

Olfactory function in healthy children: Normative data for odor identification

Erik van Spronsen, M.D., M.Sc., Fenna A. Ebbens, M.D., Ph.D., and Wytse J. Fokkens, M.D, Ph.D.

ABSTRACT

Background: Olfactory disorders in children may be encountered frequently in the common ear, nose, and throat (ENT) practice. The need for objective measurements in the diagnosis, treatment, and evaluation of olfaction is present. However, for young children most olfactory tests need further normative data to be useful in clinical practice. Therefore, this study aimed to provide normative data in children and to determine possible parameters that influence odor identification test outcome.

Methods: In 201 healthy children reflecting the Dutch population, the Sniffin' Sticks screening test was performed and possible outcome determinants (age, height, gender, weight, peak nasal inspiratory flow, previous ENT surgery, and parental smoking habits) were assessed.

Results: Age, gender, and previous ENT surgery seem to influence significantly the outcome of the olfactory test.

Conclusion: In a general population-based sample of children, normative data of the Sniffin' Sticks screenings test are supplied as well as possible determinants of outcome.

(Am J Rhinol Allergy 27, 197–201, 2013; doi: 10.2500/ajra.2013.27.3865)

Hearing, olfaction, taste, touch, and vision are our five senses that we take for granted. It is not until one of these faculties is lost that its quality is fully appreciated. Loss of smell and its associated loss of taste can profoundly influence a patient's quality of life.^{1,2}

In the general population, smell disorders are common and are present in up to 0.9% of adults.¹ Because human beings can respond to olfactory stimuli from the neonatal period onward,² it is well possible that otolaryngologists may encounter young children with a disturbed sense of smell.³

The differential diagnosis of olfactory dysfunction is long and can be divided into four categories: conductive olfactory dysfunction, essential (perceptive) olfactory dysfunction, central (perceptive) olfactory dysfunction, and olfactory dysfunction of multifactorial origin. Among conductive causes that are of importance in the differential diagnosis of olfactory dysfunction in (young) children are (allergic) rhinitis, sinusitis, cystic fibrosis, and nasal polyposis.^{4–6} These diseases can be successfully treated. Monitoring the sense of smell is indispensable in establishing the presence of olfactory dysfunction in these disorders. In addition, one could hypothesize using olfactory tests in the evaluation of therapeutic success.

Over time, various scientists have tried to quantitatively and qualitatively assess the amount of olfactory disturbance (for a review see the study by Dawes⁷). In routine clinical practice, discrimination tests are most useful. However, these tests are developed for language-proficient adults and not for children. Recent data on subjective olfactometry in children indicate that children <5 years old are not capable of producing truly meaningful results. Nevertheless, some have shown that 3- and 4-year olds can successfully match odors to pictures.⁵ In addition, it has been shown that in children, receptive vocabulary, odorant familiarity, and gender have more influence on test outcome than actual odor discrimination and olfactory threshold.^{4,8} Despite the fact that odor discrimination tests are reliant on verbal competence, intellectual capacity, and odor familiarity it remains a fast and relatively easy screening tool to check for olfactory dysfunction. However, results of such tests among young children are lacking.

In routine clinical practice, the screenings set (containing 12 odor pens) of the Sniffin' Sticks test battery (Burghart Medizintechnik, Erlangen, Germany) is easy to perform (even in young children) but has been validated for adults only. Our current study provides normative values for the Sniffin' Sticks screenings test in young children (6–11 years of age). Because olfactory testing is unreliable in children aged ≤5 years, only individuals aged ≥6 years were included.^{2,8}

MATERIALS AND METHODS

Participants

Healthy children were recruited on two occasions (science day at our institute, visit to a local primary school) for the assessment of their sense of smell. Before inclusion, demographic details (including the subject's date of birth, length, weight, sex, and ethnic origin), a general ear, nose, and throat (ENT) history (including a history of previous ENT surgery), and informed consent from each child and his/her parent and/or supervisor were obtained. Current treatment regimens for sinonasal disease were noted (*i.e.*, topical steroids and/or antihistamines). Subjective normosmia was established using a visual analog scale (VAS). A VAS score of ≥8 was regarded as normosmia. Each subject was allowed to voluntarily discontinue participation at any time. If necessary, the investigator was allowed, at his/her discretion, to discontinue a subject from participating at any time.

