ORIGINAL ARTICLE

Normal peak nasal inspiratory flow rate values in Greek children and adolescents

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Abstract

Background and aim: Peak Nasal Inspiratory Flow Rate (PNIFR) is a clinical trial that has been instituted in clinical practice in order to determine the extent of nasal airway patency and it is used to assess the degree of nasal obstruction. This study attempts to provide tables referring to normal values of PNIFR in children and adolescents.

Patients and Methods: Three thousand one hundred and seventy pupils aged between 5 – 18 years, were selected to enter the study. Children with acute or chronic upper airway obstruction, such as acute obstructive pulmonary disease or allergic rhinitis and children below the 3rd percentile for weight and/or height were excluded from the study. All children that took part in the study were subjected to PNIFR measurements by using a portable Youlten Peak Flow meter.

Results: A continuous increase of PNIFR values for boys and girls in relation to age increase was recorded. PNIFR values were higher in boys compared to girls and this difference was statistically significant until the age of 12.

Conclusion: Normal ranges for PNIFR standards are of great importance for the study of nasal patency, evaluation of the degree of nasal obstruction and application of treatment. This is the first time that a detailed description of PNIFR standards becomes available for the Greek population of children and adolescents. Hippokratia 2008; 12 (2): 94-102

Key words: nasal inspiratory flow rate, normal values, children, adolescents

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Nasal obstruction, may be related to age, body position, rhinic cycle or may be due to the presence of infection (tonsillitis, infection of adenoids), tonsilar or adenoidal hypertrophy, nasal polyps and allergies[1]. A positive family history should also be considered as an important risk factor of nasal obstruction[2]. Rhinoscopy is a reliable examination in order to decide the degree of nasal patency. The measurement of Peak Expiratory Flow Rate (PEFR) is a non-specific way to evaluate the presence of obstructive pulmonary disease and its response to treatment. The Peak Nasal Inspiratory Flow Rate (PNIFR) is an objective measurement for nasal obstruction and response to treatment regardless the etiology[3-8].

It is a useful test for patients suffering from allergic rhinitis, for establishing the diagnosis and for monitoring treatment efficacy[4,9] and furthermore, it is a useful clinical tool to study various environmental factors that may cause nasal obstruction at home or at work[10], or for deciding bronchial asthma treatment[11].

In this retrospective study, we estimated the normal range of PNIFR values in Greek children according to age and sex and established the standards for Greek children.

Patients – Methods

Four thousand one hundred eleven children (2010 boys and 2101 girls) aged between 5-18 years were examined. Children younger than 5 years old were excluded, as they could not follow the instructions. Of them 941 children (489 boys and 462 girls) or 22.88% (24.32% of the boys and 21.51% of the girls) were excluded from the study (Table 1). Eligibility was based on the European Respiratory Society (ERS) criteria for population studies[12] (Table 2).

Table 1. Needed criteria to include children and adolescents to the study according to European Respiratory Society (ERS).

1. Absence of acute disease.
2. No chest malformations, congenital abnormalities or respiratory tract diseases.
3. No cardiovascular or neuromuscular system diseases.
4. Free from symptoms of allergic rhinitis for the last 12 months.
5. Somatometric parameters above the 3rd percentile.

Three thousand one hundred and seventy (3170) children (1521 boys and 1649 girls) were selected for the

Table 2. Number of children who took part, excluded from or included in the statistical analysis of our study according to sex.

	Number of children participating	Number of children excluded	Number of children included
BOYS	2010	489 (24.32 %)	1521
GIRLS	2101	452 (21.51 %)	1649
TOTAL	4111	941 (22.88 %)	3170

study. Authorities of the primary and high school supported the survey. Parental consensus was obtained. Parents were informed about the study and had to answer a questionnaire 2 or 3 days before their child's clinical examination. Following the recommendations of ISAAC (International Study of Allergy and Asthma in Children)[13,14] the questions were simply-worded and understandable, without the use of any medical terms. Each clinical examination took place in a classroom that was properly ventilated and had the appropriate temperature of 22-23° C. Children had to rest for at least 30 minutes before the examination.

The children were dressed with their usual clothes, did not wear shoes and were in upright position when subjected to the test, as suggested in current literature[15].

The Seca Model 713 was used for height and weight measurement, as proposed by previous studies[16].

PNIFR measurements were performed with a Youlten Peak flow meter[9], which is similar to a mini-Wright flow meter. Peak Nasal Inspiratory Flow Rate expressed in L/min is defined as the maximal instantaneous airflow achieved during forced inspiration through the nose. Asking the patient to take a deep, quick forced inspiration after having expired normally, performs the test. The amount of air left in the lungs after a tidal breath out is the Functional Residual Volume (FRV). Then the patient is instructed to inspire deeply through the nose, so that the Total Lung Capacity (TLC) is achieved. Total Lung Capacity (TLC) is the total volume of gas contained in the lungs at the end of a maximal inspiration[1,3]. The apparatus function was demonstrated and each pupil was instructed how to inhale forcefully. It is known that the number of attempts a child has to do in order to achieve the best score is inversely proportional to the child's age. Younger children may achieve the best score after the fourth or fifth attempt. The literature indicates that 5 repeated nasal inspirations do not obstruct nose vessels and do not affect the child's score. In our study, all children made 3 attempts of inspiration but only the best score was registered for each child as recommended in the literature [9,17-23]. The Youlten Peak flow meter is a rather inexpensive portable device which is easy to use and which should be available, in clinical practice, to all physicians.

