Original Study

Asia Pacific Allergy

OPEN

Quantitative assessment and correlational analysis of subjective and objective indicators in patients with allergic rhinitis

Jia Gu†, Zhuo-Ping Liang†, Wei Xu, Tian-Zhen Liu, Zhen-Rong Li, and Gang Qin*

ABSTRACT

Background: The diagnosis of allergic rhinitis is mainly based on the typical medical history, clinical manifestations, and corresponding allergen test results of the patients. However, there are often clinical inconsistencies among the 3.

Objective: To study the clinical characteristics of patients with allergic rhinitis from both subjective and objective aspects to determine the correlations between the quantitative assessment outcomes of subjective and objective indicators.

Methods: A total of 111 patients with allergic rhinitis who visited our outpatient clinic from June 2022 to December 2022 were selected. The 22-item sino-nasal outcome test (SNOT-22) and the visual analog scale (VAS) for the severity of the disease were used to score the subjective indicators of allergic rhinitis. The objective indicators of allergic rhinitis were evaluated by serum inhalant allergens immunoglobulin E test, nasal endoscopy modified Lund-Kennedy (MLK) scoring method, and acoustic rhinometry.

Results: SNOT-22 score, total VAS score for symptoms, and the VAS score for nasal itching were positively correlated with the number of positive allergens ($r = 0.266$, $P = 0.005$, $r = 0.576$, $P < 0.001$, and $r = 0.271$, $P = 0.004$, respectively). No differences were found in all subjective indicators scores between the total immunoglobulin E positive and negative groups ($P > 0.05$). SNOT-22 score, total VAS score for symptoms, and the VAS score for nasal congestion were positively correlated with MLK total score of nasal endoscopy ($r = 0.343$, $P < 0.001$, $r = 0.438$, $P < 0.001$, and $r = 0.225$, $P = 0.018$, respectively). Parameters of acoustic rhinometry were not correlated with the subjective indicators scores of allergic rhinitis ($P > 0.05$).

Conclusion: A multifaceted quantitative assessment of allergic rhinitis using a combination of subjective and objective methods can help physicians make an accurate diagnosis and create reasonable treatment plans.

Keywords: Acoustic rhinometry; allergens; allergic rhinitis; endoscopy; symptom assessment

1. Introduction

Allergic rhinitis is a noninfectious inflammatory disease of the nasal mucosa mediated by immunoglobulin E following exposure to inhaled allergens and characterized by nasal itching, sneezing, runny nose, and nasal congestion. Allergic rhinitis affects 20% to 30% of adults and up to 40% of children in the United States and Europe [1], and this is increasing every year. Allergic rhinitis has a serious impact on the life, work, and study of the patients; thus, it is a serious burden on the national health economy [1]. Presently, the subjective and objective clinical assessment outcomes of patients with allergic rhinitis are often inconsistent, which poses difficulties for diagnosis and treatment.

Clinically, the main instrument for assessing subjective symptom indicators in patients with allergic rhinitis is the visual analog scale (VAS), which is a psychometric response score that enables patients to self-assess the severity of their symptoms, such as nasal itching, sneezing, runny nose, and nasal congestion based on their subjective perceptions; this tool can be used to assess the disease control of allergic rhinitis [2]. Even though the 22-item sino-nasal outcome test (SNOT-22) is presently used for symptom and quality of life assessment in patients with chronic sinusitis, 3 of the 22 items on the SNOT-22 scale (ie, nasal congestion, runny nose, and sneezing) are typical symptoms associated with allergic rhinitis [3]. Lauriello et al. [4] and Weinstein et al. [3] have also used the SNOT-22 in the posttreatment assessment of patients with allergic rhinitis; however, the efficacy of the evaluation was variable.

Objective examination methods for allergic rhinitis assessment include allergen testing, nasal endoscopy, and nasal acoustic reflex. Allergen testing includes a skin prick test and serum inhalant allergen immunoglobulin E test. Among these, the serum immunoglobulin E test is one of the most widely used methods to diagnose allergic rhinitis in clinical practice because it is not

Department of Otolaryngology Head and Neck Surgery, Affiliated Hospital of Southwest Medical University, Luzhou, China

**Correspondence to Gang Qin, Department of Otolaryngology Head and Neck Surgery, Affiliated Hospital of Southwest Medical University, NO. 25, Taiping Street, Jiangyang District, Luzhou 646000, Sichuan, China.*

Tel: +86-830-8950737

Fax: +86-830-2392753

Email: qing_lzmc@163.com

†Jia Gu and Zhuo-Ping Liang contributed equally to this article.

Received: 14 August 2023; Accepted: 26 January 2024

Published online 4 April 2024

http://dx.doi.org/10.5415/apallergy.0000000000000141

affected by subjective factors and is safer for patients. However, a lack of consensus exists in the application of serum-specific immunoglobulin E (sIgE) and total immunoglobulin E (tIgE) levels to evaluate the severity of patients with allergic rhinitis [5-8]. In clinical work, nasal endoscopy is often chosen to evaluate the nasal mucosal color, mucosal edema, and secretions in patients with allergic rhinitis because it allows direct visualization of the lesions in the nasal cavity of patients from multiple angles. The modified Lund-Kennedy (MLK) nasal endoscopic scoring system is an objective and reliable way to score the nasal signs of patients with chronic rhinosinusitis [9], because the system includes 3 following items: nasal polyps, secretions, and mucosal edema. Nasal polyps are not included in the typical nasal signs during allergic rhinitis attacks. Therefore, its application in the diagnosis and treatment of allergic rhinitis is somewhat limited. Acoustic rhinometry is an objective test that uses the principle of acoustic reflex to assess the nasal airway, and it determines the exact extent of different degrees of narrowing in the nasal cavity by describing parameters such as nasal cavity volume (NCV) and nasal minimal cross-sectional area (NMCA) [10]. Therefore, the use of acoustic rhinometry to reflect the nasal structure in patients with allergic rhinitis is also very important. Whether it correlates with the severity of the conscious nasal congestion symptoms of patients is still unclear [11-14].

Therefore, this study intends to quantitatively evaluate and correlate the subjective and objective indicators of patients with allergic rhinitis to provide more reliable information for the clinical diagnosis and treatment of allergic rhinitis.

2. Materials and methods

2.1. Study population

The study was reviewed and approved by the Medical Ethics Committee of the Affiliated Hospital of Southwest Medical University (Chairperson Zheng-jun Chen) on June 2, 2022 (reference number: KY2022202), and we obtained written informed consent from the study participants (patients younger than 18 years old were given informed consent signed by their legal guardians). A total of 111 patients with allergic rhinitis (64 males, 47 females; age: 6.00–81.00 years; median age: 25 years) attending our otolaryngology head and neck surgery outpatient clinic from June to December 2022 were enrolled in this study. The patient inclusion criteria included the following: (1) meeting the relevant diagnostic criteria for allergic rhinitis in the Allergic Rhinitis and its Impact on Asthma Guidelines 2016 Revision [15]; (2) testing positive for serum sIgE for at least one allergen; (3) complete clinical data; and (4) age >5 years, no gender limitation. The study exclusion criteria included the following: (1) combined nasal polyps, severe nasal septal deviation, sinusitis and atrophic rhinitis, and other nasal diseases; (2) combined immunodeficiency diseases, malignant tumors, cardiovascular diseases, psychiatric diseases, and important organ dysfunction, as well as other serious wasting diseases; (3) combined history of respiratory and other allergic diseases; (4) receiving local, systemic glucocorticoids, antihistamine, or immunotherapy in the last month; (5) age ≤5 years; (6) concurrent participation in other medical studies.

