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Impact of Allergic Rhinitis on Voice in Children

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Allergic rhinitis · Children · Fundamental frequency · Voice analysis

Abstract
Introduction: The purpose of the present study was to determine the possible effect of allergic rhinitis (AR) on voice change in children with acoustic analysis and Turkish children's voice handicap index-10 (TR-CVHI-10). ***Methods:*** This is a case-control study. Forty-one children with AR, and a positive skin prick test, as well as 39 children of controls who had produced a negative skin prick test and lacked a history of allergic disease, were selected for the study. Each assessment included recordings for the purposes of acoustic voice analysis (fundamental frequency [f0], jitter %, shimmer %, and harmonics-to-noise ratio (HNR)), and aerodynamic analysis (maximum phonation time (MPT) and s/z ratio). All participants completed TR-CVHI-10. ***Results:*** The mean TR-CVHI-10 score of the AR group was significantly higher than the control group ($p = 0.013$). No difference was observed between the AR and control groups in terms of jitter, shimmer, HNR, and MPT values and s/z ratio ($p > 0.05$). Conversely, the f0 value was more pronounced in controls (270.9 ± 60.3 Hz) than in the AR group (237.7 ± 54.3 Hz) ($p = 0.012$). ***Conclusion:*** The study's results revealed that AR can have an effect on fundamental frequency and voice quality in children. The diagnostic process should include AR as a potential cause of voice disorders in children.

Introduction

Allergic rhinitis (AR) is one of the most common chronic inflammatory conditions affecting 10–20% of the pediatric population, and this percentage appears to be increasing of late [1, 2]. Children with AR are more susceptible to throat-related problems, such as sore and dry throat, coughs, laryngitis, difficult to shift mucus, and vocal issues [3]. Also, chronic cough and laryngeal tension may cause edema, as well as an inflammation of the vocal folds, thereby affecting the voice quality.

A comprehensive clinical voice examination usually entails visual, perceptual, patient-based subjective, and instrumental acoustic assessment techniques such as laryngostroboscopy, acoustic voice analysis, and aerodynamic measurements to meet the pediatric voice assess-

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ment guidelines [4]. Moreover, it has been noted that up to 20% of children aged 10 years or younger find invasive procedures like laryngostroboscopy intolerable [5]. Alternatively, acoustic voice analysis provides for an objective and noninvasive assessment of the voice function through the analysis of vocal output. Subsequently, acoustic voice analysis is considered to be easily applicable in pediatric voice care because this procedure is tolerable even for young children [5].

Patients with voice disorders were discovered by Roy et al. [6] to sustain more respiratory allergies when compared to patients who did not have voice disorders. A study by Millqvist et al. [7], where patients were assessed using the voice handicap index, confirmed that patients who had suffered from a birch pollen allergy experienced more voice problems every day. When evaluating the effects of birch pollen allergies on voice function in patients, Ohlsson et al. [8] noted that patients had more voice symptoms during pollen seasons when compared to the control group. Moreover, during the non-pollen season, those in the patient group enjoyed a reduction in symptoms, but this was not so in the control group, who did not undergo a similar reduction [8]. The negative impact of AR on voice-related quality of life was also pointed out in a recent study conducted by Turley et al. [9]. These studies demonstrate the effects of allergies on voice in adult patients. Unfortunately, very little published data exist on voice disorders in children with AR, and the reporting of the effects of AR on voice change is poor. Filiz et al. [10], who studied 123 children with AR, showed that the mean pediatric voice handicap index (pVHI) score was significantly higher in the AR group, but their findings were not supported by the use of an objective method such as acoustic analysis. Over the course of this study, we were unable to locate in the literature evidence of an objective method such as acoustic voice analysis being used to examine the relationship between AR and voice disorders in children. The purpose of the present study was to evaluate the impact of AR on voice in pediatric patients utilizing acoustic voice analysis, aerodynamic assessment, and Turkish children's voice handicap index-10 (TR-CVHI-10).

