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NASALANCE SCORES IN LEBANESE ENGLISH-SPEAKING ADULTS USING NASOMETRIC ANALYSIS

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Hamdan AL, Ziade G, Jabbour J, Khneizer G, Kutkut I. Nasalance scores in Lebanese English-speaking adults using nasometric analysis. J Med Liban 2015 ; 63 (4) : 203-208.

ABSTRACT • Objective : To obtain normative data for nasalance scores in Middle Eastern English-speaking adult population. **Design** : Cross-sectional study. **Participants** : A total of 102 subjects were recruited in the study, 26 were excluded, thus, 77 Middle Eastern English-speaking adults (mean age = 23.77 ± 4.295 ; 39 males, 38 females) with normal speech and no hearing problems participated in the study. **Interventions** : Using Nasometer II 6450, nasalance scores were obtained for each participant's readings of 3 passages : Zoo and Rainbow passages and nasal sentences. **Main outcome measures** : Mean nasalance score, standard deviation and range. **Results** : Mean nasalance scores for Zoo passage, Rainbow passage and nasal sentences were 25.21 ± 11.07, 34.04 ± 9.30 and 41.29 ± 9.87 respectively. Mean scores didn't differ significantly between males and females, though scores for the Zoo passage were slightly higher among males (26.51 ± 11.66) than females (23.87 ± 10.42). In within-session reliability testing, 86% of retests for all three passages fell within 5 nasalance points of the previous test. In across-session reliability testing, 93% of retests for all 3 passages were within 5 points of initial test. **Conclusions and Relevance:** This study provides normative data for nasalance scores among Middle-Eastern adults, which can help make nasometer and determination of nasalance more clinically useful in this population.

Keywords: nasalance, nasality, nasometer, Middle-East

Hamdan AL, Ziade G, Jabbour J, Khneizer G, Kutkut I. Scores de nasalance pour adultes libanais de langue anglaise utilisant l'analyse nasométrique. J Med Liban 2015 ; 63 (4) : 203-208.

RÉSUMÉ • Objectif : Obtenir des données normatives pour les scores de nasalance dans la population adulte anglophone du Moyen-Orient. **Protocole** : Étude transversale. **Participants** : Sur un total de 102 sujets recrutés, 26 ont été exclus ; 77 adultes anglophones du Moyen-Orient (âge moyen = 23,77 ± 4.295 ; 39 hommes, 38 femmes), ayant un discours normal et sans problèmes auditifs, ont participé à l'étude. **Interventions**: On a demandé aux participants de lire 3 passages chacun: les passages Zoo et Rainbow et des phrases nasales; les scores de nasalance ont été obtenus avec un Nasometer II 6450. **Principaux critères de jugement:** le score de nasalance, l'écart type et la gamme. **Résultats** : Les scores de nasalance pour les passages Zoo, Rainbow et les phrases nasales étaient de 25,21 ± 11,07, 34,04 ± 9,30 et 41,29 ± 9,87 respectivement. Les scores moyens ne diffèrent pas significativement entre hommes et femmes, bien que les scores pour le passage Zoo aient été légèrement plus élevés chez les hommes (26,51 ± 11,66) que chez les femmes (23,87 ± 10,42). Les tests de fiabilité menés dans la même session ont montré que 86% des nouveaux essais pour les trois passages se trouvaient à presque 5 points de nasalance de l'essai précédent. Dans les tests de fiabilité entre sessions, 93% des nouveaux essais pour les trois passages se trouvaient à moins de 5 points du test initial. **Conclusions et pertinence:** Cette étude fournit des données normatives pour les scores de nasalance pour les adultes du Moyen-Orient, ce qui peut aider à rendre le nasomètre et la détermination de nasalance plus utile cliniquement dans cette population.

INTRODUCTION

Speech has several acoustic and aerodynamic measures that relate to velopharyngeal function, among which is nasality. The assessment of nasality has traditionally been a perceptual task performed by speech language pathologists. The reliability of these perceptual ratings has always been subject to criticism in view of the diversity in the rating scales used and the presence of confounding factors in speech that may mask the perception of nasality [1-4]. Thus, despite the extensive information provided by the speech therapists in the evaluation of patients with velopharyngeal incompetence and the relative validity of such information, the need for other assessment tools has risen.

