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## Subjective and objective assessments of seasonal effect in children with seasonal allergic rhinitis

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### ABSTRACT

**Background:** Epidemiological and clinical studies suggest a relationship between rhinitis and asthma. Upper and lower airways may be influenced by a common inflammatory process.

**Objective:** This study aimed to investigate the relationships between rhinitis symptom scores, and both nasal and bronchial airflow among children with seasonal allergic rhinitis (SAR) by means of spirometric and rhinomanometric measurement during and outside the pollen season.

**Methods:** Twenty-nine children with both seasonal allergic rhinitis and asthma (AR + A), 30 children with SAR and no asthma (AR) and 36 non-allergic healthy children were evaluated prospectively during and outside the pollen season. Symptom severity was evaluated using both total symptom score and visual analog score (VAS). All participants also received rhinomanometric evaluation and pulmonary function testing.

**Results:** In children with SAR the median total nasal flow, FEV<sub>1</sub>, FEF<sub>25–75</sub> values were lower than control group during pollen season ( $p = 0.01$ ,  $p < 0.001$  and  $p < 0.001$  respectively). They had also higher total nasal resistance compared with control groups ( $p = 0.01$ ). Nasal symptom scores were higher among patients with concurrent asthma than patients who had only SAR out of pollen season ( $p < 0.001$ ). There was no significant difference between SAR participants with or without asthma and control group in terms of total nasal flow and total nasal resistance measured out of season ( $p = 0.105$  and  $p = 0.19$ ). FEF<sub>25–75</sub> values of patients with and without asthma were significantly lower than those of controls out of season ( $p = 0.022$ ,  $p < 0.001$  respectively).

**Conclusion:** Our data suggests that as the presence of AR worsens asthma control, the presence of asthma may worsen symptoms of AR out of pollen season. We found that total nasal flow, FEV<sub>1</sub>, FEF<sub>25–75</sub> values of patients with SAR were lower than those of controls out of season. FEF<sub>25–75</sub> values of patients with asthma and without asthma were significantly lower than those of controls out of season. Thus, a careful evaluation of lower airways should be performed in even patients with seasonal allergic rhinitis alone.

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### 1. Introduction

Allergic rhinitis (AR) is a common chronic inflammatory disorder of the nasal mucosa. Though not a debilitating condition, AR is associated with reduced quality of life, decreases in academic and work performance, sleep disorders, and social as well as emotional problems [1,2].

AR severity is derived chiefly from patient history and clinical findings, as well as symptom scores. Recently the visual analog scale (VAS) has been proposed as a useful parameter for the

evaluation of patients with AR [3–5]. Objective evaluation of nasal blockage may be performed using rhinomanometry, a technique involving simultaneous measurements of nasal airway resistance, nasal airflow, and transnasal pressure [6,7]. Symptom severity in patients with AR has been shown by rhinomanometry to affect nasal air flow measure [8,9].

Nasal and bronchial airways are considered to be united and patients with allergic rhinitis often have varying degrees of impairment in pulmonary function and sometimes have bronchial reactivity, which put them at risk of developing asthma [10–14]. Asthma is characterized by a reversible airflow obstruction and forced expiratory volume/1 sn (FEV<sub>1</sub>) is considered the main parameter to evaluate bronchial obstruction [15]. Moreover, small airways are involved in the pathogenesis of asthma

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[16]. Although, there is no direct parameter for assessing small airways, it has been assumed that the forced expiratory flow at the 25% and 75% of the pulmonary volume (FEF<sub>25–75</sub>) might be considered as a measure of the caliber concerning distal airways [17,18]. Particularly, subjects with mild asthma and normal FEV<sub>1</sub> may show impaired FEF<sub>25–75</sub> only [19,20].

This study aimed to investigate the relationships between rhinitis symptom scores, and both nasal and bronchial airflow among children with seasonal allergic rhinitis (SAR) by means of spirometric and rhinomanometric measurement during and outside the pollen season.

