Assessing nasal resistance in Japanese children by active anterior rhinomanometry

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Abstract

Objectives: The mean bilateral nasal resistance in normal Japanese adults is 0.25±0.12 Pa/cm^3/s, but this value in children remains unknown. This study aimed to determine the mean nasal resistance values in Japanese children.

Methods: We measured nasal resistance in a normal rhinosinal status and rhinosinal morbidity in elementary school children by active anterior rhinomanometry. We used a nasal nozzle that has been recommended for the standard measurement of nasal resistance by the Japanese Standardization Committee on Rhinomanometry.

Results: The mean value of bilateral nasal resistance at ΔP 100 Pa in 1204 normal children was 0.35±0.13 Pa/cm^3/s on inspiration and 0.37±0.14 Pa/cm^3/s on expiration (ΔP is an abbreviation for the pressure gradient). Nasal resistance in children decreased with growth, making it difficult to determine a single value of nasal resistance in normal children. The mean value of bilateral nasal resistance at ΔP 100 Pa in 838 children with nasal problems, including marked adenoidal hypertrophy, was 0.56±0.87 Pa/cm^3/s on inspiration and 0.55±0.47 Pa/cm^3/s on expiration.

Conclusions: Bilateral nasal resistance is significantly greater in children with nasal morbidity than in normal children. Additionally, nasal resistance in normal children is best assessed according to the body height category.

Keywords: Nasal resistance, Rhinomanometry, Nasal patency, Children, Japanese

Introduction

Rhinomanometry is well established for the objective assessment of nasal patency and has contributed to understanding of nasal respiratory physiology.[1] To achieve consistency, the International Standardization Committee on Objective Assessment of Nasal Airway (ISCOANA) has recommended active anterior rhinomanometry as the world standard method.[2] In Japan, we measure and evaluate nasal resistance according to the recommendations of the Japanese Standardization Committee on Rhinomanometry, and these recommendations are similar to those of ISCOANA.

There are differences between the guidelines that should be considered. The Japanese committee recommends applying nasal resistance at ΔP 100 Pa and using a nasal nozzle because of specific anatomical characteristics of Japanese people (ΔP is an abbreviation for the pressure gradient). These characteristics include the average size and shape of nostrils or average pulmonary function. The ISCOANA recommends applying a nasal mask at ΔP 150 Pa. However, the differences between the two guidelines can be disregarded as an error in calculation. Moreover, ISCOANA has been approved using the Japanese Standard in Japanese populations because it has good validity and convenience. In Japan, mean bilateral nasal resistance, using the ΔP 100 Pa standard by active anterior rhinomanometry with a nasal nozzle, has already been determined as 0.25±0.12 Pa/cm^3/s in normal adults.[3] However, standardisation of nasal resistance in Japanese children has not been established. This study aimed to measure nasal resistance in Japanese children by active anterior rhinomanometry with a nasal nozzle to achieve the standard nasal resistance profile in this population.

Methods

Participants

Informed consent was obtained from the guardians of elementary school children before participation. This study was conducted with the approval of the medical research ethics

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review committee of FHU (approval no. 13-039). Right and left unilateral nasal resistance was measured at ΔP 100 Pa during spontaneous nasal breathing by active anterior rhinomanometry with a nasal nozzle. We then calculated bilateral nasal resistance using Ohm's law equation for parallel resistors according to the Japanese guideline of rhinomanometry.[3] Testing was performed at our institutes or at elementary schools. Addition, we included data from two other similar studies[4,5] in Japanese elementary school children to provide dependable statistical assessment. Permission was granted for the use of these data.

Procedures

To determine whether children had a normal rhinosinal status or rhinosinal morbidity, including marked adenoidal hypertrophy, we asked the children and their guardian detailed questions regarding nasal symptoms and performed rhinoscopy. Children with suspected symptoms were further examined by nasal fibroscopy, sinus X-ray, and/or computed tomography, as appropriate. To decide whether marked adenoidal hypertrophy was present, we examined the children for evidence of severe mouth breathing and typical adenoidal facial features (elongated face, pinched nostrils, open mouth, high arched palate, shortened upper lip, and vacant expression). When adenoidal hypertrophy was suspected, the children underwent nasal fibroscopy and lateral face X-rays, as appropriate.

Statistical analysis

Statistical evaluations between each group were analysed by analysis of variance, and a p value of <0.05 was considered statistically significant. The relationships between nasal resistance and body height on inspiration and expiration were statistically assessed by linear regression analysis.

