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Inhibitory effects of facemasks and eyeglasses on invasion of pollen particles in the nose and eye: a clinical study*

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SUMMARY

The incidence of Japanese cedar pollinosis is estimated to be about 13% of the Japanese population. In Japan it is generic to wear a facemask and eyeglasses to prevent pollen inhalation. We examined the usefulness of a facemask and eyeglasses in cooperation with volunteers. The number of pollen particles in the nasal cavity and on the conjunctiva was unchanged by wearing a facemask and eyeglasses. However, the pollen invasion rate was lower in subjects with a facemask and eyeglasses than in subjects without a facemask and eyeglasses. The decrease in pollen invasion rate in the nasal cavity due to wearing a facemask was statistically significant. This suggested that wearing a facemask has a protective effect on pollen invasion to the nose. The pollen invasion rate in the nasal cavity and on the conjunctiva was increased with increases in the wind speed. It may be difficult to avoid pollen even when wearing a facemask and eyeglasses when the wind speed is high. Further study is required to clarify the relationship between the amount of allergens and clinical symptoms.

Key words: allergen avoidance, allergic rhinitis, eyeglasses, facemask, Japanese cedar pollinosis

INTRODUCTION

The incidence of Japanese cedar pollinosis is estimated to be about 13% of the Japanese population [1], and it has become a national disease. Since this disease is a typical type I allergy, symptoms only occur during allergen exposure. Therefore, treatment should be focused on the removal or avoidance of the causative allergen. It has been reported that facemasks and eyeglasses inhibit pollen from entering the nose and eyes in model experiments for pollinosis, but the reduction of allergen load needed to reduce symptoms is still unclear [2].

In this study, we examined the effects of wearing a facemask and eyeglasses, specific to pollinosis, on the suppression of invasion and accumulation of pollen in subjects' noses and eyes. Since the effects of wearing facemasks may vary due to the different shape and size of the nasal cavity of individuals, comparative studies were performed in the same subjects with and without a facemask and eyeglasses.

SUBJECTS AND METHODS

The subjects were 10 male healthy volunteers aged 24-34 years (mean 29.4 years) who gave informed consent. We got approval from the Ethics Committee and performed experiments 12 times between the 2000 to 2002 pollen seasons.

Non-woven fabric surgical facemask (MM-71, Hogi Medical Inc.) (Figure 1) and eyeglasses with side guard frames for pollen avoidance (YK-2 the Kafun. Yamamoto Kogaku Co., Ltd. Osaka, Japan) were used (Figure 2, front view and side view). In Japan it is generic to wear a facemask to prevent pollen inhalation. Recently facemasks made with a non-woven fabric have become popular.

Figure 1. Non-woven fabric surgical facemask

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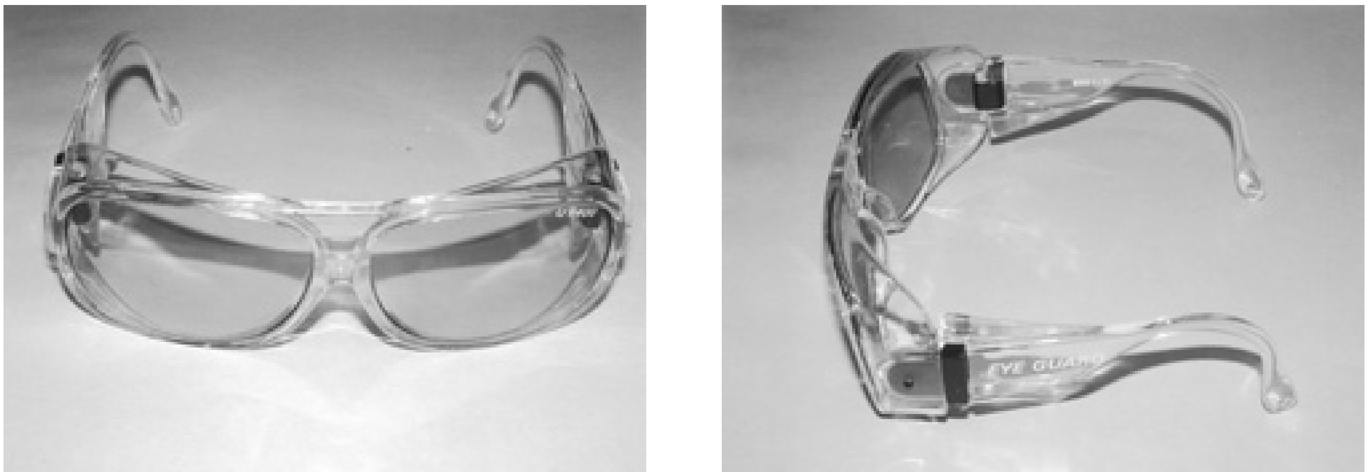

