

Measurement of nasal patency by acoustic rhinometry in Japanese school children

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Summary

Objective: The present study was planned in order to evaluate (1) the reference value of Japanese school children at a certain grade, (2) the relationship between subjective sensation of nasal obstruction and acoustic rhinometry, and (3) relationship of acoustic rhinometry with gender and body status.

Methods: 75 school children in the second grade, which include 39 girls (52%) and 36 boys (48%), ranging in age from 7 to 8 were studied in July 2006.

Results: The normal mean values of the minimal cross-sectional area and nasal volume were 0.389cm^2 and 2.63 cm^3 in this group. In those with nasal obstruction sensation, the cross sectional areas at the third and the fourth notches were significantly smaller than those without nasal obstruction sensation ($p<0.05$). Nasal volume weakly correlated to body weight and body mass index. The distance from the nostril to the i-notch was significantly higher in the girls than in the boys ($p<0.01$). The area at the i-notch was significantly higher in the boys than in the girls. Height, weight, body mass were significantly higher in the boys than in the girls ($p<0.01$).

Conclusion: Acoustic rhinometry is an useful method for evaluation of nasal patency in school children.

Introduction

Acoustic rhinometry is a well-established method for evaluation of nasal patency [1]. Because of its accuracy, reproducibility and non-invasiveness, it has been widely used in the field of rhinology. Because of this feature, acoustic rhinometry has been used for evaluation of the nasal patency of children. In order to establish the usefulness of the method in evaluating nasal patency in the diseased nose, it is necessary to obtain reference values in the normal nasal cavities. Recently, reference values in preschool and school children has been reported [2,3].

It is known that nasal patency is influenced by several factors. Morgan et al [4] reported that race has a significant effect on acoustic rhinometry measurements. Moreover, recently it has been clearly demonstrated that nasal cavity dimensions in children and adults change by gender and age [5].

The relationships between subjective sensation of nasal obstruction and acoustic

rhinometry for each individual have been studied.

The present study was planned in order to evaluate (1) the reference value of Japanese school children at a certain grade, (2) the relationship between subjective sensation of nasal obstruction and acoustic rhinometry, and (3) relationship of acoustic rhinometry with gender and body status.

Materials and methods

75 school children in the second grade, which include 39 girls (52%) and 36 boys (48%), ranging in age from 7 to 8 were studied in July 2006. This season was chosen because children were the least affected by common cold (December to March) or Japanese cedar pollinosis (February to April).

Prior to acoustic rhinometry, their body weight and height were measured. BMI (body mass index) was calculated by the individual's body weight (kg) by the square of their height (m). At the time of measurement, the children were asked if they have nasal obstruction and anterior rhinoscopy was performed to determine the swelling of their inferior turbinates. The children were then submitted to acoustic rhinometry in a constant temperature (25°C) environment. An acoustic rhinometer (SRE 2100; Rhinometrics A/S, Lyngø, Denmark) was used for all measurements. One person performed all measurements (Y.M.) to eliminate the possibility of tester variability. Subjects sat comfortably upright in an examination chair, with quiet respirations. Medium nose adapters (Rhinometrics A/S) were used for all children. In order to guarantee the accuracy of the test, at least three curves were obtained for each nostril. The results were considered to be adequate when the coefficient of variation was less than 10%. A mean curves for each nostril was then constructed for each patients based on the recorded curves. All the examinations were carried out by the same observer (Y. M.).

Written informed consents were obtained from their parents. This study was approved by the Ethics Committee of Mie University. The procedures followed were in accordance with the ethical standards of the Ethics Committee and with the Helsinki Declaration of 1975, as revised in 1983.

Statistical analysis

In the area-distance curves, several notches are observed. The first notch corresponds to the nasal valve and is called i-notch. The second notch corresponds to the anterior part of the inferior turbinate and is called c-notch. Moreover, we analyzed the third and the fourth notch, which correspond to the posterior choana and adenoid, respectively. The distance from the anterior nostril to each notch is defined as D1, D2, D3, and D4. The area at each notch is defined as A1, A2, A3 and A4. The volume from the anterior nostril to each notch was defined

as V1, V2, V3, and V4. P values less than 0.05 was considered significant.

