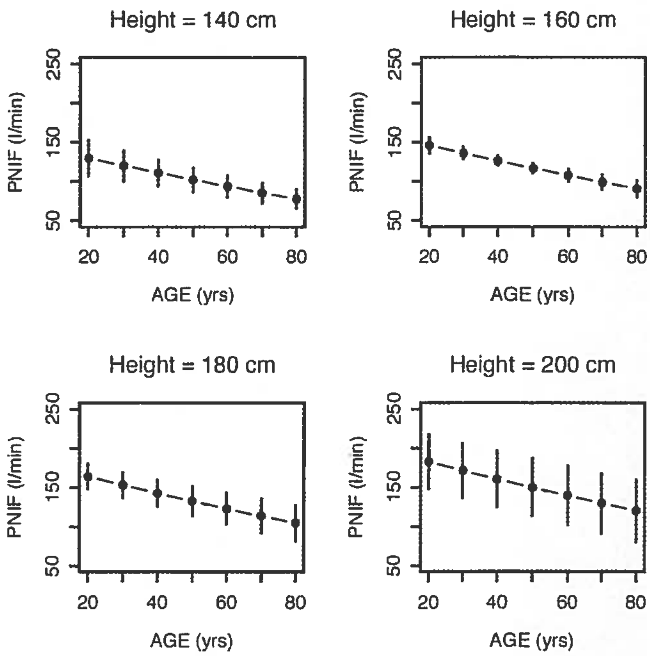

Figure 3b. Mean estimates of PNIF for females with specified age (years) and height (cm).

PNIF.

A plot of this variable against age, for each sex, is shown in Figure 2. We have included on this figure the mean estimates of PNIF for subjects for respective heights 140, 160, 180 and 200 cm. On this scale there was a much reduced heterogeneity in variance with age, hence our subsequent modelling used the transformed variable MODPNIF.

Having explored various model structures, the most appropriate seems to be

$$MODPNIF = \mu + \beta Im + \gamma AGE + \tau HEIGHT + \varepsilon \qquad (2)$$

in which Im is an indicator variable that takes the value of 1 for a male subject and 0 for a female subject, and ε is a Normal random variable with variance σ^2. Models with greater complexity, including additional variables, or with interaction terms were found to provide no significant improvement. In particular, this implies that the effect of age and height can be taken as common for the two sexes.

From this it seems that age is strongly significant, but sex and height are only marginally significant. The picture is clearer however from an analysis of variance.

It is now clear that sex is highly significant to the model, but that after its inclusion, the effect of height is reduced. We would have found a similar result with the variables reversed, had we changed the order of variable input. Consequently, neither sex nor height is crucial to the model, but the effect of the second variable after the inclusion of the other is less critical. Nonetheless, even after the inclusion of sex, the effect of height remains marginally significant, though not quite at the 5% level. However, given the scientific plausibility of an effect due to height our preference was to keep it in the model, despite its marginal significance.

	Estimate	Std. Error	t value	Pr(>[t])
Intercept	7.29677	3.21672	2.268	0.0249
AGE	-0.04292	0.00758	-5.663	8.8e-08
SEXM	0.65957	0.33742	1.955	0.0527
HEIGHT	0.03529	0.01877	1.880	0.0623

Model estimate summary

In Figure 3 we show the mean estimate of PNIF at specified age and heights.

One disadvantage of the fitted model is that it expresses the mean relationship for MODPNIF rather than PNIF, whereas PNIF is the variable more commonly used in Clinic.

However, since:

$$PNIF = (MODPNIF)^2,$$

we can use the relationship:

$$E(PNIF) = \{E(MODPNIF)\}^2 + Var(MODPNIF)$$

which is valid for all values of the covariates and where the expectation and variance on the right hand side of this expression are obtained immediately from the least squares regression.

This leads to the relationship between PNIF and the various explanatory variables.
Additionally:

$$Var(PNIF) \oplus 4(MODPNIF)^2 * Var(MODPNIF)$$

for every combination of covariates. Hence, again using the variance computations from the regression of MODPNIF, we can obtain variance, standard error and consequently confidence interval calculations for PNIF.
On this basis, Figure 3 shows 95% confidence intervals for the mean levels of PNIF at a variety of covariate combinations.

DISCUSSION

It is of considerable value to assess the degree of nasal obstruction.
Rhinomanometry is a well established method to assess nasal airway resistance. Although it is an acceptable and safe method to assess nasal airway obstruction with a small error of the method, it is time-consuming, needs experience, is not easily transportable and the equipment is rather expensive. The use of a reliable, cheap and simple method for assessing nasal airway obstruction would be of value [7].

The purposes of this pilot study in adults were:

- to see if there is any relation between PNIF with the variables of age, height and sex
- provide tables relating PNIF normal values with age, height and sex in an adult population.

Recently, Blomgren et al. [13] have reported that height and age showed no appreciable association with PNIF In contrast to this, our study shows that studying adult healthy volunteers, without nasal blockage or any other nasal symptom, who were non-smokers, non-asthmatic, without any previous surgery to the nose and paranasal sinuses, the effect of the three variables is significant, in particular the effect of age and sex. We suggest that the difference in our results could be attributable to technique with careful performance of the PNIF manoeuvre holding the mask tightly on the face and encouraging maximal inspiratory effort. The effect of learning by the patient can be seen in the difference between the first and second PNIF recordings.
Although the study has not been conducted upon a population based group, we believe that, as it is extremely difficult to find an ideal normal population, it is a reasonable compromise to use the most accessible group of volunteers. Thus, we can consider these data as preliminary, but nonetheless of importance as they address an area of need in rhinology.
We can conclude that the measure of PNIF could be useful for allergologists and rhinologists for assessing nasal patency in diagnosis eg for nasal provocation and for pre- and post- therapeutic assessment even in the home enviroment. Finally, it could also be useful for general practitioners as a method for diagnosis and follow-up of nasal diseases in primary care.

We believe that the tables presented in this work will be of help as a reference for the normal PNIF ranges for any doctor attempting to study nasal patency in a Caucasian population. However, further variables may exist which can refine the modelling of this data. We believe that more studies have to be done on this topic and we propose to undertake a study including pulmonary function studies for this purpose and to consider the effects of ethnicity.

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