Materials and Methods

The study was conducted between January 2019 and March 2020 at the University of Health Sciences Umraniye Education and Research Hospital otorhinolaryngology department. The local institutional Ethics Committee approved the study (reference number: B.10.1.TKH.4.34.H.GP.0.01), and written informed consent was given by the parents or legal guardians of the patients.

Patient Selection

Eighty participants aged between 7 and 12 years were recruited for the study. The children were assigned into 2 groups: the AR group and control group. All children underwent a skin prick test, parental consent was sought, and provided in every case. The AR group consisted of 41 pediatric patients with AR, who were referred from the pediatric allergy department. Patients were diagnosed with AR after a thorough review of their clinical history, a clinical examination, and produced a positive result from a skin prick test, according to AR and its impact on asthma (ARIA) guidelines [11]. The control group consisted of 39 children selected from the general pediatric department, and the subjects lacked a history of allergic disease and produced a negative skin prick test. Children were excluded from the study if they had used any of the following: nasal, inhaled, or systemic steroids, antihistamines, or any anti-reflux medication for a period of at least 3 months before the examination. Furthermore, skin prick tests were administered to all subjects to rule out the possibility of a patient with a history of allergies still producing a negative skin prick test result. The study did not unearth such a case. Patients were also excluded if they had a history of nasal, pharyngeal, or laryngeal surgery, had been diagnosed with gastroesophageal reflux, hearing loss, or a related disability that might affect one's speech or voice, or if they were suffering from an upper airway infection. All participants underwent flexible fiberoptic laryngoscopy to rule out additional airway diseases.

Skin Prick Test

All patients underwent a skin prick test to provide concrete evidence of the existence of allergens. Allergens tested for included pollens (grass mixture, tree mixture, and cereal weeds), mold (*Alternaria*, *Aspergillus*, and *Cladosporium* species), as well as allergies to cats, dogs, chickens, cockroaches, and house dust mites (*Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*). A histamine solution (histamine phosphate 10 mg/mL) was used as a positive control and a saline solution was used as a negative control. Skin reactions were evaluated 15 min after the skin prick test. For the purposes of the exam, a wheal diameter of at least 3 mm was seen as a positive response.

Subjective Voice Analysis

The TR-CVHI-10 is a quality-of-life questionnaire completed by the children. TR-CVHI-10 is a self-assessment tool for pediatric dysphonia. Ricci-Maccarini et al. [12] developed CVHI-10, and the original tool was translated into Turkish by Ozkan et al. [13] The Turkish version has been validated for use on the pediatric population [12, 13]. The TR-CVHI-10 consists of 10 statements, of which children are asked to pick the one that most correlates to their situation using a Likert scale ranging from 0 (never) to 3 (always). All participants completed TR-CVHI-10 (Table 1).

Objective Voice Analysis

For the objective voice evaluation, all children underwent acoustic voice analysis and aerodynamic assessment. Recording voice analysis was performed in a soundproof room with a microphone (Dynamic Rode® NT1; Rode, Sydney, Australia) at a stable mouth-to-microphone distance of 20 cm. The multidimensional voice was assessed using Praat speech processing software (University of Amsterdam, The Netherlands). The children were required to say/a/phoneme for approximately 3 s. Here, the mean

Table 1. Children Voice Handicap Index-10* (0 = never, 1 = sometimes, 2 = many times, and 3 = always)

People have difficulty hearing me because of my voice	Never	Sometimes	Many times	Always
People have difficulty understanding me in a noisy room	Never	Sometimes	Many times	Always
My voice difficulties prevent me to stay with people	Never	Sometimes	Many times	Always
I feel left out in conversations because of my voice	Never	Sometimes	Many times	Always
My voice difficulties reduce my school outcome	Never	Sometimes	Many times	Always
I feel I have to strain to produce voice	Never	Sometimes	Many times	Always
My voice is not light	Never	Sometimes	Many times	Always
My voice problem upsets me	Never	Sometimes	Many times	Always
My voice makes me feel inferior to other children or other boys	Never	Sometimes	Many times	Always
People ask me "what's wrong with your voice?"	Never	Sometimes	Many times	Always

* Validated Turkish form of the index has been used in our study.