Sniffin' Sticks Screening Test

The sense of smell was assessed using the abbreviated Sniffin' Sticks screening test containing 12 pen-like odor dispensing devices (Burghart Medizintechnik, Erlangen, Germany) and was conducted as described by the manufacturer. All measurements were performed in a well-ventilated room with little or no odor. Odorants were presented to each subject in a set order and were to be identified using a forced-choice multiple response answer set containing four alternatives. In case a written descriptor was unclear, visual support was provided to the subject. For odor presentation, the pen's tip was placed 2 cm in front of both nostrils for ~3 seconds, allowing the completion of several respiratory cycles. After each odor, an interval of 30 seconds was provided to prevent olfactory desensitization.⁶

Peak Nasal Inspiratory Flow

Peak nasal inspiratory flow (PNIF) was measured using a portable Youlten peak inspiratory flow meter (Clement Clark International, Harlow, United Kingdom) by using the technique as described by

From the Department of Otorhinolaryngology, Academic Medical Center, Amsterdam, the Netherlands

The authors have no conflicts of interest to declare pertaining to this article

Address correspondence and reprint requests to E. van Spronsen, M.D. M.Sc., Department of Otorhinolaryngology Head and Neck Surgery, Academic Medical Centre, Meibergdreef 9, 1105 AZ Amsterdam, the Netherlands

e-mail address: e.vanspronsen@amc.uva.nl

Copyright © 2013, OceanSide Publications, Inc., U.S.A.

Table 1 Subject characteristics

	Age (yr)					
	6 (n = 28)	7 (n = 22)	8 (n = 30)	9 (n = 40)	10 (n = 50)	11 (n = 31)
Male sex, n (%)	14 (50.0%)	16 (72.7%)	13 (43.3%)	14 (35.0%)	24 (48.0%)	20 (62.5%)
Allergy, n (%)	0	0	0	1 (2.5%)	1 (2.0%)	1 (3.2%)
Asthma, n (%)	0	1 (4.5%)	4 (13.3%)	0	3 (6.0%)	1 (3.2%)
Use of local steroids, n (%)	0	2 (9.1%)	3 (10.0%)	0	2 (4.0%)	1 (3.2%)
Use of antihistamines, n (%)	0	0	0	0	1 (2%)	2 (6.5%)
Previous ENT surgery, n (%)	1 (3.6%)	0	3 (10.0%)	6 (15.0%)	10 (20.0%)	6 (19.4%)
Parental smoking, n (%)	12 (42.9%)	8 (36.4%)	16 (53.3%)	11 (27.5%)	12 (24.0%)	7 (22.6%)
Highest PNIF, mean (SD)	63.3 (18.0)	63.6 (11.9)	81.6 (27.5)	86.1 (24.5)	90.5 (26.5)	96.6 (38.1)

ENT = ear, nose, and throat; PNIF = peak nasal inspiratory flow.

Table 2 Descriptive statistics of normative values of the Sniffin' Sticks obtained in healthy 6- to 11-yr-old Dutch children

Age (yr)	Female Subjects	Male Subjects
6		
n	14	14
Mean	6.93	8.00
SD	1.94	1.47
Minimum	4	5
Maximum	11	10
7		
n	6	16
Mean	9.83	7.38
SD	1.60	1.86
Minimum	8	4
Maximum	12	11
8		
n	17	13
Mean	8.47	7.15
SD	1.51	1.99
Minimum	6	3
Maximum	11	10
9		
n	26	14
Mean	9.50	8.86
SD	1.70	1.610
Minimum	6	6
Maximum	12	11
10		
n	26	24
Mean	9.69	8.88
SD	1.26	1.48
Minimum	7	5
Maximum	12	11
11		
n	11	20
Mean	9.55	9.20
SD	1.86	1.47
Minimum	6	6
Maximum	12	11

rized with frequencies and percentages for categorical data and mean and standard deviations for continuous measures. Multiple linear regression analysis was performed to determine whether age, gender, weight, length, body mass index (BMI), PNIF, previous ENT surgery, or parental smoking are of influence on Sniffin' Sticks screening test outcome. Because of the relative small groups, subset analysis was not possible. Chi-square analysis was performed to check whether parental smoking is critical for cigarette smoke recognition. The level of statistical significance was set as a value of $p < 0.05$, and all reported p values are two sided.