## 2. Materials and methods

### 2.1. Patients

The patients for this study were selected among those who were referred to the Pediatric Allergy and Asthma Clinic from January to December 2010 for the evaluation of seasonal nasal symptoms. A detailed medical history was obtained for all participants, and information regarding their age, gender, allergic rhinitis symptoms, disease duration, family history of atopy, and comorbid conditions were recorded. Three study groups were formed: patients with seasonal allergic rhinitis and asthma (AR + A, *n* = 29); patients with allergic rhinitis, without asthma (AR, *n* = 30); and non-allergic healthy control children (C, *n* = 36). Allergy was assessed by performing a skin prick test. The children were tested with a panel of common inhalant allergens including house dust mites, a mixture of 12 grass pollens, a mixture of four grain pollens, tree pollens, weed pollens, molds, *Cladosporium* mixture, animal epithelium, cockroach (Stallergenes SA, 92160, Antony, France). A mean wheal diameter greater than 3 mm was considered positive. The control group consisted of healthy children (i.e., without AR symptoms) matched for age and gender who attended the clinic during the same period. The control groups were all skin test negative. Asthmatic patients fulfilled the criteria for asthma according to GINA guidelines [21]. Diagnosis of seasonal allergic rhinitis was based on criteria in ARIA consensus statement [1].

This study was performed in the Pediatric Allergy and Asthma outpatient clinic of Dr. Sami Ulus Children's Hospital in Ankara, Turkey and was approved by the ethics committee of Ankara Keçiören Teaching and Research Hospital (2010/01-199; 11.01.2010).

### 2.2. Study design

The patients who met the following criteria were eligible for inclusion in the study: age between 6 and 17 years, living in Ankara for the previous years; history of seasonal allergic rhinitis and/or asthma due to seasonal allergen exposure. Participants who had had upper respiratory tract infection (URTI) or acute rhinosinusitis within 2-weeks prior to participation and those with anatomical deformities causing airway obstruction, such as a tumor, polyp, and choanal atresia, were excluded from the study. None of the patients were taking any treatment for allergic rhinitis and/or asthma (such as nasal or inhaler steroids, nasal or oral antihistaminics or decongestants) and they did not receive specific immunotherapy before measurement procedures.

All SAR patients were evaluated both within and out of the season. Pollen season was determined according to Ankara's pollen map for 2010 ([www.aid.org.tr/aid.polen.ankara](http://www.aid.org.tr/aid.polen.ankara)). The period from March to July was considered 'in season' for tree pollens, from March to August for grass pollens and from May to October for weeds. Healthy children were taken as one group and were evaluated independent of the season.

### 2.3. Nasal symptoms

#### 2.3.1. Total symptom score (TSS)

AR symptoms were assessed using the total symptoms score (TSS) by calculating the sum of scores for nasal obstruction, rhinorrhea, nasal itching, and sneezing. Each nasal symptom was scored on a scale from 0 to 3 (0 = no symptoms; 1 = mild; 2 = moderate; 3 = severe) according to TSS. Any symptom not causing significant discomfort was considered mild. Any symptom causing discomfort but not interfering with daily activity and/or disturbing sleep was considered moderate. Any symptom that interfered with daily activity and sleep pattern was considered severe.

#### 2.3.2. Visual analog scale (VAS)

VAS was used to quantify the subjective feeling of nasal obstruction and other symptoms, including itching, sneezing, and rhinorrhea. VAS ranges from 0 (i.e., no obstruction) to 10 (i.e., complete obstruction). Patients were asked to place a cross on a line to indicate their perception of nasal obstruction.

### 2.4. Rhinomanometric evaluation

Nasal flow and resistance of all participants in the AR and control group were evaluated using anterior rhinomanometry. Measurements (total nasal flow and nasal resistance) were performed twice (in season and out of season) for patients with AR and once for healthy controls. The instrument ZAN 100 Rhino; (ZAN Messgeraete GmbH, Germany) was used. Each participant was allowed to rest for 20 min at room temperature (22–24 °C) before being requested to maintain an upright sitting position. After placing a nasal probe into either nostril, the participant was asked to breathe through one nostril with a closed mouth, during which transnasal flow and pressure measurements were recorded using a computer. The average of three consecutive nasal cavity flow measurements was recorded as the final result. All measurements were made using a steady pressure of 150 Pa as recommended by the European Rhinomanometry Standardization Committee [22].

### 2.5. Spirometric evaluation

Spirometric evaluation was performed for all participants on the same day as rhinomanometric evaluation using a ZAN 100 spirometry device and/or a portable spirometer (Spirobank MIR, Rome, Italy) at room temperature with patients in an upright sitting position using a nose clip. Participants with AR were tested twice (in season and out of season) while healthy controls were tested once. The best values of at least three consecutive measurements were recorded for each participant. Recorded measurements included forced vital capacity (FVC), forced expiratory volume in one second (FEV<sub>1</sub>), mid-flow rate/forced expiratory flow at 25–75% of FVC (FEF<sub>25–75</sub>), peak expiratory flow (PEF), and FEV<sub>1</sub>/FVC. Results were interpreted according to the predicted values published in national consensus reports of the American Thoracic Society and the European Respiratory Society (ERS) [23,24].

