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An attempt to estimate parameters useful for establishing a normal range for peak nasal inspiratory flow

Próba oceny parametrów przydatnych do wyznaczenia normy dla nosowego szczytowego przepływu wdechowego

Abstract

Introduction: Measurement of peak nasal inspiratory flow (PNIF) has gained wide acceptance among clinicians due to its simplicity. Unfortunately, due to the lack of reference values, a single measurement does not provide any relevant information on the degree of nasal obstruction. We have therefore attempted to evaluate parameters that would be useful for establishing reference ranges for PNIF.

Material and methods: The study was a part of an epidemiological study ECAP (*Epidemiologia Chorób Alergicznych w Polsce* [*The Epidemiology of Allergic Diseases in Poland*]). Inhabitants of Wrocław, Poland, aged 6–7, 13–14 and 20–45 years were randomly selected for the study. All the subjects had their medical history taken and their PNIF measured (using an In-Check inspiratory flow meter manufactured by Clement-Clark). Patients with a diagnosis of rhinitis and/or asthma were excluded from the study. In each subject, the highest of the five measurements (PNIF MAX) was included in the analysis.

Results: A total of 221 healthy individuals were enrolled in the study. PNIF MAX differed significantly between females and males. A significant correlation was observed between height and PNIF MAX, although no such correlation was found between age and PNIF MAX. For this reason, in order to establish a reference range for PNIF, a regression equation that included sex and height was analysed. The following relationship was arrived at: PNIF MAX $= -137.7 - 22.5x + 1.7y$, where x is the sex (1 for females and 0 for males) and y is the height. The coefficient of determination (R^2) for this relationship was 0.45, which means that the regression equation explains about 45% of the observed variability of PNIF MAX.

Conclusions: We found that PNIF MAX correlated with sex and height and that it did not correlate with age. The difficulties in establishing normal ranges for PNIF are most likely due to the differences in nasal anatomy between the subjects.

Key words: PNIF, reference values, nasal obstruction

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Introduction

Obstruction of nasal passages is a common symptom of rhinitis. The degree of obstruction is difficult to establish through physical examination. Objective methods of measurement, such as rhinomanometry, are therefore used. Because rhinomanometry requires specialist equipment and the interpretation of results is difficult, this method is not in widespread use.

The measurement of peak nasal inspiratory flow (PNIF) has gained wide acceptance among clinicians thanks to its simplicity and the use of an

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easy-to-operate portable measuring device. PNIF is the simplest measure of nasal obstruction and may also be determined at home. Unfortunately, due to the lack of normal ranges, a single measurement does not provide any relevant information on nasal obstruction. This does not diminish the significance of widespread use of multiple measurements of this parameter in challenge tests or in the evaluation of therapeutic effects of drugs [1–6].

We therefore attempted to evaluate some of the parameters that would potentially be useful for establishing reference ranges for PNIF.

Material and methods

The study was a part of an epidemiological study ECAP (*Epidemiologia Chorób Alergicznych w Polsce* [*The Epidemiology of Allergic Diseases in Poland*]). Children aged 6–7 and 13–14 years and adults aged 20–45 years, all inhabitants of Wrocław, Poland, were randomly selected for the study. The study sample was compiled by random selection of PESEL numbers.

Each subject had his or her medical history taken, had their PNIF measured and underwent anterior rhinoscopy. Individuals with a diagnosis of rhinitis and/or asthma were excluded from the study. PNIF was measured with an In-Check inspiratory flow meter manufactured by Clement-Clark. Each subject received appropriate instructions and took five measurements under supervision of a doctor. The highest of the five recorded measurements (PNIF MAX) was included in the analysis.

The results were compiled using Statistica 9. The normality of the distribution was checked with the Shapiro-Wilk test. As the investigated parameters did not show a normal distribution, non-parametric tests were used for comparisons. The investigated parameters were described by median, minimum and maximum values (Me, Min–Max). The comparison of two independent samples was performed using the Kolmogorov-Smirnov test, while the Wilcoxon signed-rank test was used for dependent samples. The comparisons of three groups of patients were performed using Kruskal-Wallis ANOVA or Friedman ANOVA. A regression equation was used to establish the reference ranges.