2.2. Research methods

2.2.1. Subjective indicator score.

(1) SNOT-22 score. Patients were assessed in terms of 22 problems related to allergic rhinitis symptoms and quality of life based on their observation over the past week, which included responding to questions on the 3 dimensions: physical problems, functional limitations, and emotional outcomes. Each response was scored over a range of 0 to 5, with "0" representing "no disturbance" and "5" representing "extremely severe distress," and the maximum total score was 110.

(2) VAS score for the severity of the disease. Patients undertook a VAS assessment for the overall degree of symptoms encountered during the allergic rhinitis episodes in the past 1 week, which included 12 assessment items: nasal itching, sneezing, runny nose, nasal congestion, itchy eyes, tearing, red eyes, eye pain, cough, breath holding, wheezing, and pressure sensation. Scores 0 to 10 on the VAS scale indicated the degree of distress of the above-mentioned symptoms to the patients, with "0" representing "no distress" and "10" representing "great distress." The more severe the symptoms, higher was the score, and the maximum total score was 120.

2.2.2. Objective indicator evaluation.

[1] Inhalation allergen detection. The assay was performed by using a Blotray 866 automatic blotting instrument (Shenzhen Rayto Life Science Co., LTD, Shenzhen, Guangdong Province, China) in accordance with the kit instructions. The allergen types included house dust, dust mite combination (*house dust mite/dust mite*), tree pollen combination (*cypress/elm/sycamore/willow/poplar*), grass combination (*bitter wormwood/Artemisia/ragweed*), mold combination (*Penicillium punctatum/Mycosphaerella/Aspergillus fumigatus*/Cross-streptomycetes/*Rhizopus/Trichoderma*), and animal dander combination (cat dander/dog dander). The sIgE test results were classified into grades 0 to 5 according to the concentration: grade 0, <0.35 IU/mL; grade 1, 0.35 ≤ sIgE < 0.70 IU/mL; grade 2, 0.70 ≤ sIgE < 3.50 IU/mL; grade 3, 3.50 ≤ sIgE < 17.50 IU/mL; grade 4, 17.50 ≤ sIgE < 50.00 IU/mL; grade 5, sIgE ≥ 50.00 IU/mL. The score of ≥0.35 IU/mL was judged as positive and grade 0 was judged normal. Positive results of serum allergen tIgE were judged based on the following: age <3 years, tIgE ≥20 IU/mL; age 3 to 6 years, tIgE ≥35 IU/mL; age 6 to 20 years, tIgE ≥51 IU/mL; age >20 years, tIgE ≥100 IU/mL.

[2] Nasal endoscopy MLK score. The MLK scoring method was applied to score the nasal mucosa morphology and nasal secretions of patients with allergic rhinitis by the same physician in accordance with the results of nasal endoscopy. The main items included mucosal color, mucosal edema, and secretions. Three grades were considered, 0 = normal or none; 1 = mild mucous pallor, mild edema, and a small number of thin secretions; 2 = severe mucous pallor, severe edema, and excessive thin secretions. Both the nasal cavities were scored, and their total scores were summed.

[3] Acoustic rhinometry. Before the test, the subject was allowed to rest for 30 minutes in the sitting position, and the physician selected a suitable nasal sound probe and placed it in the anterior nostril of one side of the patient, asking the patients to hold their breath for 3 to 5 seconds in order to reduce any potential error. The same method was applied for the nasal examination of the other side. The NCV and the NMCA at a distance of 0 to 6 cm were recorded. The larger the NCV and NMCA, the larger the nasal cavity.

2.3. Statistical analysis

SPSS 26.0 software (International Business Machines Corporation, Armonk, New York, USA) was used for statistical processing, and the obtained measurement data were tested for normal distribution. Data that conformed to normal distribution were described by the mean ± standard deviation, while those that did not conform to normal distribution were expressed by the median and interquartile range (IQR). Comparisons between the 2 groups were made using the independent samples *t* test or Mann-Whitney *U* test. Correlational analyses were performed using Spearman rank-correlation analysis. $P < 0.05$ was considered to indicate a statistically significant difference.

3. Results

3.1. Subjective indicator score

A total of 111 patients with allergic rhinitis self-rated 22 problematic disturbances directly related to allergic rhinitis symptoms and quality of life that occurred within 1 week, yielding a median SNOT-22 score of 35 (IQR: 29–45). The 12 symptoms of nasal itching, sneezing, runny nose, nasal congestion, eye itching, tearing, eye redness, eye pain, coughing, breath holding, wheezing, and pressure sensation were also scored separately, and the median total VAS score for symptoms was found to be 45 (IQR: 35–51). As shown in Table 1, the VAS scores of the 4 major nasal symptoms of allergic rhinitis were highest for the VAS score for sneezing symptom and lowest for the VAS score for nasal itching symptom.

3.2. Objective indicator evaluation

Among the 111 patients with allergic rhinitis, 69 tested positive for allergen tIgE, with a positive rate of 62.16% (69/111). As shown in Fig. 1, the highest positive rate of inhalant allergens was 57.66% (64/111) for house dust mite/powder mite, followed by 45.05% (50/111) for house dust, and the lowest positive rate was 3.60% (4/111) for absinthe/wormwood/ragweed. As shown in Table 2, most patients with allergic rhinitis were mainly allergic to a single allergen, followed by allergy to 2 allergens, and the least to 4 or more. The highest positive intensity of sIgE was predominantly graded 1, followed by grade 5, and the least grade 4. Nasal mucosal color, nasal mucosal edema, and nasal secretions were scored in 111 patients with allergic rhinitis having a bilateral nasal cavity, and the median MLK total score of nasal endoscopy was 6 (IQR: 4–9). Furthermore, acoustic rhinometry results and statistical analysis revealed that the median NCV of 111 patients with allergic rhinitis was 10.57 cm^3 (IQR: 9.63–11.70), and the median NMCA was 0.35 cm^2 (IQR: 0.23–0.44).

Table 1.

Subjective indicator score

Scoring items	Score
SNOT-22 score, median (IQR)	35(29–45)
Total VAS score for symptoms (12 symptoms), median (IQR)	45(35–51)
VAS score for nasal itching symptom, median (IQR)	7(5–8)
VAS score for sneezing symptom, median (IQR)	5(4–8)
VAS score for runny nose symptom, median (IQR)	8(5–8)
VAS score for nasal congestion symptom, median (IQR)	7(5–9)

IQR, interquartile range; SNOT-22, 22-item sino-nasal outcome test; VAS, visual analog scale.

3.3. Correlation analysis of quantitative assessment outcomes of subjective and objective indicators

3.3.1. Comparison of the SNOT-22 and VAS scores between patients in the positive and negative groups for inhaled allergens tIgE. No significant differences were found in the SNOT-22 score, total VAS score for symptoms, and allergic rhinitis 4 major symptoms VAS scores between the 2 groups ($P > 0.05$), which indicated that negative and positive results of inhaled allergen tIgE did not affect the SNOT-22 score and VAS score for the severity of the disease of patients with allergic rhinitis (Fig. 2).