Statistical analysis of recorded PNIFR included the estimation of mean, SD, SE and median values corresponding to the 50th percentile value of PNIFR. Curves for the 3rd, 5th, 95th and 97th percentiles values of PNIFR were calculated too[24]. Analysis of variance (ANOVA) was used to test hypothesis concerning means. Following that, correlation coefficients were calculated and the statistical significance of the Pearson correlation coefficient (R) was separately evaluated for boys, girls and for the total number of subjects. $P < 0.05$ was considered to be significant.

Results

The mean values of PNIFR, SD, SE and 95% confidence intervals for boys and girls according to their age are shown in Table 3.

PNIFR values for each percentile for boys and girls in relation to their age are shown in Table 4. A continuous increase of PNIFR values for boys and girls was observed in relation to age increase.

Figure 1 represents the mean PNIFR values for boys and girls when establishing 95% limits of significance. Boys achieved slightly greater scores compared to girls. The difference between boys and girls became statistically significant after the age of 12 ($p<0.05$).

Table 3. Number of children of each group (No), mean, standard deviation (sd), standard error (se) and the 95% confidence interval (CI) for **PNIFR** (L/min) for boys (B) and girls (G) according to their age (per year).

Age	Sex	No	Mean	Sd	Se	95%CI	
5-6	B	24	79.6	28.1	5.7	67.7	91.4
	G	23	80.4	29.9	6.2	67.5	93.4
6-7	B	99	100.1	34.2	3.4	93.3	106.9
	G	98	95.3	31.6	3.2	88.9	101.6
7-8	B	106	110.9	29.5	2.9	105.3	116.6
	G	128	100.0	30.9	2.7	96.6	108.5
8-9	B	105	115.0	32.8	3.2	108.7	121.3
	G	110	107.6	33.3	3.2	101.3	113.9
9-10	B	126	118.7	37.2	3.3	112.1	125.2
	G	120	110.4	38.7	3.5	103.4	117.4
10-11	B	117	131.4	35.3	3.3	124.9	137.9
	G	145	126.9	39.2	3.3	120.4	133.3
11-12	B	158	149.8	38.0	3.0	143.9	155.8
	G	136	145.0	40.9	3.5	138.1	152.0
12-13	B	148	168.7	27.4	2.3	164.3	173.2
	G	170	155.6	23.6	1.8	150.0	162.2
13-14	B	147	181.9	30.9	2.5	176.9	186.9
	G	179	160.2	29.2	2.2	155.9	165.5
14-15	B	171	190.0	33.9	2.6	184.9	195.1
	G	160	164.6	30.2	2.4	159.8	169.3
15-16	B	146	199.0	42.5	3.5	192.0	205.9
	G	180	168.7	33.4	2.5	162.8	173.6
16-17	B	125	204.3	40.3	3.6	197.2	211.4
	G	140	170.9	33.5	2.8	165.3	176.5
17-18	B	49	205.8	35.2	5.0	195.7	215.9
	G	60	172.5	30.4	3.9	164.6	179.4

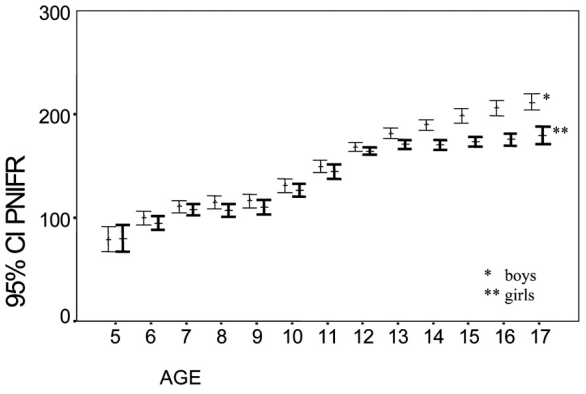

Figure 1. Mean and 95% confidence interval (CI) for PNIFR according to the age (years) for both sexes (boys I. girls **I).**

Discussion

Result interpretation, following examinations of the respiratory system, requires the standards of the reference population. Reference of measured variables to population standards will help doctors to decide if there is aberration from the normal. Accurately defined population standards are of great importance.

The term standardized values has been widely used and has substituted the term normal values. The term standardized has been considered as correct since it is very difficult to define accurately the concept of being normal. Measurements characterized as standardized reflect the effort to establish new values and to modify old tables, because the somatometric parameters of the individuals change as time goes by[14,25].