The study was approved by the Medical University of Warsaw Bioethics Committee and the Chief Inspector for Personal Data Protection. The subjects gave written consent to participate in the study.

Results

A total of 333 subjects (including 174 [52%] females) completed the study. Ninety-one of them gave a history of symptoms suggestive of rhinitis or asthma and were excluded from further participation. Table 1 summarises the characteristics of the remaining 221 healthy subjects. The study subjects were divided into three age groups: younger children (6–8 years of age), older children (13–14 years of age) and adults (20–45 years of age).

All the subjects measured their PNIF for the first time in their lives. Each subject performed a total of five measurements and the highest value (PNIF MAX) was included in further analysis. Figure 1 shows histograms for PNIF MAX in specific groups of the subjects.

PNIF MAX differed significantly between the group of females and the group of males. A statistically significant correlation was observed between height and PNIF MAX, although no such correlation was found between age and PNIF MAX. For this reason, in order to establish a reference range for PNIF, a regression equation that included sex and height was analysed. Figure 2 shows scatterplots of PNIF MAX values relative to height in the group of females and in the group of males.

The following relationship was arrived at: PNIF MAX = –137.7 – 22.5x + 1.7y, where x is the sex (1 for females and 0 for males) and y is the height. The coefficient of determination (R^2) for this relationship was 0.45, which means that the regression equation explains about 45% of the observed variability of PNIF MAX.

Discussion

Measurement of PNIF has become widely used in clinical practice to assess the degree of nasal obstruction despite multiple problems encountered while interpreting the results. Concerns are raised by the repeatability of the measurements, correlation of the result with the severity of symptoms assessed by the patients and, most importantly, by the lack of defined reference ranges for this parameter. In 2006, the attempt to establish the reference ranges in a group of 170 healthy individuals failed due to the considerable variability of PNIF between the subjects [7].

A smaller study led to similar results: statistically significant differences between men and women, a correlation between PNIF and height and the lack of correlation between PNIF and age. However, the regression equation with these variables describes a mere 45% of the values obtained. This may be associated with a correlation between PNIF and other parameters, such as spirometric parameters, for instance. Such a correlation was found in a study published in 2005 [1]. The study showed a

Table 1. Characteristics of the patients according to age and sex

The test parameter	Median	Minimum	Maximum	Mean ± SD
		Total (n = 221)		
Age (y)	14	6	54	17,5 ± 11,2
Height [cm]	163	108	191	154,7 ± 20,7
PNIF MAX [l/min]	110	40	320	121,6 ± 58,5
		Children 6 years (n = 73)		
Age (y)	7	6	8	6,6 ± 0,6
Height [cm]	128	108	140	125,9 ± 7,1
PNIF MAX [l/min]	70	40	170	75,0 ± 23,6
		Children 13 years (n = 82)		
Age (y)	14	11	15	13,6 ± 0,7
Height [cm]	165	145	191	165,0 ± 8,4
PNIF MAX [l/min]	130	50	290	134,2 ± 53,4
		Adults 20 years (n = 66)		
Age (y)	29	20	54	30,7 ± 8,1
Height [cm]	168	154	190	169,3 ± 8,4
PNIF MAX [l/min]	132	40	320	151,1 ± 59,4
		Female (n = 108)		
The test parameter	**Median**	**Minimum**	**Maximum**	**Mean ± SD**
	Total (n = 108)			
Age (y)	14	6	54	19,5 ± 11,5
Height [cm]	162	108	180	155,4 ± 17,4
PNIF MAX [l/min]	105	40	220	109,4 ± 42,6
		Children 6 years (n = 41)		
Age (y)	7	6	8	6,48 ± 0,57
Height [cm]	125	108	140	125,37 ± 7,5
PNIF MAX [l/min]	60	40	90	59,4,0 ± 14,6
		Children 13 years (n = 38)		
Age (y)	14	13	15	13,6 ± 0,6
Height [cm]	164	150	175	162,9 ± 6,7
PNIF MAX [l/min]	100	40	160	120,3 ± 31,9
		Adults 20 years (n = 29)		
Age (y)	31	20	54	31,5 ± 7,9
Height [cm]	165,5	125	189	165,2 ± 8,6
PNIF MAX [l/min]	180	40	220	140,1 ± 38,1
		Male (n = 113)		
The test parameter	**Median**	**Minimum**	**Maximum**	**Mean ± SD**
		Total (n = 113)		
Age (y)	13	6	44	15,2 ± 10,1
Height [cm]	163	110	191	155,0 ± 24,1
PNIF MAX [l/min]	110	40	320	131,1 ± 66,8
		Children 6 years (n = 32)		
Age (y)	7	6	8	6,74 ± 0,65
Height [cm]	127	111	140	125,6 ± 7,1
PNIF MAX [l/min]	70	40	170	75,0 ± 23,6
		Children 13 years (n = 44)		
Age (y)	14	13	15	13,59 ± 0,6
Height [cm]	172	147	191	169,0 ± 10,0
PNIF MAX [l/min]	120	60	290	141,2 ± 65,5
		Adults 20 years (n = 37)		
Age (y)	30	20	44	30,7 ± 8,1
Height [cm]	177	156	190	169,3 ± 8,4
PNIF MAX [l/min]	150	80	320	166,6 ± 57,4