Table 2. Demographics of patients

	AR group (n = 41)	Control group (n = 39)	LLN/ULN	p values
Mean age (±SD)	9.5 (±1.6)	9.4 (±1.9)	7.98/11.28	0.961
Gender				
Male	20	21		0.496
Female	21	18		

AR, allergic rhinitis; SD, standard deviation; LLN, lower limits of normal for age; ULN, Upper limits of normal for age. χ^2 tests $p < 0.05$.

fundamental frequency (f0 in Hertz [Hz]) was determined, as well as jitter and shimmer percentages, and the harmonics-to-noise ratio (HNR). In case of the aerodynamic assessment, the duration of the/a/phoneme after maximum inspiration was measured to gauge maximum phonation time (MPT). Children were given 3 attempts to provide MPT samples with the longest effort deemed definitive. The s/z ratio was arrived at by taking the measurement of the MPT of single consonants /s/ and /z/ in 2 separate breaths. The best /s/ and /z/ efforts were used to obtain the ratio.

Statistical Analysis

Statistical package for the social sciences (SPSS) version 20.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Distribution of groups' normality was checked with Kolmogorov-Smirnov and Shapiro-Wilk tests. Student's t test and the Mann-Whitney U test were used to analyze parametric and nonparametric data between groups, respectively. Categorical variables were assessed by χ^2 test. p values of ≤0.05 were regarded as significant.

Results

The study included 80 children (30 girls and 50 boys) with a mean age of 9.4 ± 1.8 years ranging from 7 to 12 years. Forty-one children (51.3% girls and 48.7% boys) who had a positive skin prick test and symptoms of AR formed the AR group. The mean age of patients in the AR group was 9.5 ± 1.6. Thirty-nine (46.2% girls and 53.8% boys) children who had a negative prick test without symptoms of AR compromised the control group. The mean age of patients in the control group was 9.4 ± 1.9. There was no statistically significant difference between the AR group and the control group in terms of age or gender (p = 0.961 p = 0.496, respectively). Table 2 summarizes the breakdown of the patients by demographics.

Subjective Analysis

The mean scores of the TR-CVHI-10 were as follows: 3.36 ± 3.3 in the AR group and 2.33 ± 1.99 in the control group. According to the Mann-Whitney U test, the mean TR-CVHI-10 score of the AR group was significantly higher than those of the control group (p = 0.013) (Table 3).

Objective Voice Analysis

The patient's voice analysis results confirmed that mean HNR values were 9.14 ± 5 dB in the AR group and

Table 3. Comparison of the values of objectives and subjective parameters between the AR and control groups

Groups	f0, Hz	Jitter (%)	Shimmer (%)	HNR (dB)	MPT	s/z ratio	TR-CVHI-10
AR group (±SD)	237.7 (±54.3)	0.99 (±0.82)	2.77 (±2.82)	9.14 (±5)	13.3 (±5.2)	0.7 (±0.2)	3.36 (±3.3)
Control group (±SD)	270.9 (±60.3)	0.89 (±0.77)	2.01 (±1.48)	9.97 (±6.11)	11.7 (±4.4)	0.78 (±0.24)	2.33 (±1.99)
p value	**0.012**	0.975	0.422	0.613	0.321	0.529	**0.013**

The value in bold represents the Mann-Whitney test $p < 0.05$. AR, allergic rhinitis; HNR, harmonics-to-noise ratio; MPT, maximum phonation time; TR-CVHI-10, Turkish children's voice handicap index-10.