Variable deviation from the normal may be attributed to many factors (technological, biological, environmental)[26,27]. Technological factors that may alter a result may be attributed to the accuracy of the apparatus, to the cooperation between the doctor and the patient and to the posture of the body and head's position during the clinical examination[26,28]. Biological factors affecting the normal values are somatometric parameters such as weight, height and race[25-29]. Finally, environmental factors may also be considered, such as the region's altitude, passive smoking and socioeconomic background[30].

During the last few years many researchers resorted to the PNIFR for evaluating nasal patency by using Youlten Peak Flow meter and they have proved that this method is reliable[4,9-11]. Many recent studies have shown that the two techniques are similar, easy to perform and inexpensive[18,19,31-33]. According to Wihl et al[31] repeated PNIFR measurements had a difference of 5 L/min the one from another. Gleeson et al[18] similarly to rhinomanometry have also demonstrated high accuracy in PNIFR measurements.

In clinical practice these measurements are used in order to confirm diagnosis of a respiratory tract disease or to monitor treatment efficacy. PNIFR population measurements are considered normally distributed data and the sampling distribution represented in a normal curve can be used to test hypothesis about means. Confidence intervals for each sample mean is the sample mean plus or minus 2 times the standard deviation[24,34] for the 95% confidence interval (mean ± 2sd). So, 95% of the normally distributed cases lie within the confidence limits. When a value lies out this confidence interval, then percentiles should be used in order to characterize the result as normal or abnormal.

Our results have shown that PNIFR values tend to increase in proportion with age for boys and girls. There is no statistically significant difference in the mean value of one age group (annual distribution) compared to the next age group between children of the same sex (Graph 1). The increase is in a small range in girls after the age of 13 years, while in boys it keeps increasing in the same range until the age of 17-18 years according to our study. This may be attributed to the fact that girls do not grow taller after the age of 13 years. Other investigators, who found that lung volumes increase in relation to age, reported similar observation. Aivazis et al[28] and Barbarousis et al[35] reported that lung volumes in girls stop increasing after the age of 14 years and it was attributed to small changes of their height after this age[25, 27, 28]. Comparing PNIFR values between boys and girls we see that boys, in all age groups, have higher scores compared to girls, with the exception of the 5-6 years age group where PNIFR values for girls are slightly higher compared to those for boys.

Table 4. Number of children (No) of each group and percentiles for **PNIFR** (L/min) for boys and girls according to their age (per year).

Age	Sex	No	3rd percentile	5th percentile	50th percentile	95th percentile	97th percentile
5-6	B	24	40.0	42.5	75.0	120.0	140.0
	G	23	40.0	50.0	80.0	130.0	135.0
6-7	B	99	50.0	55.0	95.0	140.0	150.0
	G	98	45.0	55.0	90.0	140.0	145.2
7-8	B	106	60.0	65.0	110.0	150.0	157.9
	G	128	50.0	60.5	95.0	150.0	155.0
8-9	B	105	65.9	70.0	115.0	160.0	170.0
	G	110	55.7	62.8	100.0	160.0	165.0
9-10	B	126	70.1	75.0	120.0	170.0	180.0
	G	120	60.0	65.0	110.0	170.5	175.0
10-11	B	117	75.0	80.5	140.0	185.0	195.0
	G	145	66.3	70.0	120.0	180.0	190.0
11-12	B	158	80.0	89.8	157.5	200.0	210.0
	G	136	70.0	80.0	150.0	200.0	205.9
12-13	B	148	110.0	124.5	170.0	220.0	230.0
	G	170	90.0	90.0	160.0	205.0	208.0
13-14	B	147	118.8	130.0	180.0	230.0	245.6
	G	179	95.0	100.0	170.0	210.0	220.0
14-15	B	171	125.0	140.0	190.0	250.0	270.0
	G	160	100.0	110.0	175.0	220.0	230.0
15-16	B	146	128.2	145.5	195.0	266.5	290.9
	G	180	102.0	115.0	180.0	230.0	235.7
16-17	B	125	135.0	150.0	200.0	277.0	302.2
	G	140	104.0	120.0	185.0	235.5	240.0
17-18	B	49	140.0	155.0	205.0	280.0	320.0
	G	60	104.9	120.5	190.0	239.5	243.1

PNIFR values for boys becomes statistically significantly higher after the age of 12 years ($p<0.001$).

To our knowledge, there are no references in Greek and international literature concerning PNIFR standards for children until now. All references available concern small groups of adults who had treatment with different drugs, especially those suffering from diseases that affect patency of the upper respiratory track system[36-40]. We, therefore, consider this study as the first internationally that attempts to assign PNIFR standards for children and adolescents in Greece and to provide an objective measure to all physicians for evaluating nasal airway patency in a relatively simple and inexpensive manner.

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