Figure 2. Eyeglasses with side guard frames for pollen avoidance; front view (a), side view (b).

Figure 3. Portable dust sampler with a pump; “mini-pump”

Sample collection

Pollen particles pre-existing in noses and eyes were removed by washing the nasal cavity or eyes with saline solution. The subjects were exposed to pollen particles for 30 min by walking in a field at normal speed carrying a portable dust sampler with a pump; “mini-pump” MP-603T, Shibata Scientific Apparatus Kogyo Inc.) (Figure 3). The power was set at 5L/min to collect airborne pollen particles. The mini-pump was fixed in a breast pocket in order to collect airborne particles floating near nose level. After a 30-min exposure, washing with 200 ml saline collected pollen particles in the nasal cavity, and washing with 20 ml saline collected those on the conjunctiva. On the basis of preliminary trials, if nasal washing is performed with 200 ml saline, the washing solution will collect about 80-90%. The lavage was individually filtered, and pollen particles on the filter paper were stained using Phoebus Blackly Ikuse-modified dye solution and then counted under a microscope (number of pollen particles in the nasal cavity and on the conjunctiva). Airborne pollen were similarly stained and counted.

The experiments were performed in Shizuoka City, Shizuoka Prefecture and in Bunkyo Ward in the center of Tokyo in the pollen seasons of 2000, 2001, and 2002. Local meteorological conditions in Shizuoka and Tokyo were provided by the Shizuoka Local Meteorological Observatory and the Tokyo district Meteorological Observatory (Chiyoda Ward, next to Bunkyo Ward). The mean wind was also recorded during the experiments. The amount of Japanese cedar pollen was measured using a Durham-type pollen collector on the roof of Shizuoka Saiseikai General Hospital in Shizuoka City and in the Bureau of Public Health Tokyo Metropolitan Government (Chiyoda Ward). These values were regarded as the amount of falling pollen (Table 1).

Table 1. Meteorological conditions.

subject	date	time	place	No. of falling pollen (/cm^2/day)	mean wind speed (m/s)
1	2000.3.26	13:45~16:00	Shizuoka City	6.5	6.2
2	2000.3.26	13:45~16:00	Shizuoka City	6.5	6.2
3	2001.4.7	14:00~15:30	Bunkyo Ward, Tokyo	6.2	3.5
4	2001.4.7	14:00~15:30	Bunkyo Ward, Tokyo	6.2	3.5
5	2001.4.12	14:10~15:35	Bunkyo Ward, Tokyo	81.8	6.0
6	2001.4.12	14:10~15:35	Bunkyo Ward, Tokyo	81.8	6.0
7	2002.3.14	16:00~17:30	Bunkyo Ward, Tokyo	84.0	4.4
8	2002.3.14	16:00~17:30	Bunkyo Ward, Tokyo	84.0	4.4
9	2002.3.28	15:30~17:00	Bunkyo Ward, Tokyo	19.1	2.9
10	2002.3.28	15:30~17:00	Bunkyo Ward, Tokyo	19.1	2.9
11	2002.4.4	15:30~17:00	Bunkyo Ward, Tokyo	56.5	8.9
12	2002.4.4	15:30~17:00	Bunkyo Ward, Tokyo	56.5	8.9

Table 2. Number of airborne pollen, number of pollen in the nasal cavity and on the conjunctiva.