Results

Normal children

In the 1204 normal children included in this study, the mean bilateral nasal resistance at ΔP 100 Pa was 0.35±0.13 Pa/cm^3/s on inspiration and 0.37±0.14 Pa/cm^3/s on expiration (Table 1). In boys, the mean bilateral nasal resistance was 0.34±0.12 Pa/cm^3/s on inspiration and 0.36±0.15 Pa/cm^3/s on expiration compared with 0.35±0.13 Pa/cm^3/s on inspiration and 0.37±0.15 Pa/cm^3/s on expiration in girls. There were no significant differences in these values between boys and girls at either inspiration or expiration.

Japanese elementary school grades were divided into the following six grades: grade 1 (6–7 years), grade 2 (7–8 years), grade 3 (8–9 years), grade 4 (9–10 years), grade 5 (10–11 years), and grade 6 (11–12 years). The mean bilateral nasal resistance values by these grades are shown in Table 1. Generally, nasal resistance decreased with increasing grade, but there was a reversal of values in some grades.

We compared nasal resistance with respect to body height, which was divided into the following four categories: <120, 120–129, 130–139, and >140 cm (Table 2). Nasal resistance consistently decreased with increasing body height. The correlation between body height and nasal resistance is shown in Figures 1 and 2 for inspiration and expiration, respectively. There were significant negative correlations between body height and nasal resistance on inspiration and expiration as assessed by linear regression analysis (p values<0.001).

Nasosinal morbid children

Among the 838 rhinosinal morbid children, including those with adenoidal hypertrophy, mean values of bilateral nasal

Table 1 Bilateral nasal resistance in normal children and grades of elementary school

Grade	Total				Boy				Girl			
	Insp.		Exp.		Insp.		Exp.		Insp.		Exp.	
	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD
Grade 1	203	0.41±0.13	203	0.43±0.15	98	0.40±0.13	98	0.42±0.13	105	0.41±0.14	105	0.44±0.16
Grade 2	202	0.39±0.14	201	0.40±0.14	98	0.38±0.15	97	0.39±0.15	104	0.39±0.13	104	0.42±0.13
Grade 3	194	0.33±0.10	192	0.35±0.11	93	0.32±0.10	91	0.34±0.11	101	0.34±0.11	101	0.36±0.11
Grade 4	213	0.34±0.13	212	0.37±0.17	94	0.33±0.12	94	0.36±0.20	119	0.36±0.14	118	0.37±0.14
Grade 5	177	0.31±0.11	177	0.34±0.14	89	0.31±0.09	89	0.34±0.16	88	0.32±0.12	88	0.34±0.12
Grade 6	215	0.29±0.11	215	0.30±0.12	93	0.29±0.09	93	0.30±0.11	122	0.29±0.12	122	0.30±0.12
Total	1204	0.35±0.13	1200	0.37±0.14	565	0.34±0.12	562	0.36±0.15	639	0.35±0.13	638	0.37±0.14

Unit: Pa/cm^3/s
Mean values of bilateral nasal resistance at ΔP 100 Pa were 0.35±0.13 Pa/cm^3/s on inspiration and 0.37±0.14 Pa/cm^3/s on expiration in normal children. There were no significant differences between boys and girls on either inspiration or expiration.

Table 2 Bilateral nasal resistance in normal children and body height

Height	Total				Boy				Girl			
	Insp.		Exp.		Insp.		Exp.		Insp.		Exp.	
	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD
120 cm>	253	0.40±0.13	252	0.42±0.15	121	0.40±0.13	120	0.42±0.14	132	0.40±0.14	132	0.43±0.16
120–129 cm	341	0.36±0.13	339	0.38±0.13	167	0.35±0.12	165	0.36±0.13	174	0.37±0.13	174	0.40±0.13
130–139 cm	328	0.33±0.13	327	0.36±0.17	161	0.32±0.12	161	0.36±0.19	167	0.35±0.13	166	0.37±0.14
140 cm<	282	0.28±0.10	282	0.30±0.10	116	0.28±0.07	116	0.29±0.08	166	0.29±0.11	166	0.30±0.11
Total	1204	0.35±0.13	1200	0.37±0.14	565	0.34±0.12	562	0.36±0.15	639	0.35±0.13	638	0.37±0.14

Unit: Pa/cm^3/s
We compared nasal resistance with respect to body height, which was divided into the following four categories: < 120, 120–129, 130–139, and > 140 cm. Nasal resistance consistently decreased with increasing body height in normal children.

