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ORIGINAL ARTICLE

Allergic rhinitis and voice change

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Abstract

The aim of this study was to investigate voice function in patients with birch pollen allergy. Voice recordings for acoustic analysis were performed during pollen season and non-pollen season, with 30 patients and 30 controls, and all participants answered a questionnaire about voice symptoms. The results show that the patients reported more voice symptoms than controls during both seasons. In the non-pollen season the symptoms were decreased in the patient group but not in the controls. Speaking fundamental frequency was lower in patients compared to controls during both seasons. The results suggest chronic edema of the vocal folds in the patients. Laryngeal examination with stroboscope was not performed but is recommended for future patients diagnosed with an air-borne allergy.

Key words: Birch pollen allergy, speaking fundamental frequency, voice symptoms

Introduction

In Sweden, 15%–20% of the young population suffers from allergic rhinitis (1,2). Allergic rhinitis causes irritation in the upper airways with itching of the nose and eyes, and excessive mucosa. Larynx and voice function may be affected by a frequent need to cough and to clear one's throat (3,4). Also, allergic edema of the vocal folds may cause a lowered speaking fundamental frequency and a reduced ability to modulate pitch (3,5). Roy et al. (6) found that subjects with voice disorders reported respiratory allergies more often than subjects who did not have voice disorders. Simberg et al. (7) found that students with air-borne allergies reported more vocal symptoms than students without allergies. The students with an allergy were attending a 3-year allergen immunotherapy program and had been tested for pollen allergy with prick tests. The criteria for immunotherapy were a severe allergy or inadequate response to allergy medication. In a study of voice symptoms among 1,250 teaching students, Ohlsson et al. (8) found that 22% had allergic rhinitis. Of these, there was a significantly higher incidence of allergic rhinitis among those students with voice problems,

36%, than among those without voice problems, 20%. Millqvist et al. (9) found that patients suffering from birch pollen allergy experienced more everyday voice problems, assessed using the Voice Handicap Index, during pollen season than during non-pollen season compared to controls. The perceptual voice analysis showed no difference between groups, but the deterioration of voice quality in pollen season was more frequent among patients than among controls.

The aim of this study was to find out if there was a difference in speaking fundamental frequency and prevalence of vocal symptoms between patients with birch pollen allergy and controls during birch pollen season.

Methods

Subjects

The subjects in this study were identical to the subjects participating in a study of Millqvist et al. (9). Thirty patients with confirmed allergic rhinitis from birch pollen and 30 controls matched for gender and age were examined regarding voice function, once in May (during pollen season) and once in October

(during non-pollen season). Patients on corticosteroid inhalation therapy or with suspected asthma were excluded. Characteristics significant for voice function are shown in Table I for patients and controls: 17 women with a mean age of 40 years (SD 9.2) and 13 men with a mean age of 39 years (SD 8.5) constituted the patient group; 17 women with a mean age of 39 years (SD 9.1) and 13 men with a mean age of 39 years (SD 9.7) constituted the control group.

Measurements

The following measurements were performed with all subjects during allergy season and off-season:

1. Allergy questionnaire (9): four questions (nasal secretions, itching, eye irritation, heavy breathing during the past week) scored between 0 (none) and 3 (very much); two questions with a visual analogue scale (nasal congestion, general voice quality); and one yes/no question ('Do you have a hoarse or unclear voice?').
2. A Swedish questionnaire about voice symptoms, ERT (*Egen Röst och Tal*; 'Your own voice and speech') (10), with 20 yes/no questions and eight visual analogue scales. This questionnaire was distributed to the patients in connection with the earlier performed voice recordings, but the results are unpublished. Five yes/no questions were used in this study: 1) 'Is your voice hoarse without having a cold?' and subsequently 'If yes, how often: more than once a month?' (scored 2), 'more than once a week?' (scored 3), or 'daily?' (scored 4); 2) 'Vocal fatigue without a cold?' (scored 0–4); 3) 'Roughness without a cold?' (scored 0–4); 4) 'Vocal fatigue after reading aloud?' (scored 0–1); 5) 'Hoarseness after long time speaking?' (scored 0–1). Furthermore, four questions for visual analogue evaluation were used in this study: 1) 'How good is your voice quality?' (end-points: 'not at all good' to 'very good' on a line of 100 mm); 2) 'Clearness

of speech?' ('not at all good' to 'very good'); 3) 'Do you experience any hoarseness?' ('not at all' to 'to a very high degree'); and 4) 'Vocal fatigue?' ('not at all' to 'to a very high degree').