### 2.6. Statistical analyses

All analyses were performed using SPSS 15 (SPSS Inc., Chicago, IL, USA). Values for categorical variables were provided in numerals and percentages of the total. Data are presented as the median, IQR (interquartile range). Categorical variables were compared using chi-square test. Two-way comparisons of numerical values were made using either Student's *t*-test for

independent samples or the Mann–Whitney *U* test where appropriate. The correlation between two continuous variables was evaluated by either Pearson's or Spearman's coefficient. For comparisons involving more than two groups, a one-way ANOVA test was the preferred parametric test, whereas the Kruskal–Wallis variance analysis test was used for nonparametric comparisons. For all values a *p* value of less than 0.05 indicated statistical significance.

### 3. Results

#### 3.1. Patients

A total of 95 patients were enrolled in the study: 59 patients with SAR and 36 healthy controls. The demographic and clinical characteristics of study population have been summarized in Table 1.

There was no significant difference between groups in terms of age ( $p = 0.831$ ) or gender distribution ( $p = 0.568$ ).

#### 3.2. Nasal symptoms

The symptom score of rhinitis in patients with SAR were higher within pollen season than determined out of season ( $p < 0.001$  and  $p < 0.001$  respectively). TSS and VAS were higher than the control group both within and out of pollen season ( $p < 0.001$  and  $p < 0.001$  respectively) (Table 2).

SAR patients with and without asthma were also evaluated separately. TSS and VAS score values were higher than the control group both during and out of the pollen season ( $p < 0.01$ ,  $p < 0.01$  respectively, a summary of these comparisons is provided in Table 3.

Total rhinitis symptom scores of patients with AR + A were higher than those of without asthma out of season ( $p = 0.032$ ) whereas total symptom scores of patients with AR + A taken during pollen season were not different from those of patients without asthma.

#### 3.3. Rhinomanometry

A comparison of rhinomanometric measurements revealed that participants with SAR had significantly lower total nasal flow rates and higher total nasal resistance during the pollen season than measured out of season ( $p = 0.042$  and  $p = 0.01$ , respectively). When measured within pollen season, total nasal flow rates were significantly lower and nasal resistance was higher in the SAR group compared to healthy controls ( $p = 0.01$  and  $p = 0.01$  respectively). Nasal flow values of SAR patients measured out of season were also lower than the control group ( $p = 0.036$ ). Results of rhinomanometric evaluation are shown in Table 2.

Nasal resistance values of asthmatic SAR patients obtained in season were higher than measured out of season ( $p = 0.02$ ). There was no significant difference between SAR participants with or without asthma and control group in terms of total nasal flow and total nasal resistance measured out of season ( $p = 0.105$  and  $p = 0.197$ ).

#### 3.4. Pulmonary function tests

In terms of pulmonary function tests, FVC, FEV<sub>1</sub>, FEF<sub>25–75</sub> obtained during the pollen season were significantly lower than corresponding values obtained out of season ( $p = 0.005$ ,  $p = 0.002$  and  $p = 0.005$  respectively). When measurements taken within pollen season were evaluated, FEV<sub>1</sub> and FEF<sub>25–75</sub> values of SAR

Table 1

Demographic and clinical characteristics of study population.

|                              | All patients, <i>n</i> = 95 (%) | Seasonal allergic rhinitis, <i>n</i> = 59 (%) | Control group, <i>n</i> = 36 (%) | <i>p</i> |
|------------------------------|---------------------------------|-----------------------------------------------|----------------------------------|----------|
| Age in years (median–IQR)    | 12 (9–14)                       | 12 (10–13)                                    | 12 (8–14.7)                      | 0.568    |
| Male gender                  | 55 (57.9)                       | 35 (59.3)                                     | 20 (55.6)                        | 0.831    |
| A. rhinitis duration (years) | –                               | 4 (2–6)                                       |                                  |          |
| Polysensitization            | 42 (44.2)                       | 42 (71.1)                                     |                                  |          |
| Passive smoking (%)          | 39 (41.1)                       | 26 (44.1)                                     | 13 (36.1)                        | 0.522    |
| Comorbidity                  |                                 |                                               |                                  |          |
| Asthma                       | 29 (30.5)                       | 29 (49.2)                                     |                                  |          |
| Allergic rhinoconjunctivitis | 30 (31.6)                       | 30 (50.8)                                     |                                  |          |
| Atopic dermatitis            | 7 (7.4)                         | 7 (11.9)                                      |                                  |          |
| Family atopy                 | 26 (27.4)                       | 26 (44.1)                                     | 0                                | <0.001   |
| Asthma                       | 18 (18.9)                       | 18 (30.5)                                     | 0                                | <0.001   |
| Allergic rhinitis            | 16 (16.8)                       | 16 (27.1)                                     | 0                                | <0.001   |