3.3.2. Correlation analysis of SNOT-22 and VAS scores with the number of positively inhaled allergens and the highest positive intensity of sIgE. The SNOT-22 score, total VAS score for symptoms, and the VAS score for nasal itching symptom of patients with allergic rhinitis were positively correlated with the number of positively inhaled allergens, with correlation coefficients of 0.266, 0.576, and 0.271, respectively, and the differences were statistically significant ($P = 0.005$, $P < 0.001$, and $P = 0.004$, respectively), whereas the VAS scores of sneezing, runny nose, and nasal congestion symptoms were not correlated with the number of positive allergens ($P > 0.05$). The higher the number of positive allergens in patients with allergic rhinitis, the more the quality of life was affected and the more severe the clinical symptoms were. The nasal itching symptom was especially more prominent. The SNOT-22 score, total VAS score for symptoms, and the VAS scores of nasal itching, sneezing, runny nose, and nasal congestion symptoms were not significantly correlated with the highest positive intensity of sIgE ($P > 0.05$) (Figs. 3 and 4).

3.3.3. Correlation analysis of the SNOT-22 and VAS scores with MLK total score of nasal endoscopy. SNOT-22 score, total VAS score for symptoms, and the VAS score for nasal congestion symptom were positively correlated with MLK total score of nasal endoscopy, with correlation coefficients of 0.343, 0.438, and 0.225, respectively, and the differences were statistically significant ($P < 0.001$, $P < 0.001$, and $P = 0.018$, respectively). Consistency was found between the results of nasal endoscopy and the severity of patients'self-conscious symptoms, especially the nasal congestion symptom can be well reflected by nasal endoscopy (Fig. 5).

3.3.4. Analysis of the correlation of SNOT-22 and VAS scores with acoustic rhinometry parameters (NCV and NMCA). The NCV and NMCA of the patients with allergic rhinitis were not correlated with the SNOT-22 score, total VAS score for symptoms, and the VAS score for nasal congestion symptom ($P > 0.05$) (Fig. 6).

4. Discussion

Allergic rhinitis is a chronic inflammatory reactive disease of the nasal mucosa mediated by immunoglobulin E after exposure to allergens in atopic individuals and involves multiple immunoreactive cells and cytokines. A study [16] showed that allergic rhinitis affects 400 million people worldwide and causes clinical signs or symptoms that, if not effectively controlled, will adversely affect patients' quality of life and health care expenditures. Therefore, the accurate assessment of the severity of allergic rhinitis is crucial for its diagnosis and treatment. In this study, the subjective indicators of patients with allergic rhinitis were scored by SNOT-22 and VAS, whereas the objective indicators of patients with allergic rhinitis were evaluated by serum inhalant allergen test, the MLK scoring method of nasal

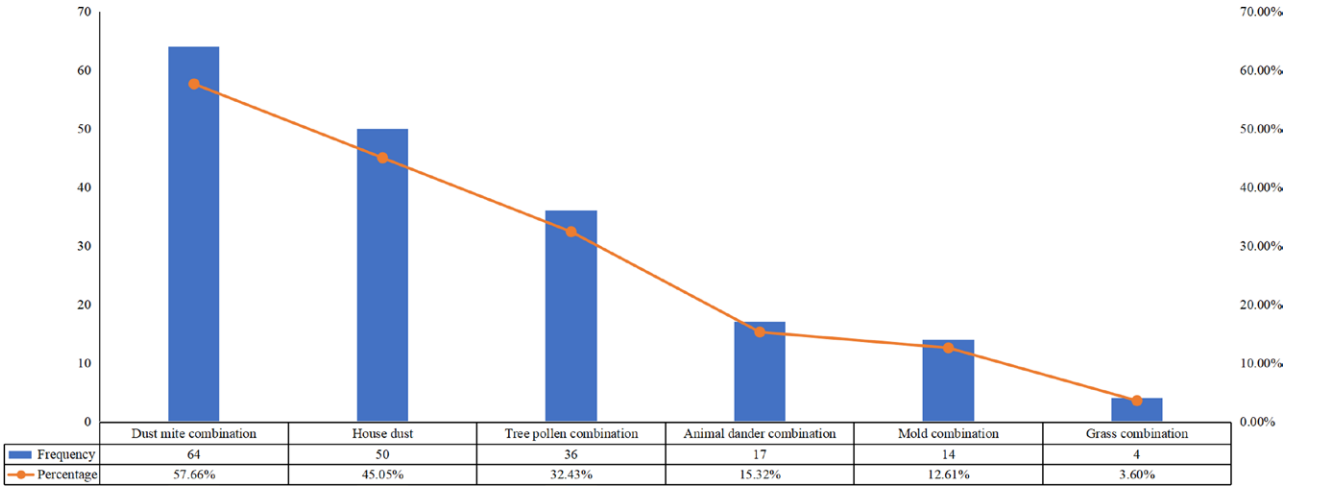

Figure 1. Results of inhalational allergen sIgE testing in 111 patients with allergic rhinitis. The positive rate of house dust mite/powder mite was the highest, while the positive rate of absinthe/wormwood/ragweed was the lowest. sIgE, specific immunoglobulin E.

Table 2.

Distribution of the number of positively inhaled allergens and the highest positive intensity of sIgE in 111 patients with allergic rhinitis

	Number of positive cases	Positive rate
Number of positively inhaled allergens		
1	60	54.05%
2	34	30.63%
3	13	11.71%
≥4	4	3.60%
The highest positive intensity of sIgE		
Grade 1	61	54.95%
Grade 2	11	9.91%
Grade 3	10	9.01%
Grade 4	7	6.31%
Grade 5	22	19.82%

sIgE, specific immunoglobulin E.

endoscopy, and acoustic rhinometry to investigate any probable correlation between the quantitatively assessed outcomes of the above subjective and objective indicators of patients with allergic rhinitis and to elaborate the clinical value of using different methods to assess the diagnosis and severity of allergic rhinitis from different perspectives.

Li et al. [17] found that the number of allergenic allergens was positively correlated with the severity of allergic rhinitis and asthma. Similar to the results of the aforementioned studies, the SNOT-22 score and the total VAS score for symptoms were positively correlated with the number of positively inhaled allergens in patients with allergic rhinitis in the present study; however, the SNOT-22 score was less correlated than the total VAS score for symptoms, probably because only some items in the SNOT-22 can assess the typical symptoms of allergic rhinitis (nasal congestion, runny nose, and sneezing) [3], which is more of an evaluation of the quality of life aspects such as sleep quality, mental status at work, and otherwise. Therefore, we concluded that the SNOT-22 rating scale could assess the quality of life of patients with allergic rhinitis to some extent; however, it is not a valid tool for assessing the severity of allergic rhinitis symptoms. We also found a positive correlation between the VAS score for nasal itching symptom and the number of positively inhaled allergens, which is consistent with the finding that patients with multiple allergies have more severe clinical symptoms than patients with single allergy as suggested by Ciprandi and Cirillo [18]. The older the patient, the more likely they are to combine multiple positive allergens [19]; in this study, adult patients accounted for most of them. Adults have more matured neural development than children, and their nasal submucosal sensory nerve endings are more abundant and more sensitive than those of children, thus making them more likely to have nasal itching symptom or more severe nasal itching. However, the pathogenesis of allergic rhinitis is complex; a series of cytokines and inflammatory proteins are involved from the entry of external allergens into the body to the binding of immunoglobulin E and the appearance of various symptoms, and various factors such as genetics and environment affect allergic rhinitis pathogenesis; hence, its specific mechanism of action needs further studies.