resistance at ΔP 100 Pa were 0.56±0.73 Pa/cm³/s on inspiration and 0.55±0.47 Pa/cm³/s on expiration (Table 3). Mean values of bilateral nasal resistance were 0.56±0.75 Pa/cm³/s on inspiration and 0.56±0.54 Pa/cm³/s on expiration in boys and 0.57±1.04 Pa/cm³/s on inspiration and 0.54±0.33 Pa/cm³/s on expiration in girls. No significant differences were observed in nasal resistance between boys and girls with rhinosinal morbidity. However, the mean nasal resistance was significantly greater in boys and girls with morbidity, on inspiration and expiration, compared with normal children. Finally, children's growth tended to correlate with decreasing nasal resistance in children without nasal problems. There was no consistent pattern among children with rhinosinal morbidity when the analysis was performed with respect to elementary school grade (Table 3) or body height (Table 4).

Discussion

While the mean bilateral nasal resistance in normal Japanese adults has been demonstrated,[3] that in normal Japanese children remains unknown. Therefore, in this national, multi-institutional study, we determined mean bilateral nasal resistance in normal Japanese children. We also evaluated whether children had a normal or morbid rhinosinal status by detailed questioning for nasal symptoms and examination by rhinoscopy and nasal fibroscopy, X-ray, or computed tomography, when necessary. We

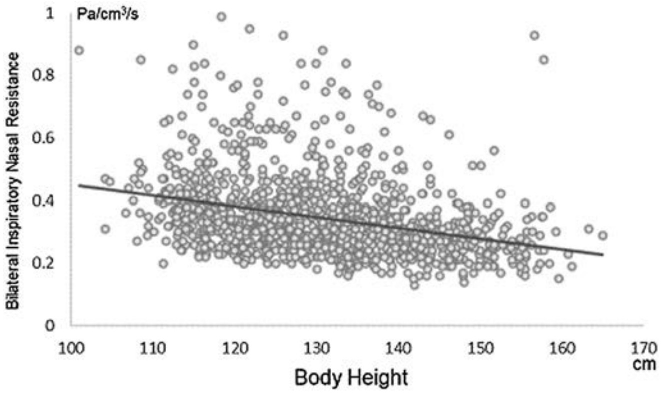

Figure 1 There was a significant negative correlation between body height and nasal resistance on inspiration as assessed by linear regression analysis.

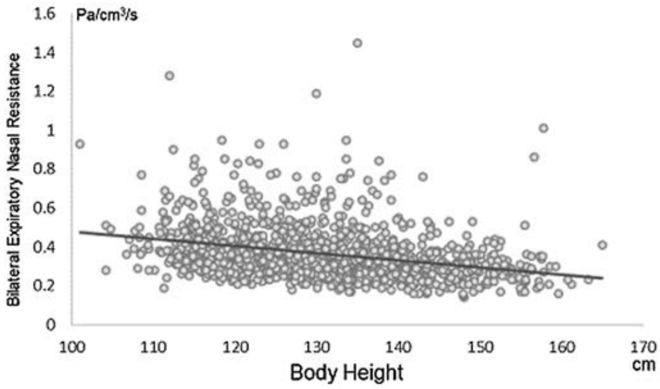

Figure 2 There was a significant negative correlation between body height and nasal resistance on expiration as assessed by linear regression analysis.

Table 3 Bilateral nasal resistance in naso-sinal morbid children and grades of elementary school

Grade	Total				Boy				Girl			
	Insp.		Exp.		Insp.		Exp.		Insp.		Exp.	
	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD
Grade 1	141	0.81±1.71	140	0.68±0.64	84	0.75±1.09	83	0.69±0.69	57	0.90±2.35	57	0.65±0.55
Grade 2	138	0.53±0.29	137	0.56±0.33	85	0.54±0.28	85	0.59±0.38	53	0.50±0.30	52	0.52±0.22
Grade 3	137	0.51±0.29	135	0.55±0.33	89	0.49±0.29	88	0.51±0.29	48	0.56±0.30	47	0.62±0.38
Grade 4	152	0.54±0.51	149	0.58±0.67	98	0.59±0.63	95	0.64±0.82	54	0.45±0.16	54	0.47±0.16
Grade 5	128	0.43±0.22	126	0.46±0.23	79	0.40±0.22	77	0.43±0.23	49	0.47±0.20	49	0.49±0.22
Grade 6	142	0.56±1.02	142	0.48±0.40	89	0.59±1.25	89	0.48±0.47	53	0.50±0.45	53	0.48±0.25
Total	838	0.56±0.87	829	0.55±0.47	524	0.56±0.75	517	0.56±0.54	314	0.57±1.04	312	0.54±0.33

Unit: Pa/cm³/s
No significant difference was observed in nasal resistance between boys and girls with rhinosinal morbidity. However, mean nasal resistance was significantly greater in morbid boys and girls, both on inspiration and expiration, compared with normal children. There was no consistent pattern among children with rhinosinal morbidity when the analysis was performed with respect to elementary school grade.