Table 2

Spirometric and rhinomanometric measurements in patients with seasonal allergic rhinitis and healthy group.

| Parameter (median–IQR)         | Seasonal allergic rhinitis, <i>n</i> = 59 |                  |                       | Control, <i>n</i> = 36 |                       |                       |
|--------------------------------|-------------------------------------------|------------------|-----------------------|------------------------|-----------------------|-----------------------|
|                                | In season                                 | Out of season    | <i>p</i> <sup>a</sup> | Independent of season  | <i>p</i> <sup>a</sup> | <i>p</i> <sup>b</sup> |
| Total symptom score            | 7 (5–10)                                  | 2 (1–3)          | <0.001                | 0 (0–0)                | <0.001                | <0.001                |
| Visual analog score            | 5.3 (3–8.3)                               | 3.5 (2.5–4.5)    | <0.001                | 1.5 (1–2.5)            | <0.001                | <0.001                |
| Total nasal flow (ml/s)        | 430 (304–550)                             | 486 (398–577)    | 0.042                 | 559 (430.2–743.7)      | 0.036                 | 0.01                  |
| Total nasal resistance (Pa/ml) | 0.35 (0.27–0.49)                          | 0.31 (0.24–0.38) | 0.005                 | 0.26 (0.20–0.34)       | 0.072                 | 0.01                  |
| Pulmonary function test        |                                           |                  |                       |                        |                       |                       |
| FVC (%)                        | 84 (79–93)                                | 87 (80–94)       | 0.005                 | 87 (82–95.5)           | 0.730                 | 0.124                 |
| FEV <sub>1</sub> (%)           | 93 (86–103)                               | 97 (90–103)      | 0.002                 | 101.5 (95–107.7)       | 0.022                 | <0.001                |
| FEV <sub>1</sub> /FVC (%)      | 107 (98–114)                              | 109 (102–115)    | 0.105                 | 112 (108.2–113.7)      | 0.086                 | 0.007                 |
| FEF <sub>25–75</sub> (%)       | 92 (84–105)                               | 103 (86–115)     | 0.005                 | 113.5 (106–134.5)      | <0.001                | <0.001                |

IQR, interquartile range.

<sup>a</sup> Out of season versus independent of season.

<sup>b</sup> Independent of season versus in season.

**Table 3**

Spirometric and rhinomanometric measurements of SAR patients with and without asthma and healthy controls.

| Parameter<br>(median–IQR)   | Asthma (+), n = 29 |                 |       | Asthma (–), n = 30 |                |       | Control n = 36           |                |                | Comparison     |  |  |
|-----------------------------|--------------------|-----------------|-------|--------------------|----------------|-------|--------------------------|----------------|----------------|----------------|--|--|
|                             | In season          | Out of season   | p     | In season          | Out of season  | p     | Independent<br>of season | p <sup>a</sup> | p <sup>b</sup> | p <sup>c</sup> |  |  |
| Total symptom score         | 7 (4–9.5)          | 2 (1–3)         | <0.01 | 6.5 (6–10)         | 1 (0–2)        | <0.01 | 0 (0–0)                  | <0.01          | <0.01          | <0.01          |  |  |
| Visual analog score         | 5.3 (3–8.5)        | 4 (2.3–5.5)     | 0.007 | 5.2 (3–7.4)        | 3.2 (2.3–4.5)  | 0.003 | 1.5 (1–2.5)              | <0.01          | <0.01          | <0.01          |  |  |
| Nasal flow (ml/s)           | 421 (303–553)      | 472 (408–570)   | 0.066 | 469 (308–526)      | 486 (385–613)  | 0.28  | 559 (430–744)            | 0.105          | 0.057          | 0.096          |  |  |
| Nasal resistance<br>(Pa/ml) | 0.36 (0.27–0.5)    | 0.3 (0.24–0.37) | 0.02  | 0.3 (0.3–0.5)      | 0.31 (0.2–0.4) | 0.084 | 0.26 (0.20–0.34)         | 0.197          | 0.114          | 0.141          |  |  |
| FEV <sub>1</sub>            | 91 (82–100)        | 98 (91–102)     | 0.004 | 95 (88–99)         | 96 (90–105)    | 0.132 | 102 (96–108)             | 0.071          | 0.047          | 0.038          |  |  |
| FEF <sub>25–75</sub>        | 92 (84–107)        | 103 (90–113)    | 0.05  | 94 (84–101)        | 101 (85–115)   | 0.042 | 113 (106–135)            | 0.01           | 0.003          | 0.002          |  |  |

TSS, total symptom score; VAS, visual analog score.