Similar to previous reports [5], the present study showed no significant differences in subjective indicator scores between the tIgE-positive and tIgE-negative groups. Increased serum tIgE levels over a period in healthy children can predict allergy [20]; however, children with high tIgE levels (>100 IU/mL) accounted for 1.7% of study subjects without allergy symptoms after 5 years of follow-up [7]. Thus, we concluded that increased serum tIgE in patients implies a relatively high probability of allergy, but allergy cannot be diagnosed, and the presence of allergic rhinitis-related symptoms in patients can be presumed. In addition, the highest positive intensity of sIgE and subjective indicator scores in 111 patients with allergic rhinitis showed no significant correlation, indicating no correlation between the degree of allergen-induced allergic rhinitis producing clinical symptoms and its impact on the quality of life and the level of sIgE produced by the organism. Exposure to allergens leads to the cross-linking of immunoglobulin E bound to the high-affinity immunoglobulin E receptor (FcεRI) on the surface of mast cells or basophils, leading to FcεRI aggregation, which in turn triggers the initiation of complex signaling events in mast cells and basophils [21], ultimately leading to the development of allergic rhinitis symptoms in the organism. Therefore, the generation of organismal symptoms is probably not directly correlated to the level of immunoglobulin E and is affected by several factors; thus, the severity of patients with allergic rhinitis cannot be assessed solely using the highest positive intensity of sIgE. Bousquet et al. [22] suggested a nonimmunoglobulin E-dependent mechanism by which allergens cause allergic rhinitis-related symptoms in the

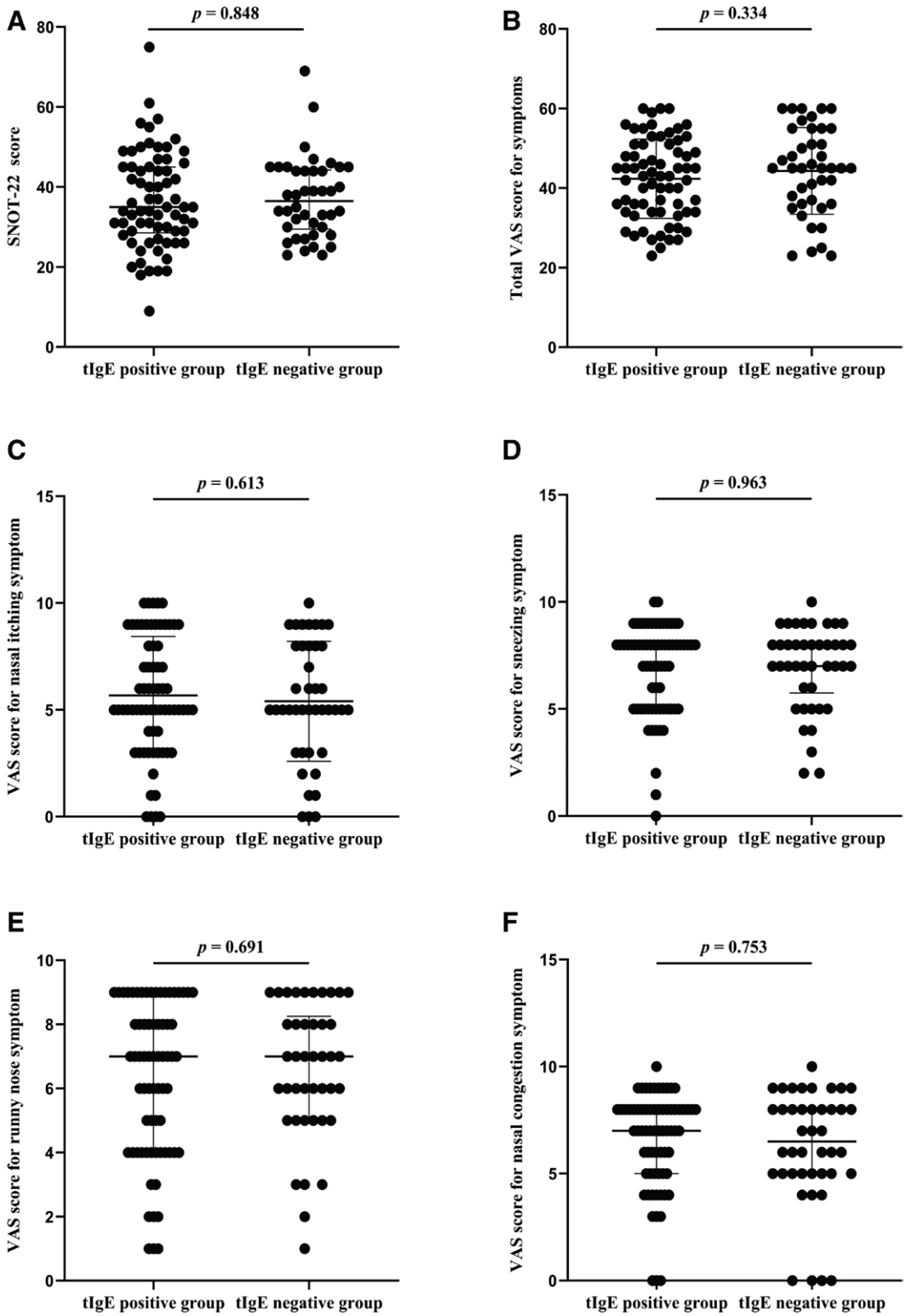

Figure 2. Comparison of the SNOT-22 and VAS scores between patients in the positive and negative groups for inhaled allergens tIgE. No significant differences in the SNOT-22 score (A), in the total VAS score for symptoms (B), in the VAS score for nasal itching symptom (C), in the VAS score for sneezing symptom (D), in the VAS score for runny nose symptom (E), and in the VAS score for nasal congestion symptom (F) between the tIgE-positive and tIgE-negative groups. SNOT-22, 22-item sino-nasal outcome test; tIgE, total immunoglobulin E; VAS, visual analog scale.

body, which may also corroborate the above findings. However, recently, Corsico et al. [23] suggested that sIgE levels in house dust mites may be a reliable biomarker of symptom severity in patients with allergic rhinitis, that is, an increase in sIgE level is correlated to allergic rhinitis severity. We believe that the effect of sIgE levels on the severity of symptoms in patients with allergic rhinitis should also be studied in more depth in a large-scale longitudinal population study.