RESULTS

Participants

In total, 201 healthy normosmic children (aged 6–11 years) were recruited. Treatment with medications known to interfere with the sense of smell (*i.e.*, amphetamines, imipramine, morphine, dopamine antagonists, kanamycin, neomycin, streptomycin, penicillamine, coumarin, and thiamazole) was not used by any of the subjects in our group. Subjective normosmia was established using a VAS. Table 1 summarizes the demographic details of the study population. As can be seen, no allergy was present before the age of 9 years and asthma was present in 4.4% (9/102) of all cases. The use of local steroids was minimal (8/201; 4%). Gender distribution and parental smoking showed no great discrepancies between the different age groups. Table 2 and Fig. 1 summarize the outcomes of the Sniffin' Stick screening test for male and female subjects aged 6–11 years.

Interactions

Multiple linear regression analysis was performed to determine whether age, gender, weight, length, BMI, PNIF, previous ENT surgery, or parental smoking are of influence on Sniffin' Sticks screening test outcome. It was shown that female gender ($p = 0.10$), increased age ($p = 0.00$), and no previous ENT surgery ($p = 0.00$) significantly influenced (positively) Sniffin' Sticks screening test outcome (Fig. 2). For all other parameters, results were not significant.

DISCUSSION

The Sniffin' Sticks screening test is a modern olfactory test that has been thoroughly validated for adults. Although others have used this test to study olfactory function in children aged 6–11 years, only small numbers of individuals were included.^{2,12} Our study provides normative values for routine clinical use in children aged 6–11 years and was based on a study on olfactory function in 201 healthy, normosmic children.

Our data clearly exhibit an age-related increase in odor identification. As has been shown previously,³ odor threshold and odor discrimination levels in children aged 6–12 years are similar for all age

Lund.⁹ Measurements were repeated three times and the highest measurements were recorded. Previous studies have shown good sensitivity and close correlation with nasal blockage symptoms and objective measurements of nasal airway function (*e.g.*, rhinomanometry).^{10,11}

Statistical Analysis

Statistical analysis was performed using SPSS 16.0 (SPSS, Inc., Chicago, IL). Demographic and clinical characteristics were summa-