Results

Distance of the nostrils to each notch (D1 to D4), area at each notch (A1 to A4) and volumes from the nostril to each notch (V1 to V4) of the 150 noses of 75 school children are shown in the Table 1 and Fig. 1. The average minimal cross-sectional area was $0.36 \pm 0.063 \text{ cm}^2$. The minimal cross-sectional area was located at the first notch in 94 noses out of 150 (63.5%) and at the second notch in 56 noses of 150 (36.5%).

Nasal cavities in which children had nasal obstruction sensation had significantly larger D2, D3 and D4 and significantly smaller A3 and A4 than nasal cavities in which they did not had nasal obstruction sensation (Fig. 2).

In order to determine the normal values of the acoustic rhinometry measurements, the entire nasal cavities were divided into two groups: one group consists of 58 nasal cavities with nasal obstruction sensation and /or inferior turbinate swelling; the other groups consists of 92 nasal cavities without nasal obstruction sensation or inferior turbinate swelling. Acoustic rhinometry measurements of the two groups are shown in the Table 1.

Correlation of acoustic rhinometry measurements and height, weight and body mass index (BMI) in the three categories is shown in the Table 2. V2 correlated weakly to height ($r=0.355$, $p<0.0001$) (Fig 3). A1, V2 and V3 correlated weakly to body weight. V3 correlated with body mass index (Table 2).

Acoustic rhinometry values were compared between boys and girls (Fig.4). D1 was significantly higher in the girls than in the boys ($p<0.01$). A1 was significantly higher in the boys than in the girls. Sex difference of height, weight and body mass were also examined. Height, weight, body mass were significantly higher in the boys than in the girls ($p<0.01$, Fig. 5).

Discussion

The present study was carried out in Japanese school children who are in the second grade of an elementary school. There are several reasons why we have chosen them as subjects of the study. First, the subjects were all Japanese, thus we can neglect the effect of racial difference on the acoustic rhinometry dimensions. Second, we thought that the students in the second grade are the youngest school children who can tell their subjective sensation of nasal obstruction. Third, we would like to examine the effect of sex and body status on the AR measurements in the limited age group.

The mean distance from the nostrils to the third notch (D3) was $3.97(\pm 0.449) \text{ cm}$. This value can be considered as the length of the nasal cavity. According to Yamagiwa⁶⁾, the length

of nasal cavity can be estimated by the formula: $1.074 \times \text{age (year)} \pm 40.56 \text{ mm}$, which give the value of 4.8mm at the year of seven. Therefore, in terms of the nasal cavity length, the values obtained by the present measurement were very close to the values estimated by X-ray by Yamagiwa [6]. For this reason, we thought that the V3 can represent the nasal volume.

Nasal cavities in which children had nasal obstruction sensation had significantly smaller A3 and A4 than nasal cavities in which they did not had nasal obstruction sensation. This result indicates that subjective sensation of the nasal obstruction is not influenced by the patency of the anterior part of the nasal cavity but by that of the posterior part of the nasal cavity, including nasopharynx in school children, in this study group. Adenoidal hypertrophy is a common cause of nasal obstruction in pediatric population. It is reported that adenoidal hypertrophy can be detected by AR [7-8] and AR is useful for pre and postoperative evaluation of adenoidectomy in children [9-11].

Acoustic rhinometry has been used to evaluate the relationship between nasal cross-sectional areas and sensations of nasal patency and several conflicting results [12-14] have been reported. Roithmann et al. [12] reported that no significant correlation was found between sensation of nasal patency and combined nasal minimum cross-sectional areas as subjects breathed voluntarily through both nasal cavities. However, when subjects were required to breathe through each nasal cavity separately, a significant correlation was found between ipsilateral sensation of nasal patency and both ipsilateral minimum cross-sectional area pre-decongestion [12]. Other reports demonstrated poor relationship between subjective sensation of nasal obstruction and AR measurements [13,14]. In the present study, we simply asked the children if they felt nasal obstruction sensation because we thought it may be difficult for them to evaluate the degree of nasal obstruction.