The results of this study showed that the MLK total score of nasal endoscopy was positively correlated with the

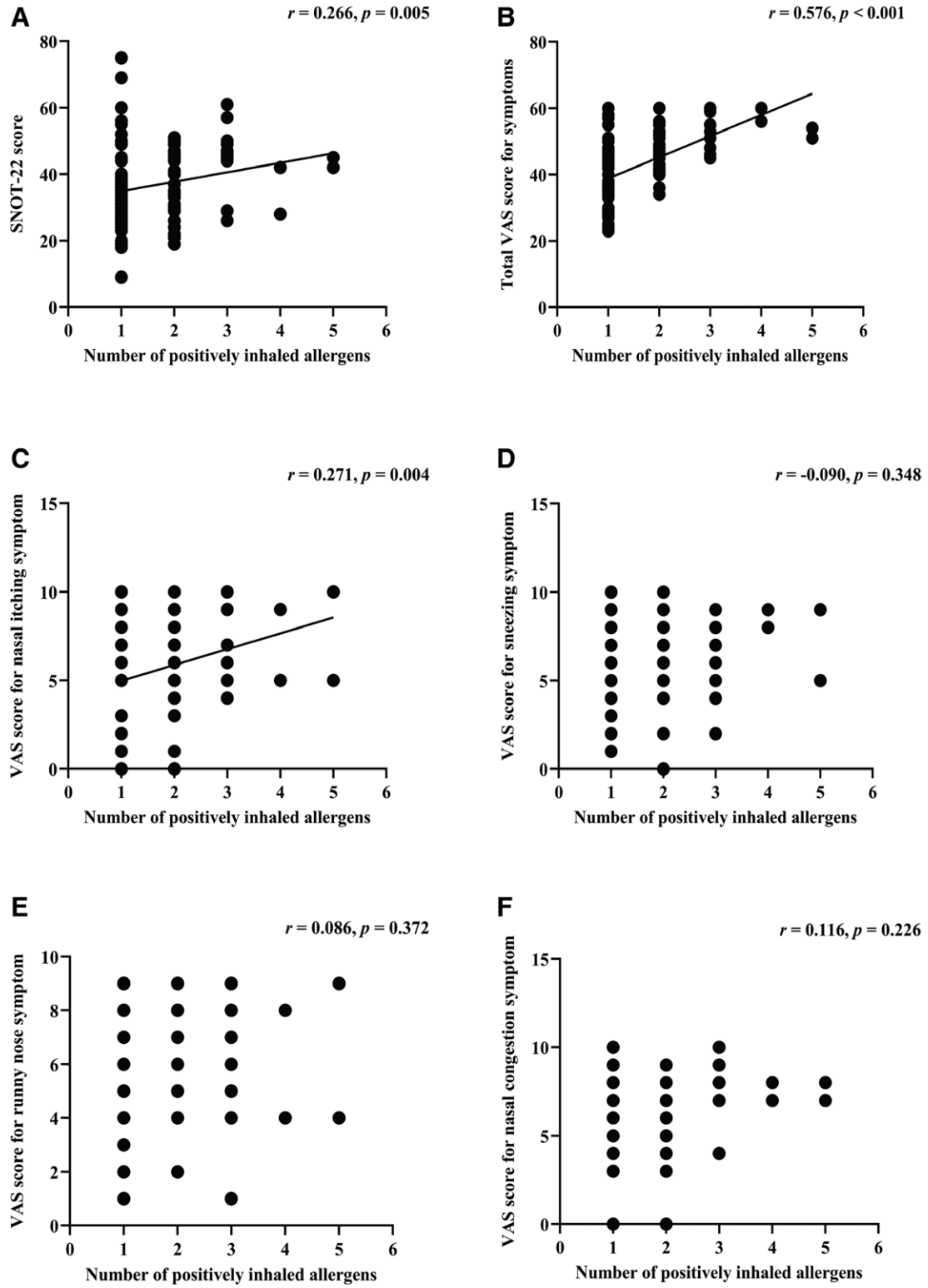

Figure 3. Correlation analysis of SNOT-22 and VAS scores with the number of positively inhaled allergens. The number of positively inhaled allergens displayed a weak positive correlation with the SNOT-22 score (A), a moderate positive correlation with the total VAS score for symptoms (B), and a weak positive correlation with the VAS score for nasal itching symptom (C); the number of positively inhaled allergens displayed no significant correlations with the VAS score for the sneezing symptom (D), the VAS score for runny nose symptom (E), and the VAS score for nasal congestion symptom (F). SNOT-22, 22-item sino-nasal outcome test; VAS, visual analog scale.

total VAS score for symptoms, which was consistent with the results of Liu et al. [24]; the MLK total score of nasal endoscopy was positively correlated with the VAS score for nasal congestion symptom, which was presumably related to the fact that nasal congestion symptom is mainly caused by nasal mucosal edema and massive secretion exudation. This pathological change can be visualized by nasal endoscopy. In addition, this study showed that the SNOT-22 score was