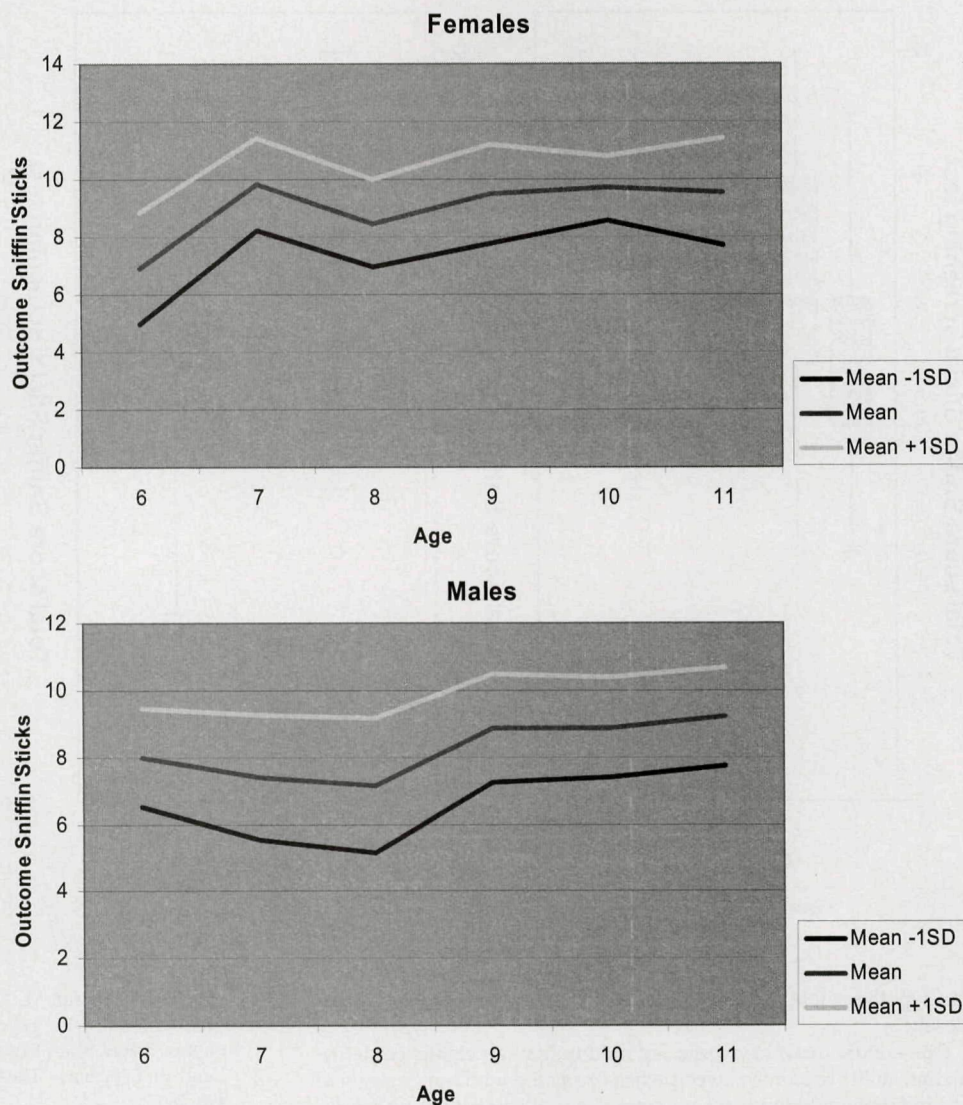


Figure 1. Descriptive statistics of normative values obtained in healthy 6- to 11-year old Dutch children.

groups. Odor identification, however, has been shown to increase with age.² This increase in odor identification is likely the result of an increase in receptive vocabulary, use of intellectual capacity, and odor familiarity with age. Children aged 6–11 years are known to be in the process of acquiring a substantial odor vocabulary.¹³ This odor vocabulary, however, still remains less developed in comparison with adults.¹⁴

Besides an age-related increase in odor identification, a statistically significant effect of the subject's gender was observed with girls being more sensitive than boys. Although gender-associated differences in odor identification are known to exist in adults,^{15–17} to date, no data showing a significant effect of gender on the outcome of olfactory screening in prepubescent children have been published.² Although some suggest that this better performance of girls is the result of a positive influence of various hormonal factors, especially estrogens, on the female olfactory epithelium,¹⁸ others have suggested that women outperform men based on acquired verbal skills and/or congenital factors.^{10–12} One could debate whether in our prepubescent group hormonal factors actually play a role.

Cigarette smoking clearly reduces olfactory function.^{19,20} The effects of passive smoking are, however, less clear. Although some authors report that children exposed to passive smoke may exhibit

a reduced ability to identify odors in comparison with children raised in a smoke-free environment,²¹ these assumptions are based on relatively small numbers of children. Based on our current study, in which we could not find any evidence suggesting a role for cigarette smoke exposure, we conclude that passive cigarette smoke exposure does not influence olfactory function. In addition, although some authors suggest that children exposed to passive cigarette smoke are more likely to identify the odor of cigarette smoke based on sensory experiences at home,¹⁵ our study did not find any relationship between exposure to cigarette smoke and cigarette odor recognition.

Nasal patency and olfaction have been suggested to be closely linked. However, the dogma that olfactory loss in rhinosinusitis is attributable primarily to blockage of airflow (*i.e.*, nasal congestion) to olfactory receptors seems not to be entirely true because associations are generally lacking between measures of airway patency and olfactory function.¹⁶ Therefore, controversy remains as to whether nasal congestion alone or the disease rhinosinusitis itself results in the olfactory deficit observed in most patients. In addition, perhaps both variables are of influence. In our present study, we show that nasal patency (PNIF) does not correlate with Sniffin' Stick screening test outcome. This outcome could be an additional argument to confirm