<sup>a</sup> Asthma (positive and negative) out of season parameters versus control.<sup>b</sup> Asthma negative out of season parameters versus control.<sup>c</sup> Asthma positive out of season parameters versus control.

patients were lower than the control group ( $p < 0.001$  and  $p < 0.001$ ). When measurements taken out of pollen season were evaluated, FEV<sub>1</sub> and FEF<sub>25–75</sub> of SAR patients were lower than the control group ( $p = 0.022$  and  $p < 0.001$ ). Results of pulmonary function tests have been summarized in Table 2.

SAR patients with and without asthma were also evaluated separately. FEV<sub>1</sub> and FEF<sub>25–75</sub> values of patients with asthma were lower than the control group out of the pollen season ( $p = 0.038$ ,  $p = 0.002$  respectively). FEV<sub>1</sub> and FEF<sub>25–75</sub> values of patients without asthma were also lower than the control group out of the pollen season ( $p = 0.047$  and  $p = 0.003$  respectively). A comparison of asthmatic SAR participants, nonasthmatic SAR participants and healthy controls revealed a statistically significant difference between groups in terms of FEF<sub>25–75</sub> ( $p = 0.01$ ). Following subsequent two-way comparisons, healthy controls were found to have significantly higher FEF<sub>25–75</sub> values than SAR participants with or without asthma ( $p = 0.003$  and  $p = 0.002$ , respectively).

### 3.5. Correlations

A strong positive correlation was observed between TSS and VAS of SAR patients during the pollen season ( $r = 0.858$ ;  $p < 0.001$ ). During the same period, TSS and VAS scores were found to be negatively correlated with total nasal flow rates ( $r = -0.305$ ;  $p = 0.0019$  and  $r = -0.351$ ;  $p = 0.006$ ) and positively correlated with total nasal resistance ( $r = 0.318$ ;  $p = 0.014$  and  $r = 0.366$ ;  $p = 0.04$ ).

There was no correlation between nasal flow rates and FEV<sub>1</sub> and FEF<sub>25–75</sub> ( $p < 0.05$ ). There was also no correlation between nasal resistance and TSS, VAS, FEV<sub>1</sub> and FEF<sub>25–75</sub> ( $p < 0.05$ ).

Disease duration in SAR participants was found to correlate negatively with both FEV<sub>1</sub> values ( $r = -0.34$ ;  $p = 0.019$ ) and FEF<sub>25–75</sub> values ( $r = -0.281$ ;  $p = 0.031$ ). No significant correlation could be established between disease duration and either total nasal flow ( $r = -0.029$ ;  $p = 0.829$ ) and total nasal resistance ( $r = 0.019$ ;  $p = 0.885$ ).

## 4. Discussion

Allergic rhinitis usually presents in early childhood and is caused by an immunoglobulin E-mediated reaction to various allergens in the nasal mucosa. Allergic inflammation accounts for the occurrence of nasal symptoms, especially nasal obstruction. Nasal obstruction constitutes a crucial symptom, because it may affect quality of life, bronchial hyperreactivity, thus allowing the occurrence of several sequelae, including rhinosinusitis, otitis media, and asthma [25,26].

Evaluation of symptom severity in patients with AR is mostly based on the presence of certain clinical, immunologic, and

rhinomanometric parameters. The extent of nasal congestion/blockage is an important constituent of TSS. Nasal congestion may be evaluated subjectively by the apparent ‘openness’ of the nasal airway and objectively by measuring nasal air flow and resistance using rhinomanometry [27]. Recently, it has been suggested that the VAS may be useful for the evaluation of symptom severity in patients with AR [5]. In a multicentric study by Jauregu et al. [28] on 1275 children with AR, a significant correlation was observed between VAS and TSS, particularly in patients with moderate and severe rhinitis symptoms. Similarly, Watson et al. [29] have reported a significant correlation between nasal congestion score and VAS in children aged 6–12 years with SAR. In the present study, there was a strong correlation between TSS and VAS during the pollen season, findings consistent with the literature.