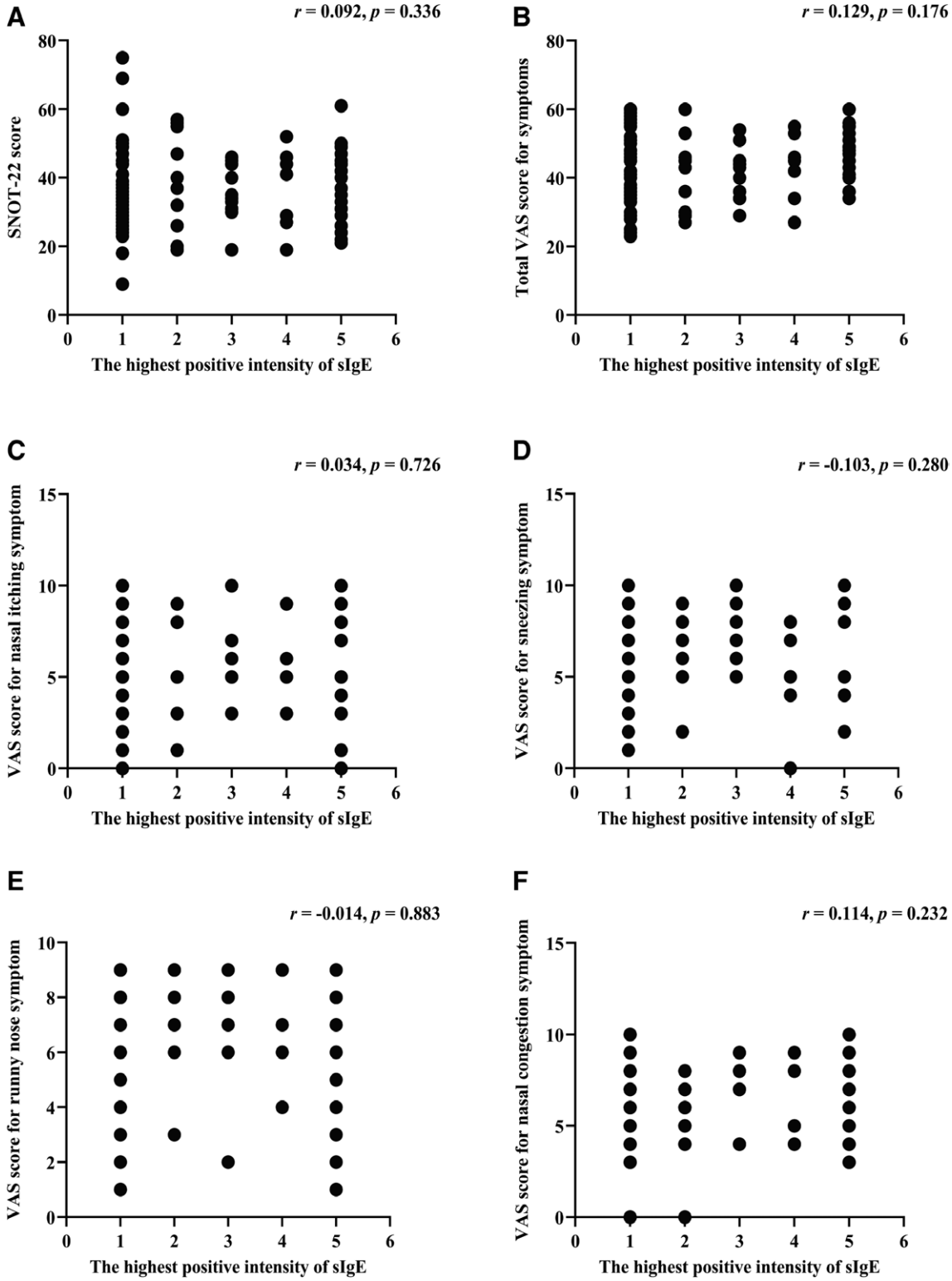

Figure 4. Correlation analysis of SNOT-22 and VAS scores with the highest positive intensity of sIgE. SNOT-22 score (A), total VAS score for symptoms (B), VAS score for nasal itching symptom (C), VAS score for the sneezing symptom (D), VAS score for runny nose symptom (E), and VAS score for nasal congestion symptom (F) were not correlated with the highest positive intensity of sIgE, respectively. sIgE, specific immunoglobulin E; SNOT-22, 22-item sino-nasal outcome test; VAS, visual analog scale.

positively correlated with the MLK total score of nasal endoscopy; however, the correlation was not as significant as the total VAS score for symptoms, probably because the SNOT-22 is more focused on the quality of life score in patients with allergic rhinitis, whereas the total VAS score for symptoms focuses on rhinitis-related symptoms in patients with allergic rhinitis, and rhinitis-related symptoms are mostly caused by signs in the MLK total score of nasal endoscopy. We concluded that nasal endoscopy MLK scores could be a valid objective evaluation tool for patients with allergic rhinitis.

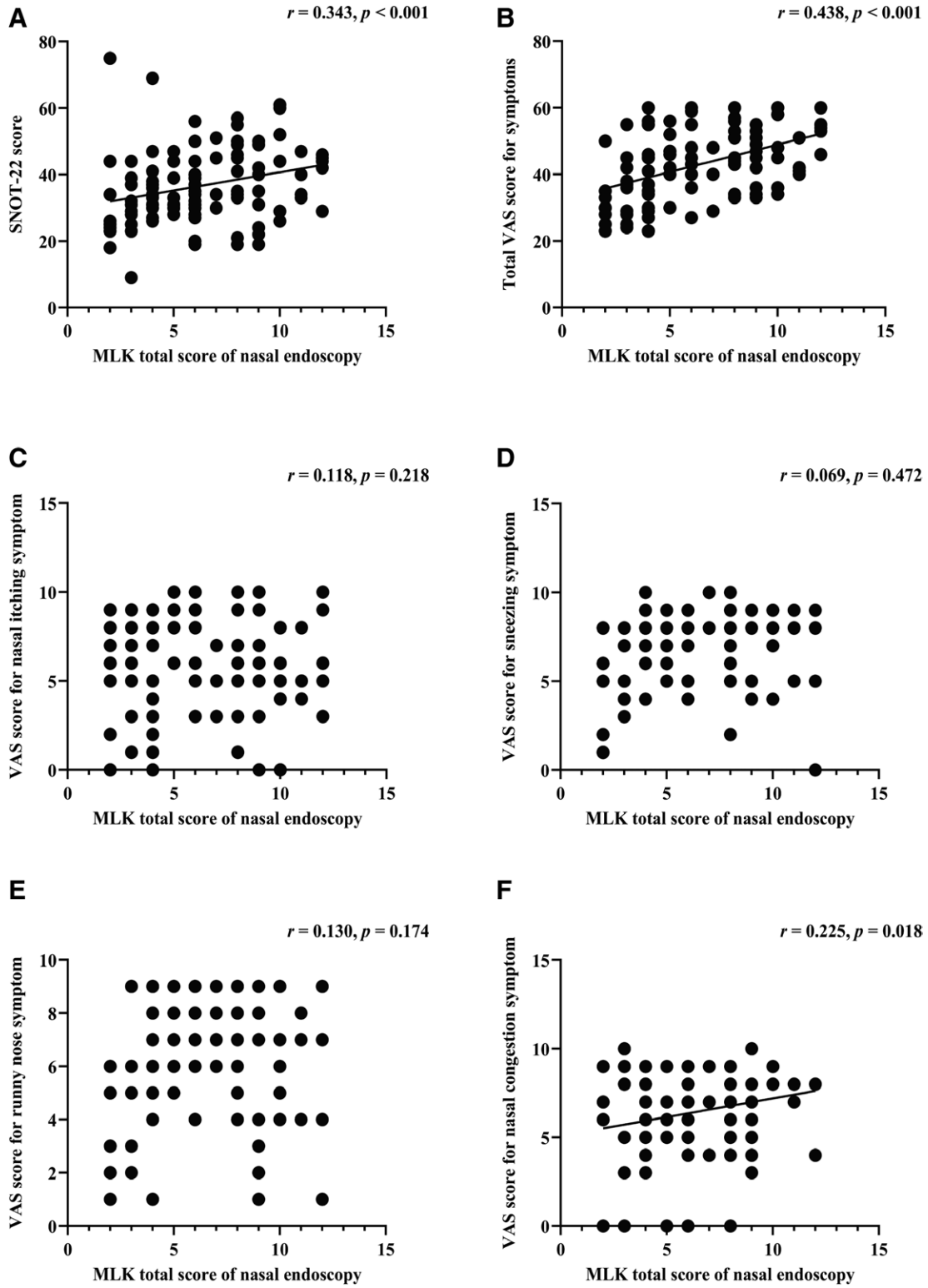

Figure 5. Correlation analysis of the SNOT-22 and VAS scores with MLK total score of nasal endoscopy. SNOT-22 score (A), total VAS score for symptoms (B), and VAS score for nasal congestion symptom (F) were positively correlated with MLK total score of nasal endoscopy, respectively, while VAS score for nasal itching symptom (C), VAS score for the sneezing symptom (D), and VAS score for runny nose symptom (E) were not correlated with MLK total score of nasal endoscopy, respectively. MLK, modified Lund-Kennedy; SNOT-22, 22-item sino-nasal outcome test; VAS, visual analog scale.