PNIF MAX — maximum peak nasal inspiratory flow; SD — standard deviation

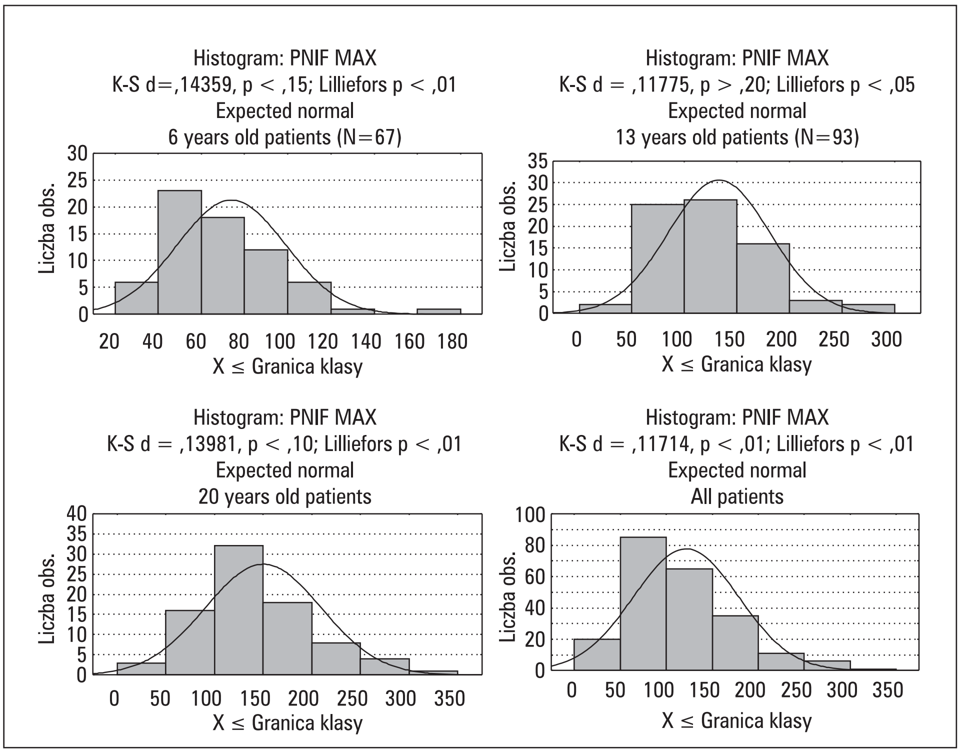

Figure 1. Histograms of maximum peak nasal inspiratory flow — total sample and groups

correlation between PNIF and forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1). This correlation is, however, weak and accounts for a small part of the PNIF variability (15%).

It seems that a significant role in PNIF variability may be played by differences in nasal anatomy between the subjects, which may also be supported by the large range of PNIF values in the group of adults (40–320 ml/s). In this case establishing reference ranges for this parameter would be impossible. However, this does not diminish the usefulness of PNIF measurement in the assessment of nasal obstruction in a given person after the personal best has been determined. The change in PNIF is most commonly used in practice to confirm an increasing nasal obstruction in challenge testing.