3. Voice recordings were performed while the subject read aloud a standard text. The subjects were recorded in a standardized fashion in the same therapy room on a Sony PCM-R500 4D with a mouth-to-microphone distance of 7 cm. The recordings were compiled on a compact disc, pairwise (from pollen season and non-pollen season for each subject in randomized order) and in randomized order regarding patients and controls.

Analyses

Analysis of the questionnaire responses was performed according to the type of question (score, mm on visual analogue scale). Mean, SD, Median, and range were calculated.

Acoustic voice analysis was conducted by Soundswell 4.0 Signal Workstation AB (Saven Hitech, Täby, Sweden). Speaking fundamental frequency in Hz (SFF) and standard deviation of SFF in Hz, i.e. the variation in fundamental frequency (VFF), were measured for all recorded voices.

Statistical analyses

Differences between groups were tested using Fisher's exact test and the Mann-Whitney *U* test. The Wilcoxon signed-rank test tested change within groups. The van Elteren test was carried out to adjust for gender.

Results

All subjects in the patient group showed allergy symptoms during pollen season but no allergy symptoms during non-pollen season. No one in the control group showed any allergy symptoms during either pollen season or non-pollen season, as described in Millqvist et al. (9).

Subjective evaluations

Significantly more patients than controls experienced voice symptoms during pollen season (Table II). During non-pollen season, voice symptoms were more common among the patients than among the controls.

The degree of hoarseness and vocal fatigue experienced, as expressed on visual analogue scales, was higher during pollen season in the patient group than in the control group (Table III). Patients evaluated their voice quality and clearness of speech more

Table I. Characteristics in patient and control groups.

Characteristics	Patients (n = 30)	Controls (n = 30)
Time since diagnosis (years)	2.5	–
Years with allergic symptoms	16	–
Voice profession	10	10
Smokers	3	4
Vocal pathology in childhood	0	0
Vocal pathology in adulthood	2	0
Throat infections > 5 a year	11	0
Hearing loss	10	8
Hearing loss among relatives	10	10

Table II. Vocal symptoms, number of 'yes' answers; difference between groups.

Symptom	Pollen season		<i>P</i> value (Fisher's exact test)	Non-pollen season		<i>P</i> value (Fisher's exact test)
	Patients <i>n</i> = 30	Controls <i>n</i> = 30		Patients <i>n</i> = 30	Controls <i>n</i> = 30	
Hoarseness without a cold	17	0	<0.001	9	4	not significant
Vocal fatigue without a cold	23	2	<0.001	13	0	<0.001
Roughness without a cold	19	1	<0.001	13	3	<0.01
Vocal fatigue after reading aloud	15	3	<0.001	18	5	<0.001
Hoarseness after a long time speaking	14	1	<0.001	11	1	<0.01

negatively than the controls evaluated theirs. During non-pollen season the differences between groups remained, except for clearness of speech. The patients experienced voice symptoms to a lesser degree during non-pollen season than during pollen season. For the control group there was no difference between seasons.

Table III shows that all of the visual analogue measurements were small: none of the subjects' evaluations exceeded 10 mm for any of the questions.

Acoustic analyses

The acoustic analyses of the recorded voice samples showed normal values for speaking fundamental frequency (SFF) and variation in fundamental frequency (VFF) for both men and women in both groups (Table IV) (11). Within groups there was no difference between seasons. SFF values were, however, lower in the patient group than in the control group during both seasons, for men as well as for women, but the differences did not reach significance (see also Table V). VFF was more restricted for women in the patient group than for women in the control group, during both seasons, but the difference did not reach significance. Among men, there was no difference in VFF between groups

during pollen season. During non-pollen season, however, VFF was more restricted among the men in the patient group than among the men in the control group, but the difference did not reach significance.

Differences between groups in SFF and VFF, during seasons and between seasons (Table V), did not reach significance either for men or for women.

When adjusting for gender using van Elteren's test (Table VI) the differences between groups were significant during both seasons, except for variation in fundamental frequency during pollen season.

Change in SFF and change in VFF, within as well as between groups, were not significant.

Discussion

The results of this study show that more patients than controls experienced voice symptoms during both pollen season and non-pollen season. At the same time, the patients' voice symptoms decreased from pollen season to non-pollen season, whilst there was no change in the control group. However, throat infections were more frequent in the patient group: 11 patients compared to none in the control group.

Table III. Voice and speech, visual analogue scales (mean, SD, MD, range); difference between groups and change within groups between seasons.

