Original Article

The effect of vocal loudness on Nasalance of vowels in Persian adults

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Objective: Nasality is one of the important parameters in pathology of voice resonance. Voice of normal adults has nasality to some extent. It appears that nasality, like other parameters of voice, can be affected by loudness which can be measured in experimental evaluations. This study was conducted to determine the effect of vocal loudness on nasalance of vowels in normal adults and to identify the relationship between these two factors in 18-28 year-old normal Persian-speaking adults.

Material and Methods: In this descriptive-analytic and cross sectional study, sample voices of sixty-five randomly selected male and female 18 to 28 year-old normal Persian-speaking students of Rehabilitation Faculty in Tehran University of Medical sciences were studied. Mean of Nasalance in Persian vowels was computed with Nasal View software. The findings were analyzed with descriptive statistical analysis and one-way ANOVA.

Results: Maximum nasalance was in low voice and minimum nasalance was in loud voice in both men and women subjects. The statistical results show that nasalance in 3 levels of low, normal and loud voices have significant differences ($p < 0.05$).

Conclusion: In normal adults, vowel nasalance is decreased with increase in vocal loudness. This is an aspect of normal speech mechanism. The findings can be explained considering function of velopharengeal port, raise in subglottal air pressure in loud voice, and increased muscle contraction of pharynx and palate.

Keywords: Nasalance, Vocal loudness, Persian language, Adults.

Introduction

Sound produced by vibration of vocal cords in larynx during exhalation is amplified and made audible as a result of influences by cavities of mouth, throat, and nose during passage through the vocal tract. In general, there are two types of resonation: oral and nasal. When the passage from throat to nose is open during speech, the generated sound is nasalized. From a clinical point of view, the relation between nasality and other vocal parameters such as fundamental frequency and loudness are important in diagnosing malfunction of velopharyngeal sphincter in patients with hypernasality, hearing impairment, dysartheria and cleft palate (1, 2&3). In the past, it was believed that in normal individuals nasality is limited to specific sounds which are produced nasally [such as sounds /m/ and /n/ in Persian language]. It was believed that other sounds, including vowels, are not nasal under normal circumstances. Results of research studies have shown that speech sounds, including vowels, are somewhat nasal in normal individuals (4) and are influenced by other voice parameters (5). After studying vowels in normal individuals, Lee (2009) concluded that typecasting a sound as nasal or oral is not absolute and vowels are nasal to some degree under normal circumstances. In a study of normal individuals (6), Ghelichi (2005) concluded that vowels are nasal and they are influenced by preceding and succeeding context (7). Zajac (2001) reported that nasality of vowels is reduced as vocal loudness increases. According to the author, this finding is independent of kind and type of the vowel but some vowels are more influenced by loudness

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than others (8).
Jenning and Kuehn (2008) studied changes in nasality of vowels as a function of loudness in professional singers and concluded that increase in loudness results in reduction of nasality in those singers. The least amount of nasalance was reported in vowel /o/ and the highest amount of nasalance was reported in vowel /i/ (9).
Researchers obtained conflicting results as they studied various characteristics to identify the relationship between other factors and changes in nasality. For example, Imatomy (2005) reported that individuals with cleft palate reduce loudness of their voice in order to reduce nasality (10). Mooris (1968) had stated that nasality is increased with vocal loudness in individuals with cleft palette (11). Culihan (1997) reported that increase in vocal loudness causes increase in nasality (11). According to Dalston (2001), the amount of nasality can be influenced by vocal loudness (12). Watterson (2009) reported that vowel nasality increases with rising in vocal loudness (13). Wenke (2010) determined that the amount of nasality is related to other sound parameters and it is changed as vocal loudness is changed (14).
These research findings demonstrate effect of vocal loudness on nasalance but the exact nature of the effect based on degree of loudness is not clear. In addition, since vowels differ from each other based on amount of mouth closure and tongue height, various degrees of loudness probably have varying effects on different vowels. To measure voice parameters, including nasalance, different assignments such as vowels, words, sentences, and paragraphs are utilized (15). Among these assignments, vowels are most popular for measuring attributes of sound (16). Vowels are all voiced, open mouth cavity to different degrees, and suitable to measure influence of attributes such as loudness. Vocal loudness is considered a psycho-acoustic aspect of sound resonation (17). Compared to other characters of voice, loudness is naturally and consciously changeable with individual's will. Regarding effect of vocal loudness on nasality, adequate knowledge and awareness is not available. Therefore, to study effects of various vocal parameters on each other, effect of vocal loudness on nasality in normal adult individuals has been studied for the first time in Iran.