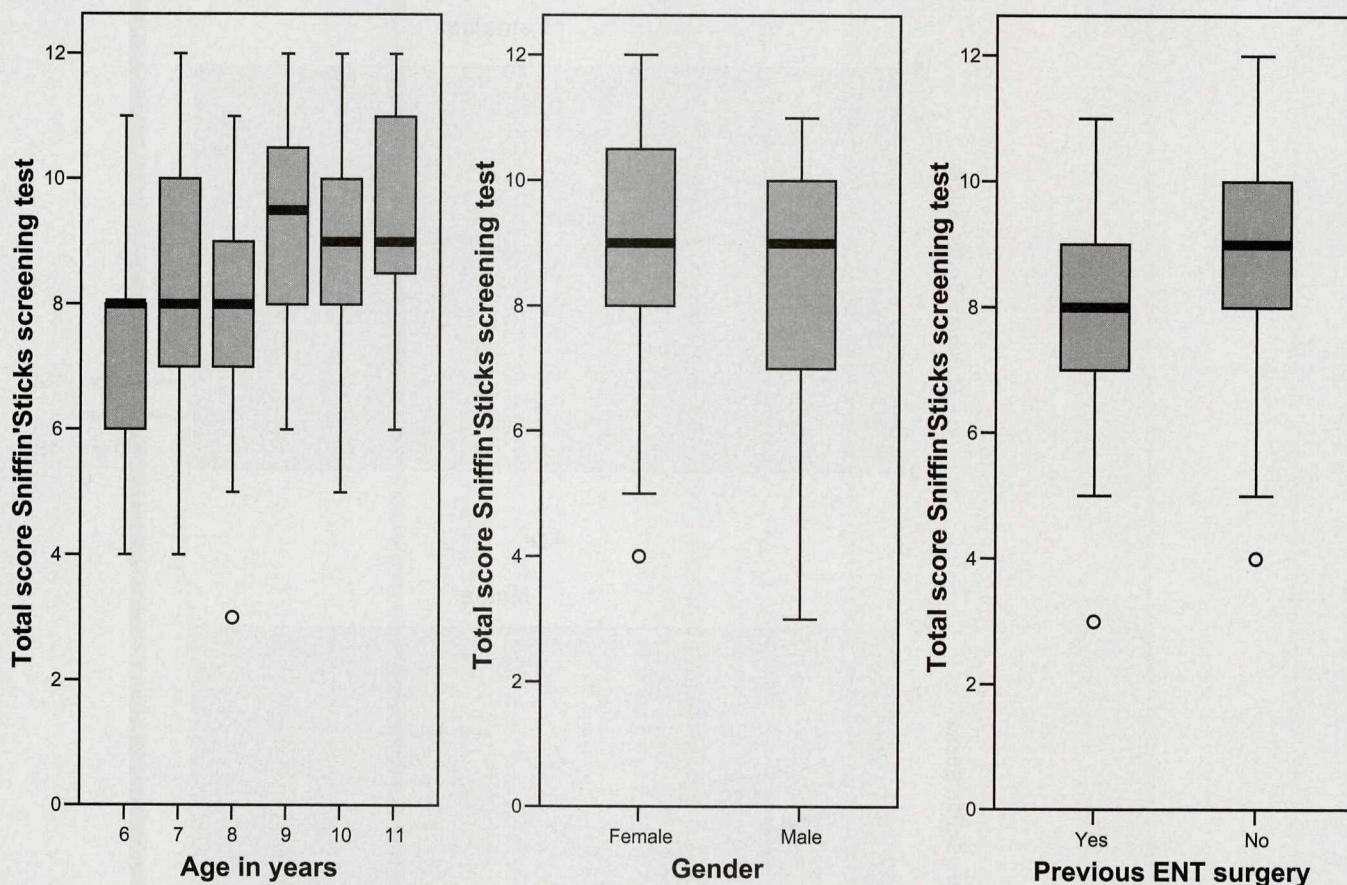


Figure 2. Effect of age, gender, and previous ear, nose, and throat (ENT) surgery on Sniffin' Sticks screening test outcome.

the hypothesis that olfactory acuity and nasal patency are not linked closely.

Obese individuals have been reported to have a heightened desire for and ability to identify sweets when compared with leaner persons. Morbidly obese individuals are more likely to present scores consistent with olfactory dysfunction.¹⁷ In 30 children, aged 10–16 years and suffering from obesity, significantly lowered odor detection thresholds have been established.²² It has been suggested that this decrease in olfactory acuity is linked to metabolic disturbances in obese individuals. In our present study we could not determine an effect of length, weight, or BMI on olfactory acuity. One of the reasons possibly explaining these results is the fact that only 5 of 201 subjects were considered to be obese (BMI, >25.0).