9.97 ± 6.11 dB in the control group. No significant difference was found between the AR and control groups in the mean HNR values ($p = 0.613$). The f0 value was more pronounced in the control group (270.9 ± 60.3 Hz) than in the AR group (237.7 ± 54.3 Hz) ($p = 0.012$). In the AR group, the mean jitter values were 0.99 ± 0.82% and the mean shimmer values were 2.77 ± 2.82%. In the control group, the mean jitter values were 0.89 ± 0.77% and the mean shimmer values were 2.01 ± 1.48%. There was no significant difference in the mean jitter and shimmer values between the AR and control groups ($p = 0.975$, $p = 0.422$, respectively). The mean MPT values and s/z ratio were similar in the AR group (13.3 ± 5.2, 0.70 ± 0.20, respectively) and control group (11.7 ± 4.4, 0.78 ± 0.24 respectively) ($p = 0.321$, $p = 0.529$). The results of the patients' voice analysis are shown in Table 3.

Discussion

AR is generally related to several multimorbid disorders [14]. Though there is no shortage of studies analyzing the nasal symptoms arising from AR, not as much has been documented on how AR affects voice and speech, especially in children. These symptoms have not received due attention owing to the voice changes being minor [10, 15].

Voice problems in AR are predominantly caused by 3 factors. Mucus hypersecretion causing inefficient mucus drainage in the nasal passage leads to throat cleaning, coughing, and dysphonia [16]. Second, hearing problems arising from chronic middle ear effusion and eustachian dysfunction have also been linked to voice disorders in children with AR [17]. Finally, single unified airway model, whereby the respiratory system is viewed as a body of organ linkages with anatomical similarities and common pathophysiological mechanisms that govern hyper-reactivity and inflammatory responses [18]. Here, it is well established that both the upper and lower respiratory tracts share a histologically similar epithelium that extends from the nose to the lungs. A mediator response in 1 organ can lead to responses elsewhere in the respiratory tract and pathologies that stem from 1 part of the unified airway can simultaneously affect other parts [19, 20]. Extensive documentation has concluded that any changes in the organs that make up the single unified airway can foster a variety of inflammatory responses in both the upper and lower respiratory tract [21, 22]. Respiratory allergies have been linked to the onset of voice disorders.

Endoscopic examination, acoustic, aerodynamics, and subjective self-assessment are essential to evaluate voice disorders [4]. In the present study, flexible endoscopic nasopharyngolaryngoscopy was performed on every participant to rule out additional pathologies, and also acoustic and aerodynamics voice analysis and TR-CVHI-10 scores were used to determine the impact of AR on voice change in pediatric patients. The results revealed that mean TR-CVHI-10 scores were significantly higher in the children with AR, pointing to the increased possibility of the children developing voice disorders. This is homogeneous with outcomes from previous studies which found that children with AR scored higher than healthy children on the pVHI. Filiz et al. [10] only used pVHI to compare the voice quality of the children with AR to the voice quality of healthy children. They did not use an objective assessment tool such as acoustic analysis. The authors claimed that endoscopic examination, acoustic, and aerodynamic voice analysis could not be easily applied to children [10]. The present study utilized these evaluation instruments safely and practically on children with a mean age of 9 years.

Fundamental frequency, jitter, and shimmer values, HNR, MPT, and also the s/z ratio were all examined in the present study. Previous studies have highlighted the decrease in f0 values as the patient ages [23–25]. However, Nicollas et al. [23] revealed that jitter and shimmer did not

significantly vary with age or gender. Furthermore, they found that f0 was significantly lower in boys than in girls. In the present study, the participants' age ranged from 7 to 12. The mean ages of the 2 groups were similar, as was the gender make-up of the 2 groups. Therefore, the bias that would have occurred as a result of the differences in age and gender while calculating f0 were eliminated.