Study Method

This was a descriptive-analytic study, performed in a cross-sectional manner. The study was carried out in School of Rehabilitation Sciences in Tehran University of Medical Sciences. The study sample was made out of 65 Persian-speaking students of the aforementioned school between ages of 18 and 28 years old. For sampling, roster of male and female students were obtained. Subjects were selected using simple random method and enrolled in the study. NasalView software system from Dr. Speech software suite was used to measure levels of vocal nasality. This system has been developed by Tiger DRS, Inc. in Seattle, Washington, USA. The system includes a calibration unit and special head gear for measuring nasalance, Figure below.

The head gear includes a plate which separates mouth from nose. Small built-in microphones in the barrier plate allow measurement of vocal signals from mouth and nose separately. The vocal signals are sent to a central processing unit via special cables. The nasalance values of the vocal signals are computed and statistical parameters of average, minimum, maximum, median, and mode are displayed as numerical and graphical outputs (18).
To enroll in the study, each candidate submitted a consent form and was invited to Speech and Language Laboratory of Rehabilitation Faculty for clinical evaluation. The inclusion characteristics for candidates were: 1) Their sound production, resonation, and psychological speech was normal, 2) They had no history of hearing impairment, 3) They were not ill on exam day or few days prior to the exam day by common cold or other conditions that adversely affect voice, 4) speaking in with standard Persian

accent.

To observe ethical guidelines, goals and methods of research and its non-invasive nature of testing were explained to the participants. During the exam, each subject sat comfortably on a chair with straight back. To justify the exams, different sound levels of low, normal, and loud were explained. The low level is equivalent to low speech but not whisper, normal level is equivalent to the usual daily speech, and the loud level is equivalent to speech level with someone who is farther than four meters as long as the level does not exceed the maximum recording level in NasalView system which is 100 dB. Each test subject first practiced the six Persian vowels (a, æ, e, o, u, i) in low, normal, and loud levels on trial basis. If the vowels were delivered correctly during the trial practice, the subject then delivered the vowels in low, normal, and loud voice for testing purposes. After evaluating each sample, average, standard deviation, median, minimum, and maximum nasality of the subject voice were calculated using analytical tools of NasalView software, and one-sided ANOVA was used to evaluate effect of vocal loudness on nasalance of different vowels.

Results

The highest nasalance was observed in low voice during vowel /i/ and the lowest nasalance was observed in loud voice during vowel /o/. The averages and standard deviations of nasalance in low, normal, and loud voice in women and men are presented in Tables 1 and 2, respectively.

Table 1. Averages and standard deviations of nasalance in three levels of voice in women

Vocal loudness criteria / vowel	Low Level		Normal Level		Loud Level	
	Average	SD	Average	SD	Average	SD
/a/	39.92	6.36	35.64	7.67	29.27	3.50
/æ/	41.82	5.32	37.22	6.38	31.83	3.88
/e/	40.60	6.24	36.46	6.17	31.96	4.27
/o/	37.19	6.62	32.06	5.20	27.39	2.72
/u/	38.44	8.17	34.92	5.92	30.04	4.69
/i/	46.76	9.27	42.72	8.21	38.06	7.08

Table 2. Averages and standard deviations of nasalance in three levels of voice in men

Vocal loudness criteria / vowel	Low Level		Normal Level		Loud Level	
	Average	SD	Average	SD	Average	SD
/a/	38.72	5.79	33.67	5.54	28.51	2.82
/æ/	39.65	5.19	34.69	5.20	31.38	7.99
/e/	38.40	5.64	33.80	5.84	29.54	3.80
/o/	34.62	4.88	30.80	4.67	27.08	3.16
/u/	35.10	5.63	31.60	4.81	28.10	4.65
/i/	40.78	7.19	37.56	7.69	33.01	6.16

ANOVA tests show significant difference in amount of vowels nasalance in different loudness levels in women (F=2.62, P=0.000) and men (F=2.64, P=0.000). The information is presented in statistical table for women, Table 3, and men, Table 4.