In order to determine the normal values of the acoustic rhinometry measurements, the entire nasal cavities were divided into two groups: one group consists of 58 nasal cavities with nasal obstruction sensation and /or inferior turbinate swelling; the other group consists of 92 nasal cavities without nasal obstruction sensation or inferior turbinate swelling.

The children without nasal obstruction sensation or inferior turbinate swelling can be considered as children with relatively normal nasal cavity. The minimal nasal cross-sectional area was obtained at the first notch and the value was 0.389 ± 0.052 (mean \pm SD)(cm^2). The ipsilateral mean nasal volume (V3) was 2.623 ± 0.735 (cm^3). These values were comparable to the results by Ho, et al who reported that the minimal cross sectional area at the age of seven was $0.38(\pm 0.10)\text{cm}^2$ [15]. Millqvist, et al. [2] reported that children from 7 to 8 years old had minimal cross sectional area of both nasal cavities of $0.99(0.91-1.06) \text{ cm}^2$ and the nasal volume of $5.66(5.09-6.23) \text{ cm}^3$.

V2 correlated weakly to height. A1, V2 and V3 correlated weakly to body weight. V3

correlated with body mass index. The correlation was weak and this is in agreement with the report by Millqvist et al.[2] who showed that minimal cross-sectional area correlated weakly to weight, height, age, and body mass index.

The comparison of the AR measurements between boys and girls showed that D1 was significantly higher in the girls than in the boys. According to Ishizuka T, et al., [16] the i-notch was located more anteriorly in Japanese men than in Japanese women and the C-notch was located more posteriorly in men than in women. The present study indicates that the former character of Japanese male is already evident in younger age.

A1 was significantly higher in the boys than in the girls. In order to clarify the background of this difference, sex difference of height, weight and body mass were also examined. Height, weight, body mass were significantly higher in the boys than in the girls. Samolinski, et al. [5] reported that before age 11 years, the intranasal spaces were slightly larger in girls than in boys and that after age 11 years the nasal parameters were larger in boys than in girls. The parameters they used are distance between i-notch and c-notch and the mean cross-sectional area at c-notch. The difference between our results and theirs may come from different parameters used or different of body status.

In conclusion, the normal mean values of the minimal cross-sectional area and nasal volume were 0.389 cm^2 and 2.63 cm^3 in the second grade school children in Japan. In those with nasal obstruction sensation, A3 and A4 were significantly smaller than those without nasal obstruction sensation, which suggests that nasal obstruction is influenced by the patency of the posterior nasal cavity and nasopharynx. Nasal volume weakly correlated to body weight and body mass index. D1 was significantly higher in the girls than in the boys. A1 was significantly higher in the boys than in the girls. Height, weight, body mass were significantly higher in the boys than in the girls.