In the present study, acoustic analyses revealed differences in speaking fundamental frequency between the 2 groups. The outcomes were in line with a study by Ohlsson et al. [8] who confirmed that most adult patients who had pollen allergies produced low f0 values. Furthermore, a study by Jackson-Menaldi et al. [16] featuring 17 allergic patients who suffered with concomitant laryngeal symptoms, confirmed that patients with air-borne allergies had a lower speaking fundamental frequency when compared to control groups. The study also revealed a commonality between the patients. Stroboscopic findings showed patients shared a common pathological feature that being vocal fold edema [16]. The results found in the literature suggest that allergic edema of the vocal folds resulting from inflammation of the airway may result in a reduction in the fundamental frequency and a reduced ability to modulate pitch [8, 16, 26]. To identify the presence of edema, a laryngostroboscope is used to examine the vocal folds; however, as children have difficulties tolerating this procedure, this examination was not performed in our study. Conversely, Jackson-Menaldi et al. [16] reported a possibility of the patients within the AR group having laryngopharyngeal reflux. In our study, the children with laryngopharyngeal reflux were also excluded.

Voice disorders negatively influence social and academic outcomes in children. The present study also pointed out that AR has an adverse effect on voice quality in children, similar to conclusions forwarded by the literature [10]. Among pediatric patients, voice disorders associated with AR may be difficult to spot because other symptoms like itchy nose and eyes may be more prominent. Therefore, it is essential not to overlook or relegate the importance of voice symptoms when examining children with AR. Moreover, children suffering from AR should undergo an examination by a laryngologist for the presence of voice disorders. Furthermore, pediatric patients with dysphonia resulting from AR should receive appropriate medical management such as medical care and voice therapy.

A caveat to the conclusions arrived at by this study is that laryngostroboscopy could not be performed on children because of the difficulties in tolerating this procedure. Another shortcoming is related to sample sizes. Future studies should include a larger sample size as the results here are based on a small sample size.

Conclusion

The main take away from the present study was the existence of a significant difference in the mean TR-CVHI-10 and the mean f0 values, when comparing children with AR to healthy controls pointing to a causal link between AR and voice disorder. Vocal edema can be a motivator in the difference in f0 values. Though AR results in mild voice changes, allergies should not be ruled out as the root cause of voice disorder during the diagnostic process.

Statement of Ethics

The present study complied with the guidelines for human studies. Appropriate prior consent was obtained, and the Ethics Committee of Umraniye Research and Education Hospital approved the study.

Conflict of Interest Statement

The authors have no conflicts of interest to disclose.

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Author Contributions

All authors conceptualized the study. All authors were responsible for maintenance of the database, data acquisition, analysis, and manuscript preparation. All authors read and approved the final manuscript.

References

1 Sih T, Mion O. Allergic rhinitis in the child and associated comorbidities. Pediatr Allergy Immunol. 2010;21(1 Pt 2):e107–13.
2 Anandan C, Nurmatov U, van Schayck OC, Sheikh A. Is the prevalence of asthma declining? Systematic review of epidemiological studies. Allergy. 2010;65(2):152–67.
3 Cingi C, Gevaert P, Mösges R, Rondon C, Hox V, Rudenko M, et al. Multi-morbidities of allergic rhinitis in adults: European academy of allergy and clinical immunology task force report. Clin Transl Allergy. 2017;7:17.