subject	With a facemask/ eyeglasses			Without a facemask/ eyeglasses		
	No. of airborne pollen	No. of pollen in the nasal cavity	No. of pollen on the conjunctiva	No. of airborne pollen	No. of pollen in the nasal cavity	No. of pollen on the conjunctiva
1	7	4	4	2	7	4
2	2	9	3	4	7	5
3	19	4	2	25	18	6
4	33	23	2	20	28	2
5	52	34	2	70	21	7
6	66	28	7	47	42	4
7	28	26	7	17	35	3
8	12	32	4	4	15	13
9	17	9	2	3	5	0
10	8	3	5	2	17	5
11	11	48	11	10	40	11
12	9	44	17	7	98	4
median (range)	14.5 (64.0)	24.5 (45.0)	4.0 (15.0)	8.5 (68.0)	19.5 (93.0)	4.5 (13.0)

Table 3. Pollen invasion rate in the nasal cavity and pollen invasion rate on the conjunctiva.

subject	With a facemask/ eyeglasses		Without a facemask/ eyeglasses	
	Pollen invasion rate in the nasal cavity	Pollen invasion rate on the conjunctiva	Pollen invasion rate in the nasal cavity	Pollen invasion rate on the conjunctiva
1	0.57	0.57	3.5	2
2	4.5	1.5	1.75	1.25
3	0.21	0.11	0.72	0.24
4	0.70	0.06	1.40	0.10
5	0.65	0.04	0.3	0.1
6	0.42	0.11	0.89	0.085
7	0.93	0.25	2.06	0.18
8	2.67	0.33	3.75	3.25
9	0.53	0.12	1.67	0.00
10	0.38	0.63	8.50	2.50
11	4.36	1.00	4.00	1.10
12	4.88	1.88	14.00	0.57
median (range)	0.68 (4.67)	0.29 (1.84)	1.91 (13.70)	0.45 (3.25)

Statistics

Statistical analysis of the number of pollen particles was performed by Wilcoxon's signed rank test. A value of $p<0.05$ was regarded as significant.

RESULTS

The average number of pollen particles in the nasal cavity (median (range)) was 24.5 (45.0) in subjects with a facemask and 19.5 (93.0) in those without a facemask. The average number of pollen particles on the conjunctiva (median (range)) was 4.0 (15.0) in subjects with eyeglasses and 4.5 (13.0) in those without eyeglasses (Table 2).

Since airborne pollen counts varied during the experiments under different meteorological conditions and with different amounts of exposed pollen, the effects of facemasks were evaluated using a “pollen invasion rate” determined by dividing the number of pollen particles in the nasal cavity / on the conjunctiva by the amount of airborne pollen measured with the minipump (Table 3).

The pollen invasion rate (median (range)) was significantly lower ($p<0.05$) in subjects with a facemask 0.68 (4.67) than in those without a facemask 1.91 (13.70) (Figure 4). The pollen invasion rate (median (range)) was 0.29 (1.84) in subjects with eyeglasses and 0.45 (3.25) in those without eyeglasses; however this difference was not significant (Figure 5).

There were correlations between the pollen invasion rate in subjects with a facemask and the mean wind speed (correlation coefficient, 0.74; $p=0.0043$) and between the pollen invasion rate with eyeglasses and the mean wind speed (correlation coefficient, 0.68; $p=0.012$) (Figure 6, 7).

The pollen invasion rates without a facemask and without eyeglasses were not correlated with the mean wind speed (Figure 8, 9).

DISCUSSION

There have been studies showing that facemasks and eyeglasses were useful in model experiments [3-6]. Since the morphology of the human nasal cavity and respiratory physiology are not accounted for in model experiments, it is unclear whether these results can be applied to pollinosis patients. In pollinosis patients, allergic reactions may be caused by pollen taken in from the nostrils by breathing, transported by cilliary movement, and finally