Acoustic rhinometry is an objective examination method that follows the principle of acoustic reflection to assess the nasal airway. In recent years, scholars worldwide have performed numerous studies on the correlation between acoustic rhinometry and subjective symptom scores in patients with allergic rhinitis; however, the results are inconsistent. Several studies [11, 13, 14] have shown that the correlation between acoustic rhinometry parameters and subjective scores is not

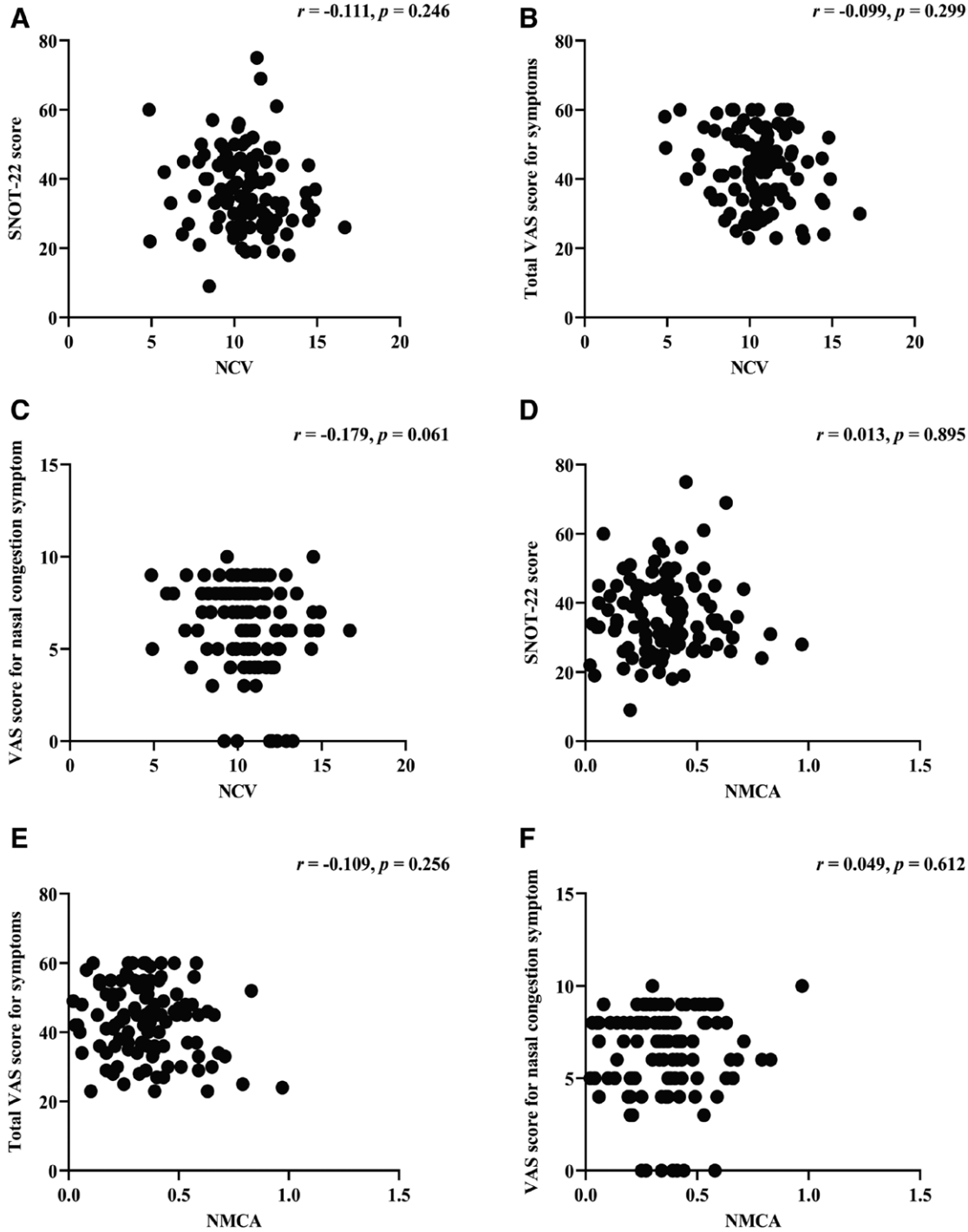

Figure 6. Analysis of the correlation of SNOT-22 and VAS scores with acoustic rhinometry parameters (NCV and NMCA). SNOT-22 score (A, D), total VAS score for symptoms (B, E), and VAS score for nasal congestion symptom (C, F) were not correlated with NCV and NMCA, respectively. NCV, nasal cavity volume; NMCA, nasal minimal cross-sectional area; SNOT-22, 22-item sino-nasal outcome test; VAS, visual analog scale.

statistically significant. However, Haavisto et al. [12] found a weak correlation between NMCA values and patients' VAS scores before using decongestants in asymptomatic children. In this study, NCV and NMCA were not correlated with the patients' subjective indicators scores (SNOT-22, total VAS score for symptoms, and VAS score for nasal congestion symptom), which may be related to the diverse causes of nasal congestion, whereas parameters such as NCV and NMCA may only reflect the structure of the nasal cavity. Recker and Hamilton [25] divided the common causes of nasal ventilation dysfunction into 3 categories: mucosal origin, structural origin, and sensory origin. We suggest that the symptom of nasal congestion in patients with allergic rhinitis can be caused by either an inflammatory response in the nasal mucosa, structural abnormalities of the nasal cavity, or parasympathetic cholinergic excitation, or a combination of all 3. In addition, a study [26] indicated that the psychosomatic state of patients with allergic rhinitis also affects VAS symptom scores. Therefore, the parameters related

to acoustic rhinometry (NCV and NMCA) have no significant advantages in evaluating the subjective symptom of nasal congestion in patients with allergic rhinitis; however, they still have a high reference value clinically because they can characterize the airway and identify the site and size of different degrees of narrowing in the nasal cavity.

In conclusion, the present study showed that there were positive correlations between the number of positively inhaled allergens and the SNOT-22 score, the total VAS score for symptoms, and the VAS score for nasal itching symptom. In addition, the SNOT-22 score, the total VAS score for symptoms, and the VAS score for nasal congestion symptom were positively correlated with the MLK total score of nasal endoscopy. The objective assessments of patients with allergic rhinitis, including serum inhalant allergen sIgE and tIgE tests, the MLK total score of nasal endoscopy, and acoustic rhinometry, do not fully reflect the actual condition of patients with allergic rhinitis. The subjective assessments, SNOT-22 and VAS for the severity of the disease, may also cause a bias in assessing patients with allergic rhinitis because patients' education and psychological statuses greatly affect these indicators. Overall, the outcomes of quantitative assessment of subjective and objective indicators are complementary. The combination of subjective and objective indicators can be used for multi-angle quantitative assessment of patients with allergic rhinitis, which can help physicians to make an accurate diagnosis and develop reasonable treatment plans.

Acknowledgements

This study was supported by Sichuan Science and Technology Program (No. 2022YFS0629), Science and Technology Strategic Cooperation Project of Luzhou Municipal People's Government-Southwest Medical University (2023LZXNYDJ012), Doctoral Research Initiation Fund of Affiliated Hospital of Southwest Medical University (No. 22154), and the school-level foundation of Southwest Medical University grants (Southwest Medical University 2016-217).

Conflicts of interest

The authors declare no conflicts of interest.

Author contributions

Conceptualization, methodology, and software: Jia Gu. Data curation, writing—original draft preparation: Zhuo-Ping Liang and Wei Xu. Investigation: Zhen-Rong Li. Supervision: Gang Qin. Software and validation: Tian-Zhen Liu. Writing—reviewing and editing: Jia Gu and Zhuo-Ping Liang.