Conclusions

1. A correlation between PNIF and sex and between PNIF and height has been found with no correlation being observed between PNIF and age.
2. The difficulties in establishing reference ranges for PNIF are most likely a result of the differences in nasal anatomy between individual subjects. It therefore seems that reference ranges established in population studies taking into account age and height cannot be characterised by satisfactory accuracy.
3. PNIF may be a valuable measure used to objectify the assessment of the clinical course of rhinitis but only after the so-called personal best has been determined.

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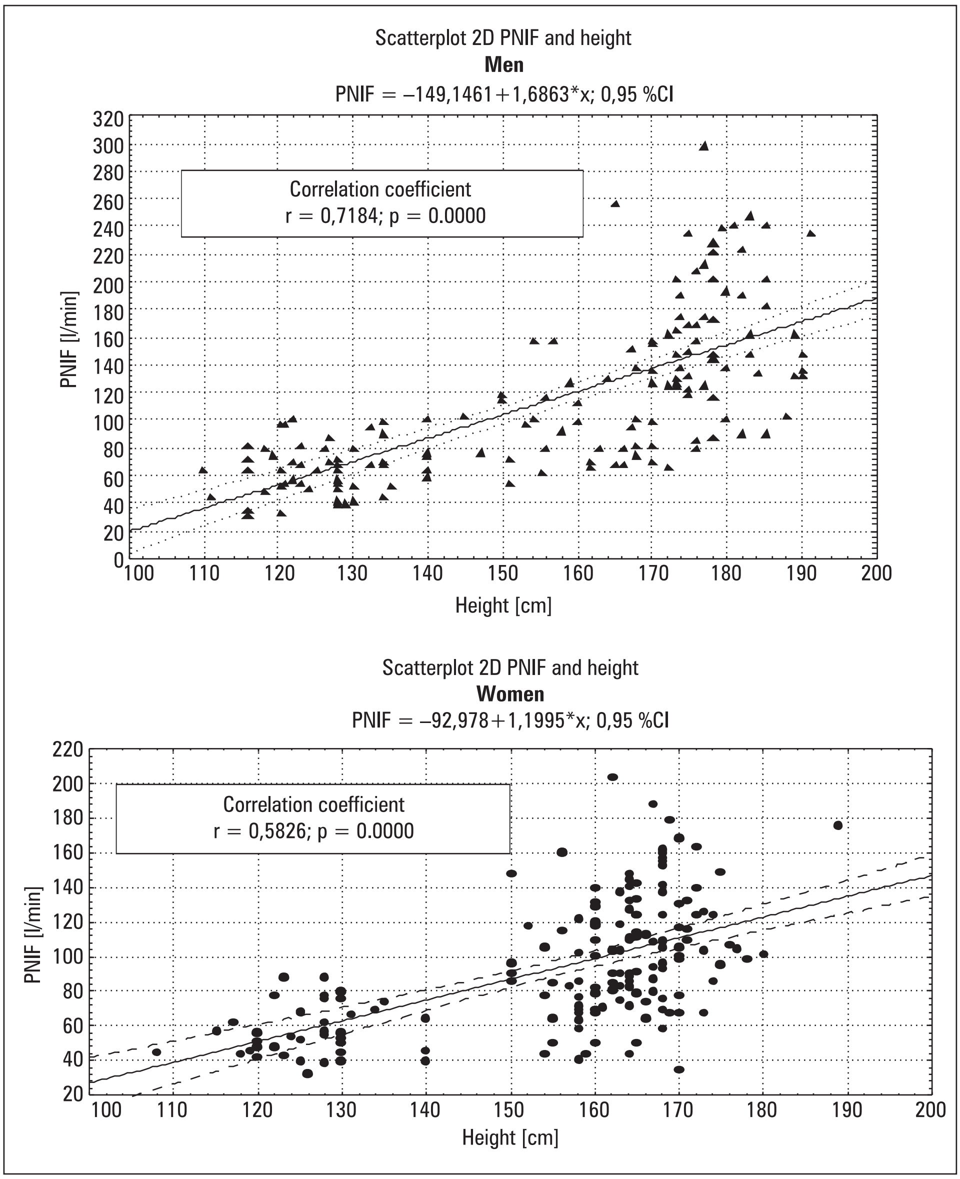

Figure 2. Scatterplots of peak nasal inspiratory flow depending on the height in women and men