CONCLUSION

To summarize our findings, our study provided normative data for routine clinical use of the short olfactory identification test in children. Assessment of olfactory function should regard gender and age of the patient because they significantly affect olfactory functioning. However, this study shows the Sniffin' Sticks to be useful from the age of 6 years and onward. Other possible effectors of olfaction, such as weight, passive smoking, and nasal patency, showed no significant effect and therefore can be disregarded. These data are essential when assessment of olfactory functioning takes place in the studied age groups.

REFERENCES

1. Estrem SA, and Renner G. Disorders of smell and taste. *Otolaryngol Clin North Am* 20:133–147, 1987.

2. Hummel T, Bensafi M, Nikolaus J, et al. Olfactory function in children assessed with psychophysical and electrophysiological techniques. *Behav Brain Res* 180:133–138, 2007.
3. Lund VJ. Olfaction—The Cinderella of the senses? *Rhinology* 49:497–498, 2011.
4. Richman RA, Sheehe PR, Wallace K, et al. Olfactory performance during childhood. II. Developing a discrimination task for children. *J Pediatr* 127:421–426, 1995.
5. Dalton P, Mennella JA, Maute C, et al. Development of a test to evaluate olfactory function in a pediatric population. *Laryngoscope* 121:1843–1850, 2011.
6. Pevsner J, Hou V, Snowman AM, and Snyder SH. Odorant-binding protein. Characterization of ligand binding. *J Biol Chem* 265:6118–6125, 1990.
7. Dawes PJ. Clinical tests of olfaction. *Clin Otolaryngol Allied Sci* 23:484–490, 1998.
8. Richman RA, Post EM, Sheehe PR, and Wright HN. Olfactory performance during childhood. I. Development of an odorant identification test for children. *J Pediatr* 121:908–911, 1992.
9. Lund VJ. Office evaluation of nasal obstruction. *Otolaryngol Clin North Am* 25:803–816, 1992.
10. Larsson M, Lovden M, and Nilsson LG. Sex differences in recollective experience for olfactory and verbal information. *Acta Psychol (Amst)* 112:89–103, 2003.
11. Schaal B, Hummel T, and Soussignan R. Olfaction in the fetal and premature infant: functional status and clinical implications. *Clin Perinatol* 31:261–285, vi-vii, 2004.
12. Hummel T, Kobal G, Gudziol H, and Mackay-Sim A. Normative data for the "Sniffin' Sticks" including tests of odor identification, odor discrimination, and olfactory thresholds: An upgrade based on a group of more than 3,000 subjects. *Eur Arch Otorhinolaryngol* 264:237–243, 2007.

13. Lehrner JP, Glumack J, and Laska M. Odor identification, consistency of label use, olfactory threshold and their relationships to odor memory over the human lifespan. *Chem Senses* 24:337-346, 1999.
14. De Wijk RA, and Cain WS. Odor identification by name and by edibility: Life-span development and safety. *Hum Factors* 36:182-187, 1994.
15. Forestell CA, and Mennella JA. Children's hedonic judgments of cigarette smoke odor: Effects of parental smoking and maternal mood. *Psychol Addict Behav* 19:423-432, 2005.
16. Doty RL, and Mishra A. Olfaction and its alteration by nasal obstruction, rhinitis, and rhinosinusitis. *Laryngoscope* 111:409-423, 2001.
17. Richardson BE, Vander Woude EA, Sudan R, et al. Altered olfactory acuity in the morbidly obese. *Obes Surg* 14:967-969, 2004.
18. Dhong HJ, Chung SK, and Doty RL. Estrogen protects against 3-methylindole-induced olfactory loss. *Brain Res* 824:312-315, 1999.
19. Katotomichelakis M, Balatsouras D, Tripsianis G, et al. The effect of smoking on the olfactory function. *Rhinology* 45:273-280, 2007.
20. Frye RE, Schwartz BS, and Doty RL. Dose-related effects of cigarette smoking on olfactory function. *JAMA* 263:1233-1236, 1990.
21. Nageris B, Braverman I, Hadar T, et al. Effects of passive smoking on odour identification in children. *J Otolaryngol* 30:263-265, 2001.
22. Obrebowski A, Obrebowska-Karsznia Z, and Gawlinski M. Smell and taste in children with simple obesity. *Int J Pediatr Otorhinolaryngol* 55:191-196, 2000. □

Copyright of American Journal of Rhinology & Allergy is the property of OceanSide Publications Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.