

Prevention of asthma induced by cold air by cellulose-fabric face mask

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We have tested the effect of a porous cellulose fabric face mask. Nine asthmatic patients, anamnesticall sensitive to cold, took part in exercise tests on an ergometer bicycle at a temperature of approximately -10°C , with and without a face mask. For comparison, exercise tests were also performed with breathing taking place through a woolen scarf. Three minutes after finishing the exercise test, there was an average fall in FEV_1 of 32% in the group without a face mask. The corresponding fall in FEV_1 was 6% with a face mask and 17% with a scarf. In order to get some idea of the patients' attitudes to the face mask, it was used by 25 asthma patients during a period of 2 weeks in winter, after which they were asked to answer a simple questionnaire. Eighty-eight percent of the patients stated that the face mask had provided satisfactory protection against asthma complaints induced by cold air, and 72% reported that they had been able to spend more time out-of-doors. The results show that porous cellulose fabric designed as a face mask offers effective protection against asthma complaints induced by cold air and exercise, and that the patients appear to appreciate this protective aid highly despite the cosmetic disadvantages.

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Exercise-induced asthma has been shown to be caused by heat/water loss from the airway mucosa (1, 6, 7, 14–16). Accordingly, breathing through a heat and moisture exchanging filter offers considerable protection (3, 4, 8, 10, 12, 13). The clinical experience, at least in Sweden, is that persons suffering from asthma protect themselves in cold weather by wrapping a scarf around the nose and mouth.

In an earlier study, we showed that a breathing filter used in respirators with documented heat-moisture exchanging properties provides effective protection against exercise/cold-induced asthma (3, 10). However, in order for the breathing filter to be a useful therapeutic aid, cosmetic and practical factors also have to be taken into account. On this basis, we have developed a breathing filter designed as a face mask. Like the breathing filter we have tested earlier, this filter consists of a porous cellulose fabric, which can therefore be assumed to have heat and moisture exchanging properties.

The aim of the present study was to test the protective effect of a face mask made of cellulose on exercise-induced asthma in cold air and to compare this effect with that obtained when using a woolen scarf. In addition, we wanted to get an idea of the patients' attitude to this protective aid.

Material and methods

Nine nonsmoking patients (four male, five female) aged 20–60 years, with a history of asthma induced by cold air, took part in the experiments. All of them had been diagnosed as suffering from clinical asthma, with a more than 20% increase in FEV_1 following inhalation of a beta-2 stimulant. The use of other medication varied. FEV_1 (% pred.) varied between 77 and 137%.

The face mask used in the tests covered mouth and nose and consisted of a porous cellulose fabric with heat/moisture exchanging properties (Wet-textduk, AB Teno, Norrköping, Sweden). Resistance to airflow reached 0.1 and 0.15 kPa/l/s at flow rates of 0.4 l/s and 3 l/s, respectively.

The patients received no medication for at least 4 h prior to the tests (no patient used long-lasting beta-stimulants). A nasal clip was used in all tests.

The patients were subjected to stress loads on an ergometer bicycle (RE 820, Rodby Elektronik, Sweden) in three load increments of 6 min each; 30, 70, and 100 W for women and 50, 100, and 150 W for men. The ergometer bicycle was placed in a cold storage room at a temperature of approximately -10°C .

Each patient performed the exercise test on three occasions in the following order: without and with a breathing filter, and with a woolen scarf wrapped twice around the mouth. The tests were performed at the same time of day with intervals of about 1 week and with identical load increments. Forced expiratory volume during 1 s (FEV_1) was determined using a spirometer (Vitalograph, UK) at normal room temperature. For each determination, three satisfactory expirations were performed, and the highest value was then used in the continued analyses. FEV_1 was determined immediately prior to each test and 0, 3, 6, and 9 min after the completion of the tests.

The protective effect of the face mask was calculated according to the following formula: $(\Delta FEV_1 \text{ without filter} - \Delta FEV_1 \text{ with filter}) * 100 / \Delta FEV_1 \text{ without filter}$. ΔFEV_1 corresponds to the maximum reduction in percentage of the initial value.

For studying the attitude to the face mask, 25 patients, 10 men and 15 women diagnosed as suffering from bronchial asthma and anamnestically sensitive to cold, were supplied with five face masks each to be used when needed during 2 weeks in winter. The average temperature during the period was -1.4°C . After the test period, the patients answered a number of questions in writing regarding the face mask.

Results

Fig. 1 shows the average results for the three test series. The average initial values of FEV_1 were as follows: without a face mask, 96% of expected normal value; with a face mask, 87%; and with a woolen scarf, 91%. At breathing without a face mask, FEV_1 was reduced by an average of 32% 3 min after the completed exercise test. The average fall in FEV_1 was 6% with a face mask and 17% with a scarf. When the patients breathed through the face mask or the scarf, the reduction in FEV_1 was significantly smaller than at normal mouth breathing ($P < 0.001$). However, the fall in FEV_1 was smaller when the patients breathed through the face mask than when the double woolen scarf was used ($P < 0.001$). The maximum post-exercise fall in FEV_1 for each patient is illustrated in Fig. 2. The face mask gave a smaller reduction in each patient, while the woolen scarf gave a smaller reduction in seven out of the nine patients. The average protective effect of the face mask was 81% (range 65–106%) and of the scarf 47% (range 21–106%). In the exercise tests without a face mask or scarf, one patient (SR) was given a beta-2 stimulant 3 min after the test had been completed due to obstructive complaints and a 54% reduction in FEV_1 .