References

1. Bousquet J, Anto JM, Bachert C, Baiardini I, Bosnic-Anticevich S, Walter Canonica G, Melén E, Palomares O, Scadding GK, Togias A, Toppila-Salmi S. Allergic rhinitis. Nat Rev Dis Primers 2020;6:95.
2. Klimek L, Bergmann K, Biedermann T, Bousquet J, Hellings P, Jung K, Merk H, Olze H, Schlenter W, Stock P, Ring J, Wagenmann M, Wehrmann W, Mösges R, Pfaar O. Visual analogue scales (VAS): measuring instruments for the documentation of symptoms and therapy monitoring in cases of allergic rhinitis in everyday health care. Allergo J Int 2017;26:16–24.
3. Weinstein SF, Katial R, Jayawardena S, Pirozzi G, Staudinger H, Eckert L, Joish VN, Amin N, Maroni J, Rowe P, Graham NMH, Teper A. Efficacy and safety of dupilumab in perennial allergic rhinitis and comorbid asthma. J Allergy Clin Immunol 2018;142:171–177.e1.
4. Lauriello M, Di Rubbo V, Sinatti G, Pasqua M, Tucci C, di Marco G-P, Necozione S, Eibenstein A. Correlation between SNOT-22, nasal cytology, and mood disorders in patients with allergic rhinitis treated with a liposomal nasal spray. Allergy Rhinol (Providence) 2019;10:2152656719866809.
5. Karli R, Balbaloglu E, Uzun L, Çınar F, Ugur MB. Correlation of symptoms with total IgE and specific IgE levels in patients presenting with allergic rhinitis. Ther Adv Respir Dis 2013;7:75–79.
6. Xu Q, Zhang Y, Zhang L. Effect of perennial dust mites allergy on symptom severity of autumn allergic rhinitis in adults. Allergy Asthma Proc 2020;41:363–371.
7. Daniluk U, Alifier M, Kaczmarski M, Stasiak-Barmuta A, Lebensztejn D. Longitudinal observation of children with enhanced total serum IgE. Ann Allergy Asthma Immunol 2015;114:404–410.e4.
8. Ciprandi G, Comite P, Ferrero F, Fontana V, Bruzzone M, Mussap M. Serum allergen-specific IgE, allergic rhinitis severity, and age. Rhinology 2016;54:231–238.
9. Psaltis AJ, Li G, Vaezeafshar R, Cho KS, Hwang PH. Modification of the Lund-Kennedy endoscopic scoring system improves its reliability and correlation with patient-reported outcome measures. Laryngoscope 2014;124:2216–2223.
10. Lam DJ, James KT, Weaver EM. Comparison of anatomic, physiological, and subjective measures of the nasal airway. Am J Rhinol 2006;20:463–470.
11. Malizia V, Fasola S, Ferrante G, Cilluffo G, Gagliardo R, Landi M, Montalbano L, Marchese D, La Grutta S. Comparative effect of beclomethasone dipropionate and cetirizine on acoustic rhinometry parameters in children with perennial allergic rhinitis: a randomized controlled trial. J Investig Allergol Clin Immunol 2018;28:392–400.
12. Haavisto LE, Vahlberg TJ, Sipila JI. Correlation between acoustic rhinometry and visual analogue scale in children with no nasal symptoms: a prospective cohort study. Clin Otolaryngol 2011;36:129–133.
13. Valero A, Navarro AM, Del Cuvillo A, Alobid I, Benito JR, Colás C, de Los Santos G, Fernández Liesa R, García-Lliberós A, González-Pérez R, Izquierdo-Domínguez A, Jurado-Ramos A, Lluch-Bernal MM, Montserrat Gili JR, Mullol J, Puiggròs Casas A, Sánchez-Hernández MC, Vega F, Villacampa JM, Armengot-Carceller M, Dordal MT; SEAIC Rhinoconjunctivitis Committee & SEORL Rhinology, Allergy, and Skull Base Committee. Position paper on nasal obstruction: evaluation and treatment. J Investig Allergol Clin Immunol 2018;28:67–90.
14. Ansari E, Rogister F, Lefebvre P, Tombu S, Poirrier AL. Responsiveness of acoustic rhinometry to septorhinoplasty by comparison with rhinomanometry and subjective instruments. Clin Otolaryngol 2019;44:778–783.
15. Brożek JL, Bousquet J, Agache I, Agarwal A, Bachert C, Bosnic-Anticevich S, Brignardello-Petersen R, Canonica GW, Casale T, Chavannes NH, Correia de Sousa J, Cruz AA, Cuello-Garcia CA, Demoly P, Dykewicz M, Etxeandia-Ikobaltzeta I, Florez ID, Fokkens W, Fonseca J, Hellings PW, Klimek L, Kowalski S, Kuna P, Laisaar K-T, Larenas-Linnemann DE, Lødrup Carlsen KC, Manning PJ, Meltzer E, Mullol J, Muraro A, O'Hehir R, Ohta K, Panzner P, Papadopoulos N, Park H-S, Passalacqua G, Pawankar R, Price D, Riva JJ, Roldán Y, Ryan D, Sadeghirad B, Samolinski B, Schmid-Grendelmeier P, Sheikh A, Togias A, Valero A, Valiulis A, Valovirta E, Ventresca M, Wallace D, Waserman S, Wickman M, Wiercioch W, Yepes-Nuñez JJ, Zhang L, Zhang Y, Zidarn M, Zuberbier T, Schünemann HJ. Allergic Rhinitis and its Impact on Asthma (ARIA) Guidelines –2016 Revision. J Allergy Clin Immunol 2017;140:950–958.
16. Nur Husna SM, Tan HT, Md Shukri N, Mohd Ashari NS, Wong KK. Allergic rhinitis: a clinical and pathophysiological overview. Front Med (Lausanne) 2022;9:874114.
17. Li J, Huang Y, Lin X, Zhao D, Tan G, Wu J, Zhao C, Zhao J, Spangfort MD, Zhong N. Influence of degree of specific allergic sensitivity on severity of rhinitis and asthma in Chinese allergic patients. Respir Res 2011;12:95.
18. Ciprandi G, Cirillo I. Monosensitization and polysensitization in allergic rhinitis. Eur J Intern Med 2011;22:e75–e79.
19. Purello-D'Ambrosio F, Gangemi S, Merendino RA, Isola S, Puccinelli P, Parmiani S, Ricciardi L. Prevention of new sensitizations in monosensitized subjects submitted to specific immunotherapy or not. A retrospective study. Clin Exp Allergy 2001;31:1295–1302.
20. Matricardi PM, Bockelbrink A, Grüber C, Keil T, Hamelmann E, Wahn U, Lau S. Longitudinal trends of total and allergen-specific IgE throughout childhood. Allergy 2009;64:1093–1098.
21. Galli SJ, Tsai M. IgE and mast cells in allergic disease. Nat Med 2012;18:693–704.

22. Bousquet J, Reid J, van Weel C, Baena Cagnani C, Canonica GW, Demoly P, Denburg J, Fokkens WJ, Grouse L, Mullol K, Ohta K, Schermer T, Valovirta E, Zhong N, Zuberbier T. Allergic rhinitis management pocket reference 2008. Allergy 2008;63: 990–996.
23. Corsico AG, De Amici M, Ronzoni V, Giunta V, Mennitti MC, Viscardi A, Marseglia GL, Ciprandi G. Allergen-specific immunoglobulin E and allergic rhinitis severity. Allergy Rhinol (Providence) 2017;8:1–4.
24. Liu B, Feng J, Hu S. The role of nasal endoscopy in allergic rhinitis and house dust mite sublingual immunotherapy. Int Arch Allergy Immunol 2021;182:690–696.
25. Recker C, Hamilton G. Evaluation of the patient with nasal obstruction. Facial Plast Surg 2016;32:003–008.
26. El Hennawi Del D, Ahmed MR, Farid AM. Psychological stress and its relationship with persistent allergic rhinitis. Eur Arch Otorhinolaryngol 2016;273:899–904.