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Figures

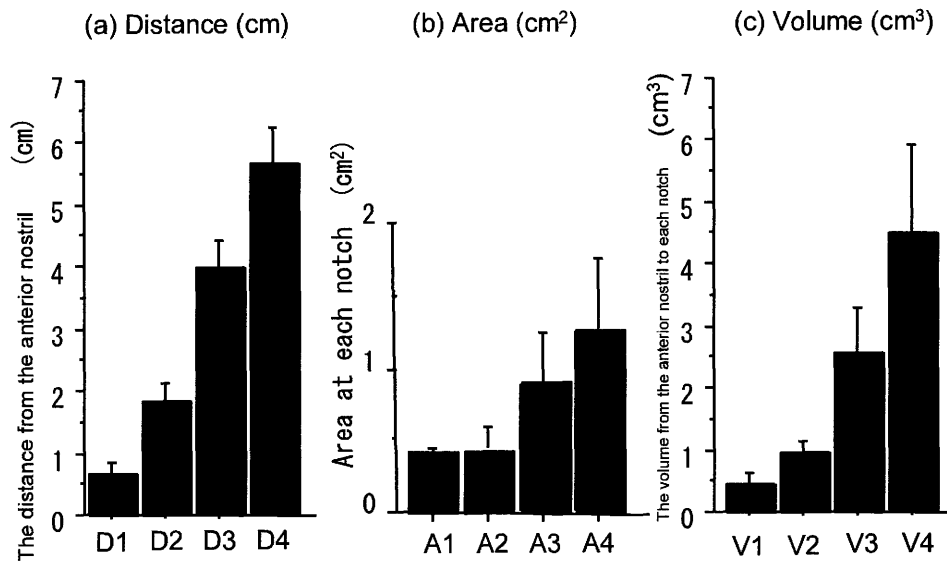


Fig.1 Mean acoustic rhinometry measurements of the 150 noses of the 75 school children.

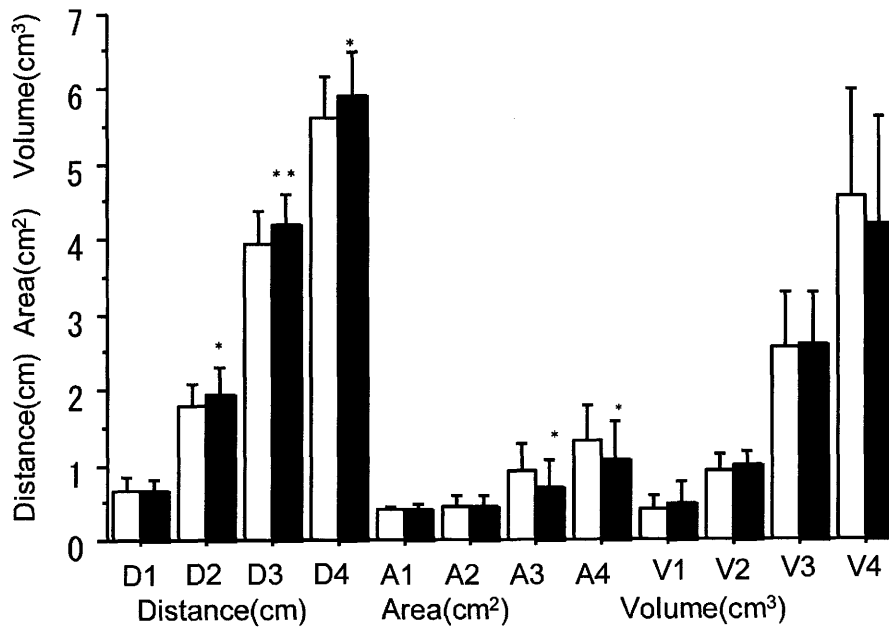


Fig.2 Comparison of mean acoustic rhinometry measurements between school children with nasal obstruction (closed bars) and those without nasal obstruction (open bars). * and ** indicate data significantly different between the two groups, at $p < 0.05$ and $p < 0.01$, respectively.