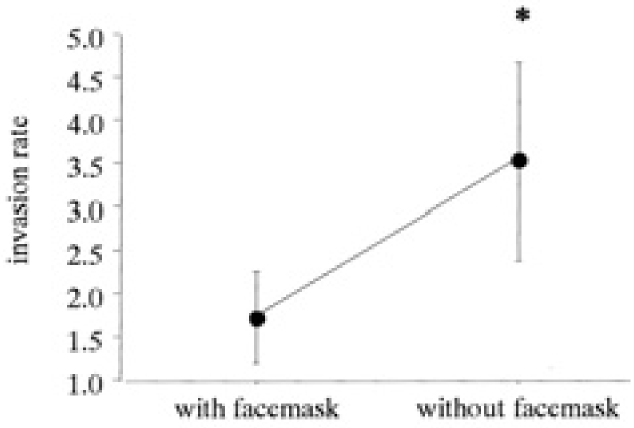

Figure 4. Changes in the pollen invasion rate by wearing a facemask (median (range)). Invasion rate with facemask is significantly lower than without facemask: $*p < 0.05$.

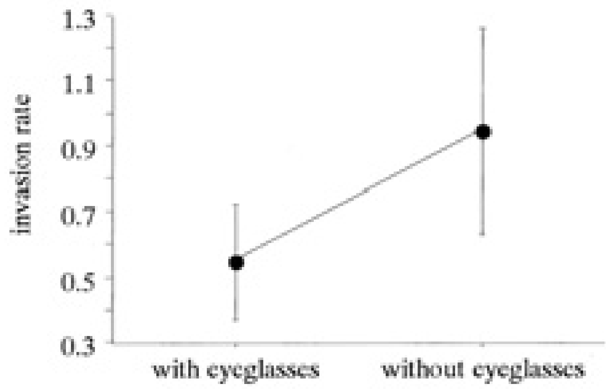

Figure 5. Changes in the pollen invasion rate by wearing eyeglasses (median (range)).

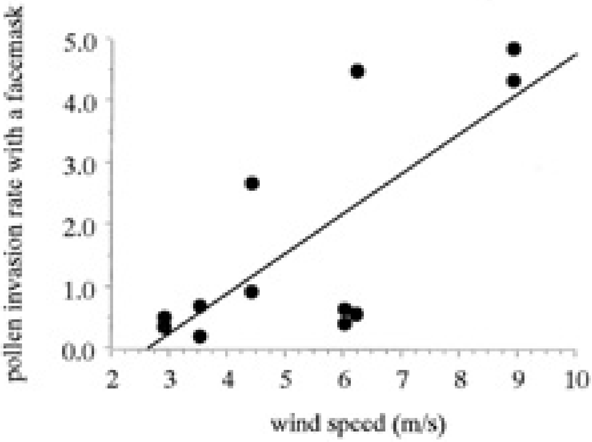

Figure 6. Relationship between pollen invasion rate and mean wind speed with a facemask. Pollen invasion rate with a facemask = -1.71 + 0.65 * wind speed (m/s); R^2 = 0.55.

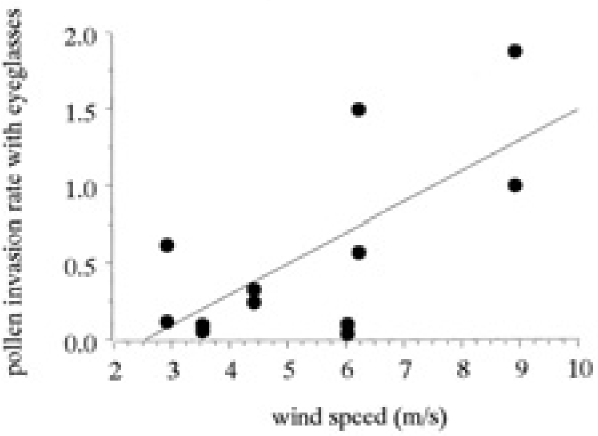

Figure 7. Relationship between pollen invasion rate and mean wind speed with eyeglasses. Pollen invasion rate with eyeglasses = -0.51 + 0.2 * wind speed (m/s); R^2 = 0.47.