4 Dejonckere PH, Bradley P, Clemente P, Cornut G, Crevier-Buchman L, Friedrich G, et al. A basic protocol for functional assessment of voice pathology, especially for investigating the efficacy of (phonosurgical) treatments and evaluating new assessment techniques. Guideline elaborated by the committee on phoniatrics of the European laryngological society (ELS). Eur Arch Otorhinolaryngol. 2001;258(2):77–82.
5 Roy N, Merrill RM, Thibeault S, Parsa RA, Gray SD, Smith EM. Development of a minimum protocol for assessment in the paediatric voice clinic. Part 1: evaluating vocal function. Logoped Phoniatr Vocol. 2012;37(1):33–8.
6 Roy N, Merrill RM, Thibeault S, Parsa RA, Gray SD, Smith EM. Prevalence of voice disorders in teachers and the general population. J Speech Lang Hear Res. 2004;47(2):281–93.
7 Millqvist E, Bende M, Brynnel M, Johansson I, Kappel S, Ohlsson AC. Voice change in seasonal allergic rhinitis. J Voice. 2008;22(4):512–5.
8 Ohlsson AC, Drevsäter A, Brynnel M, Johansson I. Allergic rhinitis and voice change. Logoped Phoniatr Vocol. 2016;41(4):143–8.
9 Turley R, Cohen SM, Becker A, Ebert CS Jr. Role of rhinitis in laryngitis: another dimension of the unified airway. Ann Otol Rhinol Laryngol. 2011;120(8):505–10.
10 Filiz S, Selçuk ÖT, Baran RT. Evaluation of pediatric voice handicap index in children with allergic rhinitis. J Voice. 2019;33(5):801–e20.
11 Bousquet J, Hellings PW, Agache I, Bedbrook A, Bachert C, Bergmann KC. ARIA 2016: Care pathways implementing emerging technologies for predictive medicine in rhinitis and asthma across the life cycle. Clin Transl Allergy. 2016;6:47. Published 2016 Dec 30.
12 Ricci-Maccarini A, De Maio V, Murry T, Schindler A. Development and validation of the children's voice handicap index-10 (CVHI-10). J Voice. 2013;27(2):258–e28.
13 Ozkan ET, Tüzüner A, Demirhan E, Topbaş S. Reliability and validity of the Turkish pediatric voice handicap index. Int J Pediatr Otorhinolaryngol. 2015;79(5):680–4.
14 Roberts G, Xatzipsalti M, Borrego LM, Custovic A, Halken S, Hellings PW, et al. Paediatric rhinitis: position paper of the European academy of allergy and clinical immunology. Allergy. 2013;68(9):1102–16.
15 Spantideas N, Bougea A, Drosou E, Assimakopoulos D. The role of allergy in phonation. J Voice. 2019;33(5):811–e27.
16 Jackson-Menaldi CA, Dzul AI, Holland RW. Allergies and vocal fold edema: a preliminary report. J Voice. 1999;13(1):113–22.
17 Baker BM, Baker CD, Le HT. Vocal quality, articulation and audiological characteristics of children and young adults with diagnosed allergies. Ann Otol Rhinol Laryngol. 1982;91(3 Pt 1):277–80.
18 Grossman J. One airway, one disease. Chest. 1997;111(2 Suppl l):11S–6S.
19 Stachler RJ. Comorbidities of asthma and the unified airway. Int Forum Allergy Rhinol. 2015;5 Suppl 1(Suppl 1):S17–22.
20 Krouse JH. The unified airway–conceptual framework. Otolaryngol Clin North Am. 2008;41(2):257–v.
21 Corren J. Allergic rhinitis and asthma: how important is the link? J Allergy Clin Immunol. 1997;99(2):S781–6.
22 Braunstahl GJ, Overbeek SE, Kleinjan A, Prins JB, Hoogsteden HC, Fokkens WJ. Nasal allergen provocation induces adhesion molecule expression and tissue eosinophilia in upper and lower airways. J Allergy Clin Immunol. 2001;107(3):469–76.
23 Nicollas R, Garrel R, Ouaknine M, Giovanni A, Nazarian B, Triglia JM. Normal voice in children between 6 and 12 years of age: database and nonlinear analysis. J Voice. 2008;22(6):671–5.
24 Bennett S. A 3-year longitudinal study of school-aged children's fundamental frequencies. J Speech Hear Res. 1983;26(1):137–41.
25 Glaze LE, Bless DM, Milenkovic P, Susser RD. Acoustic characteristics of children's voice. J Voice. 1988;2(4):312–9.
26 Reidy PM, Dworkin JP, Krouse JH. Laryngeal effects of antigen stimulation challenge with perennial allergen Dermatophagoides pteronyssinus. Otolaryngol Head Neck Surg. 2003;128(4):455–62.