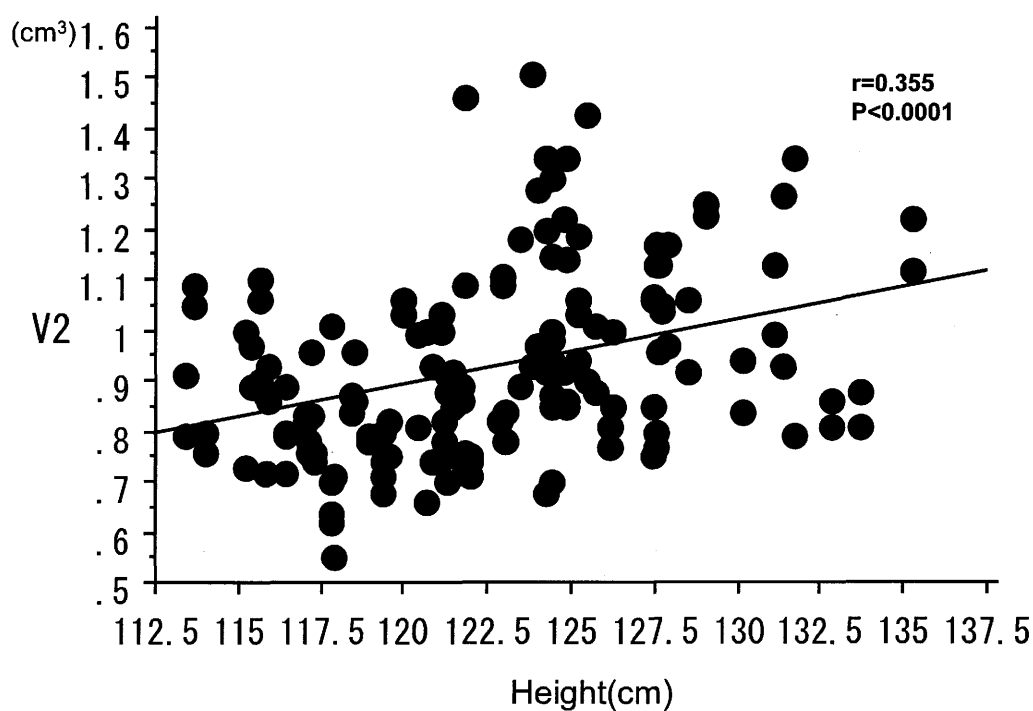


Fig.3 Association of height with volume of the anterior nostril to the c-notch.

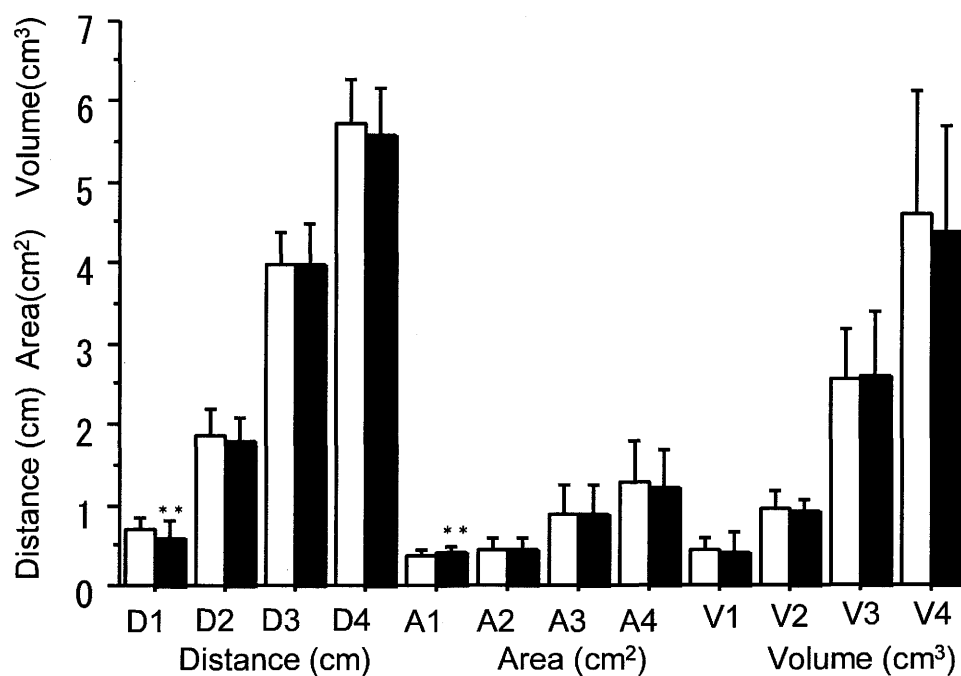


Fig.4 Comparison of acoustic rhinometry measurements between girls (open bars) and boys (closed bars). ** indicates significant difference between the two groups at $p < 0.01$.

