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Abstract

Pulmonary function tests were performed on 252 healthy young subjects free from respiratory and allergic symptoms, and 80 young subjects with past history of nasal allergy (PNA) and 10 subjects with past history of bronchial asthma (PBA). All the subjects were non-smokers. Maximal expiratory flow-volume (MEFV) curves were visually classified into five types (A-E). The percent distribution of type A in healthy subjects was significantly higher than in the PNA group, while the total sum of percentage of types B, C, and D in the PNA group was significantly higher than in the healthy subjects. The percent distribution of type E in the PNA group was similar to that in the healthy subjects. The percent distribution of MEFV types were significantly different between healthy males and healthy females. The percent distribution of types A, B and E were the highest in healthy subjects, PNA and PBA groups, respectively. Conclusively, the difference in the percent distributions of MEFV types was recognized among healthy subjects, PNA and PBA groups.

KEYWORDS: maximal expiratory flow-volme type, non-smoking, bronchial asthma, nasal allergy

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Maximal Expiratory Flow-Volume Types in Young Subjects with Past History of Nasal Allergy and Bronchial Asthma

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Pulmonary function tests were performed on 252 healthy young subjects free from respiratory and allergic symptoms, and 80 young subjects with past history of nasal allergy (PNA) and 10 subjects with past history of bronchial asthma (PBA). All the subjects were non-smokers. Maximal expiratory flow-volume (MEFV) curves were visually classified into five types (A-E). The percent distribution of type A in healthy subjects was significantly higher than in the PNA group, while the total sum of percentage of types B, C, and D in the PNA group was significantly higher than in the healthy subjects. The percent distribution of type E in the PNA group was similar to that in the healthy subjects. The percent distribution of MEFV types were significantly different between healthy males and healthy females. The percent distribution of types A, B and E were the highest in healthy subjects, PNA and PBA groups, respectively. Conclusively, the difference in the percent distributions of MEFV types was recognized among healthy subjects, PNA and PBA groups.

Key words : **maximal expiratory flow-volme type, non-smoking, bronchial asthma, nasal allergy**

Maximal expiratory flow-volme (MEFV) curves are widely used in clinical and epidemiologic studies (1–7). Landau *et al.* (8) classified MEFV curves into five types (A, B, C, D and E) based on the flow rates at lower lung volumes. In our previous papers (9,10), we studied the distribution of MEFV types classified according to our criteria (11) in patients with nasal allergy (9) and healthy subjects (10). The percent distribution of type A was significantly lower in patients with nasal allergy (NA) than in the healthy control, while the percent distribution of type E was significantly higher in NA group than in the healthy control and that of type B was particularly higher in the NA group than in the healthy control (9). Subsequently, the reproducibility of MEFV types in healthy young subjects and comparison of percent distribution of MEFV types between healthy young males and healthy young females were studied (10). In this study, the intra- and inter-individual reproducibility of MEFV types in healthy young males was demonstrated, and significant differences in the percent distributions of MEFV types were observed between healthy young males and females. The percent distribution of type A was higher in females than in males, and those of types B and E were higher in males than

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in females.

Although the percent distribution of MEFV types in the NA group and healthy subjects were clarified in our previous studies, there have been no reports on the distribution of MEFV types in subjects with past history of nasal allergy (PNA) and subjects with past history of bronchial asthma (PBA). Some of these subjects have high risks of showing some airway symptoms and even recurring asthmatic symptoms (12,13). Thus, the investigation of the distribution of MEFV types in subjects with PNA and PBA may be useful to assess the extent of the airway obstruction in these subjects.

The present study was attempted (1) to compare the distribution of MEFV types between non-smoking healthy young subjects, and non-smoking young subjects with PNA and PBA, and (2) to clarify the sex difference in the distribution of MEFV types in healthy young subjects, and subject groups with PNA and PBA.

Materials and Methods

Materials. Group 1 consisted of 252 non-smoking young subjects (193 males of average age of 23.8 years and 59 females of average age of 23.3 years) free from respiratory symptoms and airway allergy symtoms. Group 2 consisted of 80 non-smoking young subjects with PNA (69 males of average age of 23.7 years and 11 females of average age of 22.9 years). Group 3 consisted of 10 non-smoking young subjects with PBA (8 males of average age of 23.1 years and 2 females of average age of 23.0 years). All subjects were requested to complete the questionnaire made by the British Medical Research Council and an airway allergy questionnaire.