Table 3. Results of ANOVA of nasalance of Persian vowels in three levels of loudness in women

criteria / vowel	F (2, 62)	p-value
/a/	59.70	0.000
/æ/	71.74	0.000
/e/	72.88	0.000
/o/	57.86	0.000
/u/	39.54	0.000
/i/	34.35	0.000

Table 4. Results of ANOVA of nasalane of Persian vowels in three levels of loudness in men

criteria / vowel	F (2, 62)	p-value
/a/	82.55	0.000
/æ/	22.60	0.000
/e/	61.58	0.000
/o/	65.21	0.000
/u/	69.75	0.000
/i/	28.71	0.000

According to the findings, the largest nasalance was in the lowest voice and the smallest nasalance was in the loudest voice. Average of nasalance based on loudness was analyzed using ANOVA. According to the results, the difference in nasalance of each vowel in different vocal loudness levels was significant in both women (P=0.000) and men (P=0.000).

Discussion

According to the research results, there is some degree of vowel nasality in normal individuals which is in concordance with results published by Ghelichi (2005), Lee (2009), and Kuehn (2008) (7, 6 & 15). But the results of this research study regarding effect of vocal loudness on nasality do not match the views of Morris (1968) and Imatomy (2005) (11, 10). It appears that the discrepancy with Imatomy is due to the fact that he examined individuals with cleft palates. It is possible that in such patients another mechanism is responsible for changes in nasality.

According to the results, changes in vocal loudness were responsible for changes in average nasality such that nasality of vowels was decreased in both men and women with increased vocal loudness. The largest average of nasalance was in low voice and the smallest average of nasalance was in loud voice which matches studies of Zajac (2001) (8). These findings exemplify the views of Dalston (2001) and Wenke (2010) in regards to effect of vocal loudness on nasalance which showed the relationship between vocal loudness and nnasalance in normal adults. But the results of this study are in contrast with reports of Culihan (1997) and Watterson (2009) (11) & (13). Their reports indicated that the nasalance of vowels increases with vocal loudness. But in this study, the results were contrary to their views.

As vocal loudness increases, soft palate is raised higher to allow passage of more air to mouth through the vocal tract (19). In normal individuals, the velopharyngeal sphincter works with more intensity and causes closure of the passage from pharynx to nose as vocal loudness increases, resulting in lower nasality. In subjects with Velopharyngeal Impairment (VPI), the muscle activity probably occurs in an abnormal manner. When vocal loudness increases, exhaled air exists with higher pressure. Openness or imperfect closure of pharynx to nose causes excess air to exit through nose.

According to the findings, increase in vocal loudness in normal individuals is an effective cause for reduction of nasalance but its role in resonance disorders, either due to anatomical or functional impairment, requires further study and evaluation.

It is suspected that in individuals with Velopharyngeal Impairment, the relation between increase in vocal loudness and nasalance does not follow the same principle as in normal individuals. Therefore, it

would be necessary to investigate the role of vocal loudness in function of velopharyngeal sphincter in pathologic cases in future studies. It appears that understanding of principles and coping strategies to reduce nasality in cleft palate and discovering the relation between nasalance and vocal loudness in those mentioned by Morris (1968) (11), are different from normal individuals' strategies and require special clinical studies.

Conclusion

According to the findings of this study, it can be concluded that increase in vocal loudness in normal individuals is a factor in reduction of vowel nasalance and it is related to function of velopharyngeal sphincter. These findings can be useful as fundamental information in diagnosing and treating resonance disorders.

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