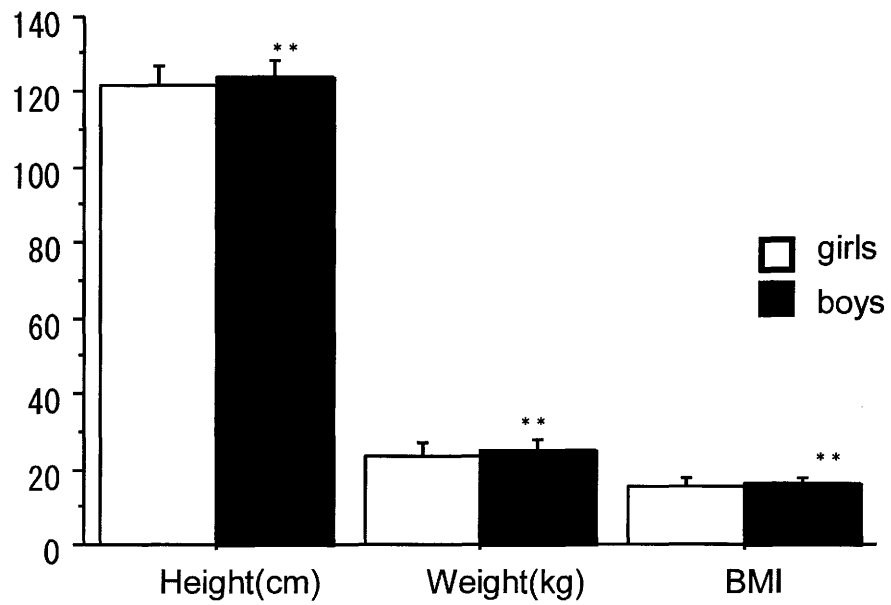


Fig.5. Sex difference of hieght, weight, and BMI (body mass index). ** indicates significant difference between the two groups at $p < 0.01$.

Tables

Table 1 Mean acoustic rhinometry measurements of the 150 noses of 75 school children.

		D1	D2	D3	D4	A1	A2	A3	A4	V1	V2	V3	V4
Whole cases (n=150)	mean	0.645	1.82	3.97	5.65	0.390	0.446	0.867	1.253	0.428	0.927	2.568	4.499
	SD	0.176	0.307	0.449	0.575	0.060	0.139	0.371	0.491	0.189	0.183	0.707	1.416
Nasal obstruction and/or inferior turbinate swelling (n=58)	mean	0.611	1.866	4.054	5.744	0.392	0.429	0.758	1.102	0.421	0.930	2.481	4.262
	SD	0.184	0.344	0.400	0.592	0.070	0.134	0.353	0.484	0.228	0.187	0.655	1.483
Without nasal obstruction or inferior turbinate swelling (n=92)	mean	0.666	1.791	3.92	5.590	0.389	0.457	0.937	1.346	0.433	0.925	2.623	4.646
	SD	0.168	0.279	0.471	0.560	0.052	0.142	0.367	0.475	0.161	0.181	0.735	1.360

Table 1. Distance of the nostrils to each notch (D1 to D4), area at each notch (A1 to A4) and volumes from the nostril to each notch (V1 to V4) of the 150 noses of 75 school children.

Table 2. Association of height, weight and BMI with acoustic rhinometry measurements

		D1	D2	D3	D4	A1	A2	A3	A4	V1	V2	V3	V4
Height	r		0.20								0.355		
	P value		0.0139								<.0001		
Weight	r			0.202		0.221					0.225	0.182	
	P value			0.0133		0.0065					0.0055	0.0269	
BMI	r	-0.171		0.234								0.178	
	P value	0.0369		0.004								0.0307	

Only those with statistical significance are shown

Table 2. Association of height, weight and BMI with acoustic rhinometry measurements. Only those with statistical significance are shown.