Pulmonary function testing. An AS-4500 flow-volume curve recorder (Minato Medical Co.,Ltd.) was used for the maximal expiratory function tests, which consisted of the procedure to determine maximal expiratory volume-time (MEVT) and MEFV. These procedures were repeated at least twice in a standing position for all subjects. All pulmonary function tests were performed under the supervision of a medical doctor.

Selection of MEVT and MEFV data. For the analysis of curve types, MEFV charts were used which had peak expiratory flow rate (PEFR) values high enough to evaluate types of MEFV curves visually, and showed inter-determination variation of volume less than 150 ml in forced vital capacity (FVC) (usually less than 3 %) and less than 100 ml in forced expiratory volume in one second (FEV_1) (usually less than 2 %). The MEFV chart with the largest PEFR and FVC values obtained from each individual was used for the analysis.

Classification of MEFV types. MEFV curves were visually classified into five types from A to E according to the criteria described previously (11).

Calculation of pulmonary function indices. Pulmonary function indices were simultaneously calculated from the curves using a microcomputer.

Statistical analysis. Mean values and unbiased standard deviation (USD) were calculated for each index. Chi-square test was performed for percent distribution of MEFV types among three groups, (healthy, PNA and PBA), using an $m \times n$ contingency table and a 2×2 contingency table. Student's t-test was done for MEVT and MEFV indices.

Results

Age, height and conventional spirometry data. Age, height and conventional spirometry data for the subjects of the present study are shown in Table 1. There was no significant difference in all indices among the three groups of subjects tested.

$FEV_{1\%}$ values for individuals showing different MEFV types. The mean $FEV_{1\%}$ values for individuals showing type E was significantly lower than those for individuals showing types A and B in the male healthy subjects, but there was no significant difference in the mean $FEV_{1\%}$ values among individuals showing any one of the five MEFV types in female subjects (Table 2). There were significant differences in mean $FEV_{1\%}$ values for individuals showing types B and E in all the three groups, but there was no significant difference in the mean $FEV_{1\%}$ values for individuals showing any one of the five MEFV types between the healthy subjects and the PNA subjects.

Percent distribution of MEFV types in

Table 1 Age, height and conventional spirometry data for non-smoking male and female young healthy subjects, and young subjects with PNA and PBA tested in the present study.

		Male			Female		
		H	PNA	PBA	H	PNA	PBA
Number of subjects		193	69	8	59	11	2
Age (year)	Mean	23.8	23.7	23.1	23.2	22.9	23.0
	USD	2.0	2.1	2.0	1.1	0.4	0.0
Height (cm)	Mean	168.7	171.7	170.2	158.2	159.1	156.6
	USD	5.1	5.3	3.2	2.8	3.7	6.7
%FVC (%)	Mean	109.4	112.1	108.3	103.8	111.0	105.0
	USD	10.8	12.2	7.5	10.1	14.5	8.9
$FEV_{1\%}$	Mean	86.8	86.6	84.4	91.7	93.0	82.0
	USD	5.3	5.1	4.2	4.8	4.6	4.9

H: Healthy subjects, PNA: Subjects with past history of nasal allergy. PBA: Subjects with past history of bronchial asthma.
%FVC : Forced vital capacity expressed as the percentage of predicted vital capacity calculated from Baldwin's equation (17).
$FEV_{1\%}$: Forced expiratory volume in 1.0 sec as the percentage of forced vital capacity.
USD : Unbiased sample standard deviation.

healthy subjects, subjects with PNA and subjects with PBA. Percent distribution of MEFV types in healthy subjects, the PBA subjects and the PNA subjects are shown in Table 3.

Table 2 Conventional spirometry value($FEV_{1\%}$) for individuals showing each MEFV type in healthy, PNA and PBA groups

Group	M	Male		Female	
		No.	Mean ± USD	No.	Mean ± USD
H	A	56	88.7 ± 4.7	41	92.0 ± 4.7
	B	34	88.8 ± 5.6	6	89.9 ± 6.8
	C	18	85.6 ± 4.8	0	—
	D	3	91.6 ± 8.5	0	—
	E	82	83.6 ± 5.8	12	90.1 ± 5.4
PNA	A	12	88.7 ± 5.4	4	95.3 ± 5.2
	B	16	90.4 ± 4.9	4	91.7 ± 4.7
	C	11	86.3 ± 5.7	1	88.5
	D	3	82.9 ± 8.9	0	—
	E	27	84.0 ± 5.5	2	91.9 ± 5.5
PBA	A	0	—	0	—
	B	2	96.7 ± 4.2	0	—
	C	0	—	0	—
	D	0	—	0	—
	E	6	81.0 ± 4.8	2	89.8 ± 2.5

Abbreviations: The same as in Table 1.
M: maximal flow valume type.