Table 4 Bilateral nasal resistance in naso-sinal morbid children and body height

Height	Total				Boy				Girl			
	Insp.		Exp.		Insp.		Exp.		Inspi.		Exp.	
	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	N	mean±SD
120 cm>	166	0.76±1.58	164	0.66±0.59	93	0.73±1.03	92	0.68±0.66	73	0.81±2.08	72	0.63±0.49
120–129 cm	250	0.54±0.30	248	0.56±0.33	157	0.54±0.29	156	0.57±0.34	93	0.53±0.31	92	0.55±0.30
130–139 cm	225	0.54±0.80	223	0.52±0.34	146	0.55±0.96	144	0.53±0.38	79	0.51±0.38	79	0.52±0.27
140 cm<	197	0.46±0.51	194	0.48±0.61	128	0.48±0.61	125	0.50±0.75	69	0.42±0.21	69	0.44±0.19
Total	838	0.56±0.87	829	0.55±0.47	524	0.56±0.75	517	0.56±0.54	314	0.57±1.04	312	0.54±0.33

Unit: Pa/cm³/s
There was no consistent pattern of nasal resistance among children with rhinosinal morbidity when the analysis was performed with respect to body height.

believe that the present methodologies were sufficient for dividing the children into two groups, even for when children's nasal conditions were changeable. The core findings of this study provide important standardisation information regarding nasal resistance in normal Japanese children.

Mean bilateral nasal resistance at ΔP 100 Pa in 1204 normal children was 0.35±0.13 Pa/cm^3/s on inspiration and 0.37±0.14 Pa/cm^3/s on expiration. Indeed, nasal resistance tended to decrease with increasing school grade and consistently decreased with increasing height. To counter this effect, we recommend using a strategy that standardises nasal resistance with respect to elementary school grade or body height (<120, 120–129, 130–139, and >140 cm). However, body weight and height rapidly change in children because of growth. This makes indicating a single nasal resistance value for normal children across all age groups difficult. Because that there was some variability in the values with respect to grade, height categories probably represent the best of these options. The mean points at which the nasal resistance approximated adult levels was in grade 6 (11–12 years) or for a body height of >140 cm. These values could probably be used as cut-off values while using the adult parameters.

In our study, no significant differences were observed in nasal resistance between normal boys and girls, either on inspiration or expiration. Consequently, we conclude that sex differences do not need to be considered when assessing nasal resistance in normal Japanese children.

Several significant differences have been reported in nasal resistance between normal Caucasian, Asian, and black adults.[6] However, only a few studies have assessed nasal resistance in normal European[7] and Canadian[8] children. The measurements of nasal resistance in those studies did not use active anterior rhinomanometry, as recommended by the Japanese Standardization Committee on Rhinomanometry and ISCOANA. There are differences in nasal resistance between ethnic populations, and the majority of subjects in previous research were not of Asian descent. Therefore, the standard values of nasal resistance in normal children have not been established worldwide.[9] Hopefully, our study can stimulate international discussion.

In children with rhinosinal morbidity, including those with marked adenoidal hypertrophy, nasal resistance was significantly greater compared with normal children. Furthermore, we showed that nasal resistance was not affected by sex, elementary school grade, or body height in morbid children. Therefore, nasal resistance in these children might depend more on the severity of nasal disease than on sex, school grade, or body height. When evaluating nasal resistance in children with known rhinosinal morbidity, we should not pay special attention to these factors that influence normal variation with age or body height.

Conclusion

To determine the mean nasal resistance values in Japanese children, we measured nasal resistance by active anterior rhinomanometry in 1204 healthy children and 838 children with rhinosinal morbidity. In normal children, nasal resistance decreases with increased age and body height, making it difficult to provide a single value for nasal resistance in normal children. Therefore, we recommend that nasal resistance in normal children be classified with respect to height. Nasal resistance in children with rhinosinal morbidity is independent of sex, school grade, or body height, and might depend on disease severity and other rhinosinal problems. We hope that this study promotes international discussion and research on standardisation of nasal resistance in children.

Conflict of Interest

None

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