There are several investigations analyzing the relationship between allergic inflammation and nasal symptoms and/or nasal airflows in children with allergic rhinitis [30–33]. The progressive worsening of nasal airflow has also been reported in patients with longstanding persistent AR by using rhinomanometry [34]. These reports underlined the close connection between allergic inflammation and nasal airflow impairment in children with both seasonal and perennial allergic rhinitis. In the present study, rhinitis symptoms scores were found to correlate negatively with total nasal flow and correlate positively with total nasal resistance in children with SAR during the pollen season. These findings are consistent with the literature.

Symptoms of rhinitis and bronchial inflammation commonly co-exist. This may be the result of a causal nexus between primary nasal stimulation and secondary bronchopulmonary disease called the rhinobronchial syndrome [35,36]. Another explanation of co-existence may be that asthma and allergic rhinitis share numerous common pathophysiological features and primary immune response to an allergic stimulus is initially local and is followed by a more generalized airway reaction. Hence, AR and A can be considered as part of the global airway allergy syndrome [10,11,14,26]. Although limited for children, there are studies supporting both explanations. Cassano et al. [35] reported that co-existence of nasal and bronchial diseases seems to be due to the action of aeroallergens which, by releasing mediators, act on the upper and lower airways but in those cases in which severe persistent nasal obstruction predominates, a causal correlation between allergic rhinitis and lower airway hyperresponsiveness can be established.

The connection between AR and A has been the subject of many epidemiological investigations that have shown an important overlap between both diseases. Although there are studies comparing patients with asthma and patients with both AR + A, they are usually interested in the effect of the presence of AR on severity of asthma [37–42]. In one study asthma severity has been

associated with rhinitis severity and AR patients with persistent asthma were found to have significantly higher values of nasal symptom scores than AR patients with non-persistent asthma [43]. To our knowledge there are not any studies comparing AR patients with and without asthma in terms of the severity of AR. In this study, we evaluated the severity of SAR using both symptom scores and rhinomanometry both in and out of pollen season and compared groups with and without concurrent asthma. Although rhinomanometric variables were similar in these groups, nasal symptom scores were higher among patients with concurrent asthma than patients who had only SAR out of pollen season. Our data suggests that as the presence of AR worsens asthma control, the presence of asthma may worsen symptoms of AR out of pollen season.

A limitation of this study is that pollen species and levels were not taken into consideration. The possible difference of pollen counts taken during consecutive years may have affected the results.

It is shown that the duration of AR can affect the degree of bronchial hyperreactivity. In one study on a large group of patients with moderate or severe AR that had endured for more than 5 years, severe bronchial hyper-reactivity was observed in those patients with a FEV<sub>1</sub> value of  $\leq 86\%$  [44]. In consistence with these data, spirometric parameters were correlated with disease duration in our study.

Early bronchial involvement and spirometric impairment may occur in patients with persistent allergic rhinitis. In a study by Ciprandi et al. [45], FEF<sub>25–75</sub> was postulated as an early indicator of bronchial involvement in AR patients with only nasal symptoms. In this present study, SAR patients had significantly lower FEF<sub>25–75</sub> values compared to healthy controls regardless of asthmatic status both in and out of pollen season. Values obtained with pulmonary function testing (FVC, FEV<sub>1</sub>, FEF<sub>25–75</sub>) during the pollen season were also significantly lower than out of season values. Supporting our results, a recent study has shown that SAR patients with no bronchial symptoms had eosinophilic bronchial inflammation [11]. These findings suggest that the lower airways of SAR patients warrant evaluation even in the absence of bronchial symptoms. One possible explanation is that the inflammation of the upper and lower airways is mediated by common immunopathological mechanisms, which leads to early involvement of small airways in patients with allergic disorders other than asthma.

In conclusion, our study highlights the FEF<sub>25–75</sub> values of SAR patients with asthma and without asthma were significantly lower than those of controls out of season and supports the strong link between upper and lower airways. Furthermore, our data suggests that as the presence of AR worsens asthma control, the presence of asthma may worsen symptoms of AR even out of pollen season. Additional longitudinal studies and intervention studies to assess in this respect will facilitate the understanding of the mechanism underlying these diseases and enable appropriate evaluation and accurate treatment in each patient.

## Conflict of interest

The authors declare that they have no conflict of interest.

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