	Pollen season		Non-pollen season		Change	
	Patients, <i>n</i> = 30	Controls, <i>n</i> = 30	Patients, <i>n</i> = 30	Controls, <i>n</i> = 30	Patients, <i>n</i> = 30	Controls, <i>n</i> = 30
Voice quality ('not at all good' to 'very good')	6.9 (2.6)***; 7.6 (1.1 to 9.9)	9.3 (1.4); 9.8 (2.7 to 10.0)	7.8 (2.2)**; 8.7 (2.2 to 10)	8.9 (1.9); 9.6 (2.1 to 10)	-0.9 (2.9)*; -0.5 (-8.0 to 4.9)	0.4 (1.5); 0.1 (-1.1 to 7.8)
Clearness of speech ('not at all good' to 'very good')	6.2 (3.0)***; 6.9 (0.2 to 9.9)	9.0 (2.0); 9.7 (0.7 to 10)	7.7 (1.7); 7.8 (2.9 to 10.0)	8.0 (2.3); 8.8 (1.1 to 10.0)	-1.5 (3.0)**; -0.7 (-7.7 to 2.8)	1.0 (2.1); 0.2 (-2.2 to 7.2)
Hoarseness ('not at all' to 'to a very high degree')	4.4 (3.0)***; 4.1 (0 to 9.4)	0.5 (1.2); 0.1 (0 to 6.7)	3.1 (3.2)**; 1.6 (0 to 9.6)	0.9 (1.4); 0.4 (0 to 6.9)	1.3 (3.1)**; 0.7 (-5.2 to 7.8)	-0.4 (0.8); -0.2 (-2.7 to 0.8)
Vocal fatigue ('not at all' to 'to a very high degree')	4.2 (3.3)***; 4.6 (0 to 9)	0.6 (1.5); 0.2 (0 to 8)	3.0 (2.7)**; 2.4 (0 to 8.6)	0.9 (1.5); 0.3 (0 to 7.6)	1.2 (3.5)*; 0.8 (-6.5 to 7.0)	-0.3 (0.8); -0.1 (-2.5 to 1.9)

Given as: mean (SD); MD (range).

Difference between groups: Mann-Whitney *U* test. Change within groups: Wilcoxon signed-rank test.

* *P* < 0.05, ** *P* < 0.01, *** *P* < 0.001.

Table IV. Speaking fundamental frequency (SFF) and variation in fundamental frequency (VFF) in Hz; within groups; in patient group: women $n = 17$ and men $n = 13$; in control group: women $n = 17$ and men $n = 13$; pollen season and non-pollen season.

	Patients			Controls		
	Pollen season	Non-pollen season	<i>P</i> value (Wilcoxon signed- rank test)	Pollen season	Non-pollen season	<i>P</i> value (Wilcoxon signed- rank test)
SFF Women	199.2 (14.2); 200.6 (178.1 to 222.9)	200.9 (18.1); 196.4 (164.8 to 226.8)	0.49	207.0 (11.8); 209.8 (184.9 to 224.8)	208.2 (11.4); 207.9 (190.1 to 230.2)	0.53
VFF Women	39.6 (7.9); 38.3 (27.2 to 54.5)	40.5 (9.2); 39.1 (27.7 to 65.4)	0.64	43.9 (6.8); 44.6 (30.0 to 58.8)	44.3 (6.4); 44.4 (36.1 to 59.6)	0.43
SFF Men	112.3 (13.0); 113.6 (94.8 to 140.8)	111.7 (12.2); 112.8 (93.1 to 140.8)	0.57	120.2 (13.6); 116.5 (98.3 to 142.3)	121.1 (12.4); 117.9 (101.8 to 146.3)	0.89
VFF Men	20.4 (6.0); 19.4 (10.8 to 34.6)	20.1 (6.7); 18.2 (14.0 to 37.0)	0.84	20.5 (5.7); 20.5 (11.7 to 33.1)	23.0 (5.5); 21.6 (12.8 to 34.9)	0.09

Given as: Mean (SD); MD (Min–Max).

It is unclear what impact these throat infections have had on the patients' voice symptoms. The higher incidence of throat infections among the allergy patients may have caused the higher incidence of voice symptoms, or, on the other hand, the allergy may have contributed to the throat infections (12).

Findings from a study by Millqvist et al. (9) showed no group difference in perceptual voice quality between the patients with birch pollen allergy and controls. However, the acoustic analyses of the same voices in our study show differences between groups in speaking fundamental frequency, during both seasons, when adjusting for gender using van Elteren's test. Possibly the lower pitch was not detected by the listeners in the study by Millqvist et al., and, moreover, the SFF values of the subjects were within normal limits. In the present study, average speaking fundamental frequency among women in the patient group was 199 Hz during pollen season compared to 207 Hz in the control group. Corresponding values for men were 112 Hz in the patient group and 120 Hz among the controls. As speaking fundamental frequency is determined by, amongst other things, the vocal fold mass, a probable explanation for the