Table 1 summarizes the answers given by the 25

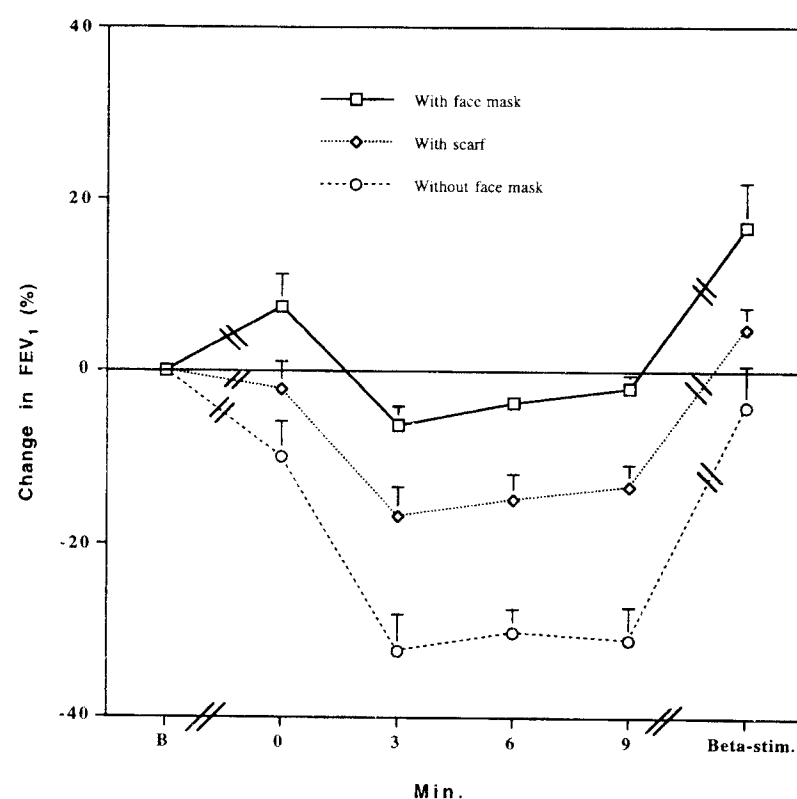


Fig. 1. Change in FEV_1 in nine asthmatics after exercise at about -10°C . Results were obtained after breathing either with or without cellulose-fabric face mask or through woolen scarf, and are mean values expressed in percentage of pre-exercise value. "B" denotes before exercise and "beta-stim" after inhalation of beta-2 stimulant. Bars represent SE.

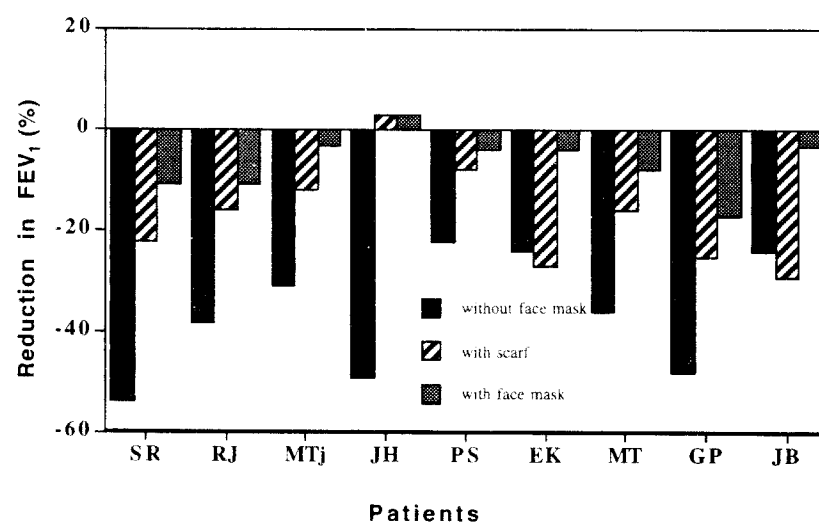


Fig. 2. Maximum reduction from pre-exercise FEV_1 in each patient after exercise on ergometer bicycle at about -10°C , breathing either with or without cellulose face mask or through woolen scarf. Reduction is expressed in percentage of pre-exercise value.

asthmatics who had had access to the face mask during 2 weeks in winter. Eighty-eight percent stated that the face mask had a good or very good protective effect in cold weather, and 44% reported that they had been able to spend much more time out-of-doors thanks to the face mask. The greatest length of time the face mask had been used continuously was 5 h (two patients during a visit to the mountains). Otherwise, the length of time the mask had been used varied between 5 min and 1 h on each occasion. Eighty percent stated that they would be