The distribution pattern of the five MEFV types was shown to be significantly different by Chi-

Table 3 Percent distribution of MFEV types in healthy and PNA groups

Group	MFEV type					Total
	A	B	C	D	E	
Total						
H	97 (38.5)	40 (15.9)	18 (7.1)	3 (1.2)	94 (37.3)	252 (100)
PNA	16 (20.0)	20 (25.0)	12 (15.0)	3 (1.6)	29 (36.3)	80 (100)
PBA	0 (0.0)	2 (20.0)	0 (0.0)	0 (0.0)	8 (80.0)	10 (100)
Male						
H	56 (29.0)	34 (17.6)	18 (9.3)	3 (1.6)	82 (42.5)	193 (100)
PNA	12 (17.4)	16 (23.2)	11 (15.9)	3 (4.3)	27 (39.1)	69 (100)
PBA	0 (0.0)	2 (25.0)	0 (0.0)	0 (0.0)	6 (75.0)	8 (100)
Female						
H	41 (69.5)	6 (10.2)	0 (0.0)	0 (0.0)	12 (20.3)	59 (100)
PNA	4 (36.4)	4 (36.4)	1 (9.1)	0 (0.0)	2 (18.2)	11 (100)
PBA	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	2 (100)
Grand total	122 (35.7)	67 (19.6)	31 (9.1)	4 (1.2)	128 (37.4)	342 (100)

Abbreviations: The same as in Table 1.
Numbers in the tarentheses indicate percentage of the number of subjects studied.

Table 4 Results of chi-square test
(A) Results of chi-square test with an $m \times n$ contingency table

Subject group	Comparison	Significance
Total	Healthy *vs* Female	*
Healthy	Male *vs* Female	*
PNA	Male *vs* Female	
Male	Healthy *vs* PNA	
Famale	Healthy *vs* PNA	

(B) Results of chi-square test with a 2×2 contingency table

Subject group	Comparison: Subject group	Comparison: Type of MEFV pattern	Significance
Total			
	H *vs* PNA and PBA	A *vs* B, C, D and E	**
		B, C, D *vs* A and E	**
		E *vs* A, B, C and E	—
	H *vs* PNA	A *vs* B, C, D and E	**
		B, C, D *vs* A and E	**
		E *vs* A, B, C and D	—
	H *vs* PBA	A *vs* B, C, D and E	**
		B, C, D *vs* A and E	—
		E *vs* A, B, C and E	**
	PNA *vs* PBA	A *vs* B, C, D and E	—
		B, C, D *vs* A and E	——
		E *vs* A, B, C and D	**
Male			
	H *vs* PNA and PBA	A *vs* B, C, D and E	*
		B, C, D *vs* A and E	*
		E *vs* A, B, C and D	—
	H *vs* PNA	A *vs* B, C, D and E	——
		B, C, D *vs* A and E	*
		E *vs* A, B, C and D	—
	H *vs* PBA	A *vs* B, C, D and E	——
		B, C, D *vs* A and E	—
		E *vs* A, B, C and D	——
	PNA *vs* PBA	A *vs* B, C, D and E	—
		B, C, D *vs* A and E	—
		E *vs* A, B, C and D	——
Female			
	H *vs* PNA and PBA	A *vs* B, C, D and E	**
		B, C, D *vs* A and E	*
		E *vs* A, B, C and D	—
	H *vs* PNA	A *vs* B, C, D and E	*
		B, C, D *vs* A and E	**
		E *vs* A, B, C and D	—
	H *vs* PBA	A *vs* B, C, D and E	—
		B, C, D *vs* A and E	—
		E *vs* A, B, C and D	*
	PNA *vs* PBA	A *vs* B, C, D and E	—
		B, C, D *vs* A and E	—
		E *vs* A, B, C and D	——

Abbreviations: The same as in Table 1.
Statistically significant differences: * $p < 0.05$, ** $p < 0.01$; No statistically significant: — $p > 0.10$, —— $0.01 > p > 0.05$

square test using an $m \times n$ contingency table between non-smoking healthy subjects and non-smoking PNA subjects, and between healthy males and females (Table 4-A).

The difference in the percent distribution of MEFV types among the healthy group, the PNA and PBA were analyzed by the Chi-square test, using a 2×2 contingency table. The results are shown in Table 4-B.