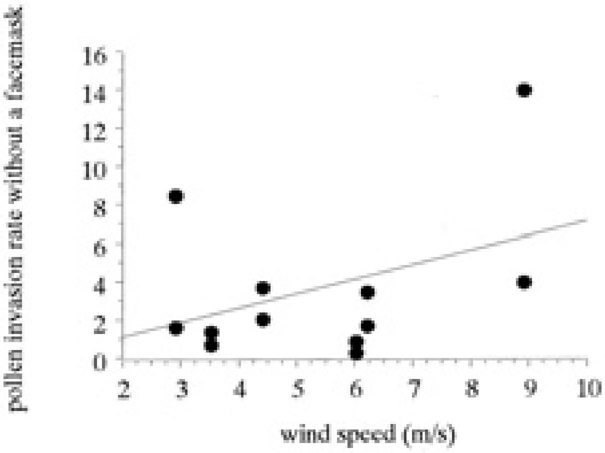

Figure 8. Relationship between pollen invasion rate and mean wind speed without a facemask. Pollen invasion rate without a facemask = -0.45 + 0.75 * wind speed (m/s); R^2 = 0.16.

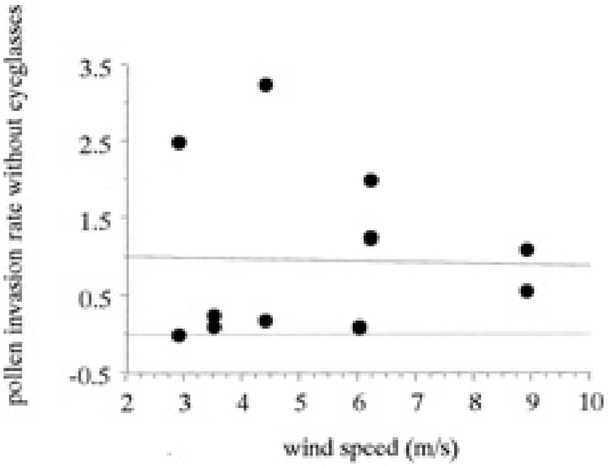

Figure 9. Relationship between pollen invasion rate and mean wind speed without eyeglasses. Pollen invasion rate without eyeglasses = 1.04 - 0.02 * wind speed (m/s); R^2 = 1.06E-3.

deposited in the nasal cavity. To make an evaluation taking these physiological mechanisms in the nasal cavity into consideration, we performed experiments with healthy human volunteers. To evaluate the effect, we employed unique methods: airborne pollen particles at the nose and eye levels were counted and protection against pollen invasion was assessed by pollen count deposited in the nose and eye by lavage. The effect was evaluated by examining the ratio of pollen in the lavage to airborne pollen and by analyzing the relationship between intra-nasal and ocular pollen and wind speed.

In experimental exposure to pollen in humans, there are problems such as variations in meteorological conditions and the number of pollen if the time of the experiment is different, even in the same subject. Since the number of airborne pollen at nose level, not at the roof top level of high buildings, is correlated with the amount of intranasal pollen [7], the effects of facemasks and eyeglasses were evaluated using the pollen invasion rate determined by dividing the number of pollen particles in the nasal cavity and the conjunctiva by the number of airborne pollen particles. By using this method, the problem with the variable amounts of airborne pollen in different situations was solved.

The number of pollen particles in the nasal cavity determined using the pollen invasion rate was significantly lower in subjects with facemasks. This result suggests that avoidance of pollen by the use of a facemask is possible to some extent, but it is not effective in comparison with a model experiment. Furthermore, there was a correlation between the mean wind speed during the experiments and the pollen invasion rate with facemask and eyeglasses (Figure 6, 7). It seems to suggest that the effectiveness of a facemask and eyeglasses depends on the wind speed. If pollen are scattered at high speed when the wind speed is high, the pollen will easily invade the nose and eyes through gaps around the facemask and eyeglasses. It is considered that the pollen count that invades is prescribed by the wind speed, but not by wind direction, because human volunteers move freely in all directions. This point differs in comparison with a model experiment.

To evaluate the effects of removing or avoiding allergens, it is necessary to study the changes in nasal symptoms with decreases in the number of inhaled pollen particles. Also the relationship between removal or avoidance of allergens and clinical effects should be evaluated.

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