lower speaking fundamental frequency among the patients with birch pollen allergy could be swelling and edema of the vocal folds. The result is in accordance with that from a study by Jackson-Menaldi et al. (3), who found that the majority of both women and men with air-borne allergies had a low speaking fundamental frequency. Examinations with stroboscope showed edema of the vocal folds in all of the patients with an allergy. In our study, the difference in speaking fundamental frequency between groups remained during non-pollen season both for women (201 Hz among patients compared to 208 Hz among controls) and for men (112 Hz among patients and 121 Hz among controls). This result further suggests chronic edema of the vocal folds, especially when taking into consideration that the patients' allergy symptoms had been long-standing, on average 15 years among the women and 17 years among the men. Chronic edema of the vocal folds could also explain why the patients experienced vocal symptoms not only during pollen season but also during non-pollen season. However, to confirm the existence of edema one must examine the vocal folds with stroboscope, and this examination was not performed in our study.

Although speaking fundamental frequency was within normal limits and the extent of voice symptoms was small, the patients differed significantly from the controls. Thus, it is important to be attentive to voice symptoms when examining patients with birch pollen allergy. Among average voice users, a laryngeal allergy may hardly be noticed because the other more dominant symptoms like itching nose and eyes are in the foreground. However, for professional singers and other professional voice users, e.g. actors and teachers, the voice symptoms are more serious because of the risk of developing voice disorders and voice distress (12–14). Also, it is important with

Table V. Difference in SFF and VFF (Hz) between groups, women and men separately; *P* values.

	<i>P</i> value (Mann–Whitney <i>U</i> test)	<i>P</i> value (Mann–Whitney <i>U</i> test)	<i>P</i> value (Mann–Whitney <i>U</i> test)
	Patients vs controls; Pollen season	Patients vs controls; Non-pollen season	Change; Patients vs controls
SFF Women	0.10	0.23	0.92
VFF Women	0.08	0.08	0.97
SFF Men	0.22	0.06	0.64
VFF Men	0.92	0.07	0.14

Table VI. Differences in speaking fundamental frequency (SFF) and variation in fundamental frequency (VFF) between groups, and change within and between groups, adjusted for gender by van Elteren's test. *P* values.

	Change		Patients vs controls		Change
	Patients (<i>P</i> values)	Controls (<i>P</i> values)	Pollen season (<i>P</i> values)	Non-pollen season (<i>P</i> values)	Patients vs controls (<i>P</i> values)
SFF	0.74	0.53	0.04	0.03	0.81
VFF	0.87	0.07	0.16	0.01	0.30

Mann-Whitney *U* test between groups and Wilcoxon signed-rank test within groups.

thorough medical history and examination in order to exclude allergy in patients with unexplained voice disorders. A study by Simberg et al. (7) on prevalence of voice symptoms among students with inhalant allergy showed that subjects who had received immunotherapy for more than 2 years reported significantly fewer voice symptoms than those who had been treated with immunotherapy less than 1 year.

During non-pollen season there were also differences in variation of fundamental frequency between the patient and control groups in the study (based on van Elteren's test). For men, variation of fundamental frequency was 20 Hz in the patient group and 23 Hz in the control group. Corresponding values for women were 41 Hz in the patient group and 44 Hz in the control group. Also, there was a group difference during pollen season, but only in women: 40 Hz in the patient group and 44 Hz in the control group. There was, however, no difference for men: 20 Hz versus 21 Hz. A cause of the restricted variation in fundamental frequency among women in the patient group might be edema leading to decreased elasticity of the vocal folds. The current group difference in variation of fundamental frequency is in accordance with the conclusions in other studies (5,13,14)—allergies may cause difficulties in controlling pitch and pitch modulation.

Fundamental frequency of the voice differs between women and men. This underlying difference is taken into consideration in van Elteren's test. Therefore, both women and men can be included in the patient and control group. The reason for using van Elteren's test in this study was to enlarge the groups, thus giving stronger statistical results. Speaking fundamental frequency was significantly lower in the patient group than in the control group, during both pollen seasons and non-pollen seasons. Also, the difference in VFF was significant, with more restricted modulation in the patient group than in the control group; however, this was during non-pollen season only.

Conclusions

The patients suffering from birch pollen allergy showed more frequent voice symptoms and a lower speaking

fundamental frequency during pollen season than controls. Moreover, the difference between groups remained during non-pollen season. The results may be explained by long-standing allergy symptoms giving rise to the development of chronic edema of the vocal folds and voice symptoms. It is recommended that laryngeal examination with stroboscope should be performed on patients diagnosed with birch pollen allergy and who also experience voice symptoms.

It is important to pay attention to air-borne allergies, especially regarding professional voice users such as teachers and singers and also within their education programs.

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