When the both sexes were combined, the percentage of type A was significantly higher in the healthy subjects than in the PNA group with or without PBA. It was also significantly higher in the healthy group than in the PBA group. The total sum of percentages of types B, C and D was significantly higher in the PNA group with or without PBA than in the healthy subjects. The percentage of type E was significantly higher in the PBA group than in the healthy or PNA group.

In the healthy subjects, the percentage distribution of MEFV types was significantly different between healthy males and females. In the subjects with PNA, the percentage distribution of MEFV types was not significantly different between males and females.

In male subjects, the percentage of type A was significantly greater in the healthy subjects than in the PNA and PBA groups combined. The total sum of percentages of types B, C and D was significantly lower in the healthy group than in the PNA with or without PBA. In female subjects, the percentage of type A in healthy subjects was higher in the PNA group with or without PBA, and the total sum of percentages of types B, C and D was significantly higher in the PNA group with or without PBA than in the healthy group. The percentage of type E was significantly higher in the PBA group than in the healthy group or the PNA group.

Discussion

The percentage distribution of MEFV types was different between healthy non-smokers and non-smoking subjects with PNA by χ^2 test using an $m \times n$ contingency table. It was also different between non-smoking healthy males and non-smoking females. However, subjects with PBA were omitted in the calculation of χ^2 values, because the number in the PBA group was limited. Thus, the discussion was limited to the distribution pattern of MEFV types in healthy subjects, subjects with PNA and patients with nasal allergy (9).

Nishioka *et al.* (9) reported that the percentage of type A in patients with nasal allergy was significantly lower than that in the healthy control, but that the percentage of type E was significantly higher and that of type B was particularly higher in the patients with nasal allergy than in the healthy controls. Yajima *et al.* (14) described that all the pulmonary function indices (%FVC, $FEV_{1\%}$, PEFR, $\dot{V}75$ and $\dot{V}50$) in the normal control group were found to be within normal limits, while flow rate indices (PEFR, $\dot{V}75$, $\dot{V}50$ and $\dot{V}25$) in patients with nasal allergy were lower than the normal limits, and $\dot{V}25$ value was especially low. They considered that the low flow rate indices suggest the presence of obstruction of the peripheral lower airways. Nishioka *et al.* (9) thought that almost all of the MEFV patterns with low $\dot{V}25$ values observed in the patients might be included in type E in their classification.

The percentage (18.8%) of type A in the PNA group observed in this study was higher than that (10.5%) in patients with nasal allergy reported in our previous paper (9). Although subjects with PNA, like patients with nasal allergy, may have not only upper airway obstruction but also lower airway obstruction, the percentage (32.5%) of type E in PNA group in this study was lower than that (45.9%) in patients with nasal allergy in our previous paper (9). In this study, the percentage of type A and the total sum of percentages of types B, C and D, were different between healthy subjects and PNA subjects, while the percentage of type E in the PNA group was similar to that in the healthy subjects. This suggests that the extent of lower airway obstruction may differ between patients with nasal allergy and subjects with PNA. Because some of the subjects with PNA show type E curves, they may have the lower airway obstruction even in the state of remission. Furthermore, they may have higher risk of exacerbation of the airway symptoms including asthmatic symptoms, when they are exposed to environmental or occupational exacerbating factors (12,13). Thus, these data suggest that the MEFV typing may be useful to predict the possibility of exacerbation of the airway symptoms in the subjects with PNA.

In addition, healthy male subjects showing types B and E MEFV curves must be examined again in future to check the possibility of latent airway allergy.

In this study, healthy females showed significantly higher percentage of type A then did healthy males, as described in the previous paper (10), but the percentage of type A in the PNA subjects was not significantly different between males and females. This may be due to the limitation of the number of females subjects with PNA.

Fujimura *et al.* (15) reported that the deep inspiration in young healthy females but not in males had a relaxation effect on the basic bronchomotor tone and that this sex difference disappeared after the blockade of cholinergic receptors. Fujimura *et al.* (16) also stated that the bronchodilating effect of deep inspiration in young healthy females might depend on the intensity of basal bronchomotor tone maintained by tonic vagus nerve activity.

Therefore, the reason for the sex difference in the percent distribution of MEFV types in subjects with PNA remains to be studied in future.

Lower airway obstruction may occur in the healthy aged people, and this may occur more easily in the aged patients with nasal allergy. Thus, changes in MEFV curves during the process of aging is necessary to be studied in future.

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