Table 1. Presentation of five questions and results after 14 days' use of face mask

Questions	Alternatives	Answers %
1. Do you consider the face mask to be effective in cold weather?	No effect	—
	Little effect	12
	Good effect	36
	Very good effect	52
2. Have you been able to go out more due to the face mask?	Not more	28
	A little more	28
	Much more	44
3. What was the greatest length of time you used the face mask continuously?	5–20 min	28
	30 min	20
	45 min	12
	1 h	16
	5 h	8
4. What was the reason for not using the filter outdoors?	Too short a stay outdoors	64
	Impractical	24
	No effect	4
	Due to appearance	48
	Forgot it	12
	Other reasons	24
5. If the face mask was for sale, would you be interested in buying it?	Yes	80
	No	20

interested in buying the mask if it was commercially available.

Discussion

Already in the early 1980s, two articles were published showing that a face mask prevented exercise-induced bronchial obstruction (4, 13). The tests were performed at room temperature and at 4°C, respectively, but the effect mechanisms were not known. The material used in the face mask is not described but can be assumed to have heat-moisture exchanging properties. In 1986, Bake et al. (3) demonstrated that a heat and moisture exchanging filter made of cellulose protected against exercise-induced asthma. Gravelyn et al. (8) published data in 1987 showing that a breathing filter made of heat-moisture exchanging cellulose material prevented hyperpnea-induced bronchial obstruction provoked by dry air at room temperature. In 1992, Nissar et al. (12) described a mask consisting of aluminum mesh, which prevented exercise-induced asthma. In addition, a metal heat-moisture exchanger to be placed in the mouth (Lungplus, Lungplus Info AB, Malmö, Sweden) is commercially available in Sweden.

Consequently, breathing through heat-moisture exchanging material is an effective way of preventing cold/exercise-induced bronchial obstruction. To be able to utilize such devices clinically, practical and cosmetic aspects have to be considered. An oral heat-moisture exchanger entails practical problems in terms of speech and saliva. Masks made of metal

are difficult to design in such a way that they are acceptable, and they are also heavy to wear. Moreover, precipitation of metal may take place in saliva and inspired air. A woolen scarf used in our tests, which partly prevented exercise-induced asthma, was on the whole perceived by the patients as uncomfortable due to moisture and itching. Cellulose has been shown to have excellent heat and moisture exchanging properties (3, 10), it can easily be given different designs, and, furthermore, it is cheap. To our knowledge, no hypersensitivity reactions have been reported with regard to cellulose and it is pleasant to the skin. Resistance to air in the cellulose fabric is low, and the patients had no complaints about high resistance. For these reasons, we decided to choose cellulose as material in our face mask.

The average protective effect of the heat-moisture exchanging breathing filter made of cellulose was, in our earlier tests, determined at 70% (10), while the average protective effect of the aluminum heat-moisture exchanger was 55%, calculated on the basis of median values (8). Several earlier studies have been published in which the protective effect of a beta-2 stimulant and cromolyn sodium was investigated. In at least two of these studies, FEV₁ was measured (2, 5). The percentage of protective effect varied in these studies between 60% and 70%. Thus, compared with other heat-moisture exchangers and pharmaceuticals, the cellulose-fabric face mask offers protection of similar magnitude.

According to the questionnaire, nine out of 10 patients stated that the face mask had a good or very good effect in cold weather, and seven out of 10 that they had been able to spend more time out-of-doors thanks to the mask. A questionnaire survey published earlier (12) revealed that three out of 10 asthmatics avoided going out-of-doors in winter due to breathing difficulties. In consequence, the extent of the problem is considerable, and it is obvious that their medication has not to a sufficient degree reduced their symptoms. An effective face mask could be useful to many of those patients, of whom some probably would prefer a "drug-free way" of treatment.

No doubt, different cultures have different attitudes to the use of face masks. For example, it seems to be much more common in Japan than in Europe to use masks for protection in different situations. It is possible that, in the future, a change in attitude will take place also in countries where masks are not worn today.

The range of application of the face mask described here may in the future be extended. For instance, recent reports showed that top-level skiers are exposed to a substantially increased risk of contracting asthma (9). The most probable explanation for this is an inflammation of the airway mucosa due

to dehydration and cold air from hyperventilation caused by training and skiing competitions in a cold climate. It is possible that regular use of heat-moisture exchanging masks would prevent asthma problems in skiers. For cold store and ice-skating-rink employees, the mask could make it easier for the wearer to maintain a normal body temperature, at the same time as the airway mucosa is protected from cooling and dehydration with the possible risk of increased incidence of asthma.

In summary, the results of laboratory tests, as well as of asthmatic patients' experience of the heat and moisture exchanging breathing filter designed as a face mask, demonstrate that the mask offers considerable protection against bronchial obstruction induced by cold air.

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