Nasal endoscopy and videofluoroscopy have been used as alternative or complementary diagnostic tests. However, both are rather invasive and one entails exposure to radiation therapy. The nasometer, a microcomputer-based instrument devised by Kay Pentax to measure nasalance and calculate a nasalance score [5], has been commonly used as a noninvasive, reliable and objective device to measure the extent of nasality [6-8]. The primary function of the nasometer is to provide a quantitative measure related to perceived hypernasality. The term nasalance is often used to reflect the ratio of nasal acoustic energy to nasal-plus-oral acoustic energy in speech. The consensus remains that nasalance can be used as a reliable supplement in the evaluation of velopharyngeal competence. This is in view of the results of extensive studies on the validity of the device that have shown a high correspondence between the perceptual judgments of nasality and the nasalance scores [3,9-10].

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In order for the nasometer to have clinical usefulness, normative data on normal speakers' nasalance scores is needed for reference. Normative data on nasalance have been published for white Americans, African Americans [11], Australian English-speaking children [12], Irish children [13], American English-speaking children [4], Canadian children [14], Puerto Rican Spanish-speaking women [15], Dutch children [16], and many others.

These studies have indicated that nasalance scores vary across languages and dialects [7], these could be language-specific, material-specific or dialect-specific. Differences in mean nasalance scores between the different languages and dialects were attributed to the usage of different vowels, oral and nasal consonants across languages [14,17] further substantiating that normative nasalance scores for each region and language are needed. So far, no study has examined the nasalance scores in English-speaking Lebanese adults. The purpose of this study is to obtain normative nasalance data for a large group of normal English-speaking Lebanese adults knowing that dialectal variations have an effect on mean nasalance scores. The standard speech stimuli: the Zoo passage, the Rainbow passage and nasal sentences will be used. It is not the purpose of this study to provide language specific material or stimuli or to look at the effect of language on nasalance scores.

MATERIALS AND METHODS

Participants

A total of 102 subjects were recruited in the study, 26 were excluded, therefore, 77 English-speaking Lebanese adult volunteers were enrolled in the study after having read and signed the informed consent approved by the Institutional Review Board at the American University of Beirut Medical Center (AUBMC) in Lebanon. Exclusion criteria included history of hearing loss, recent upper respiratory tract infection, and history of nasal or velopharyngeal surgery. The data were collected over a course of two months at the "Hamdan Voice Unit" at the AUBMC.

Materials and Procedures

Three reading passages originally described by Fletcher [18] and utilized in most clinical and nonclinical studies on nasalance [7,11,19] were used in this study: 1) the Zoo passage, which contains no nasal consonants, 2) the Rainbow passage, in which the occurrence of phonemes is similar to their occurrence in conversational speech, and 3) a set of nasal sentences loaded with nasal consonants.

The Nasometer II 6450 from Kay Elemetrics [5] was used for data collection and analysis. As previously described, this computer-based system includes headgear that contains two microphones, one on either side of a separator plate, which allows for distinct determination of nasal and oral contributions in speech [7]. The same device, computer, and headgear were used for all subjects. Prior to each testing session, the nasometer was calibrated according to the manufacturer's instructions.

After informed consent was obtained and basic demographic information (age, gender, and history of smoking and reflux) recorded for each participant, the headgear was placed using previously described techniques [20]. The participant was then asked to read the Zoo passage, Rainbow passage, and nasal sentences, in that order, one time each. All testing was carried out by one of two researchers, following the same protocol, in a quiet room, where only the participant and researcher were present.

Data Analysis

Mean, minimum, and maximum nasalance scores for each passage for each participant were computed using the "Calculate" function available in the Nasometer 6450 software package. Descriptive analysis was used to report the mean nasalance scores, standard deviations and range for each stimulus. Unpaired t-tests and ANOVA were used to assess differences across studies and between genders within this study.

Seven participants were randomly selected for reliability testing at a later stage. This involved following the same procedures as the initial test, but with each passage being read twice. The comparison was made by comparing the means of the two readings in the second session to the corresponding value collected in the initial session. This allowed for comparisons both within and across sessions.

RESULTS

Demographic Data

A total of 102 participants were recruited, however 26 subjects were excluded because they didn't fit the study's inclusion criteria, a total of 77 participants were thus included in the final analysis.

The mean age was 23.77 ± 4.295 years old, with a range from 19 to 40. Thirty-nine participants were males, and 38 females, with no significant difference in age between the two groups (males: 23.41 ± 2.704, females: 24.13 ± 5.418; $p = 0.46$). Fourteen participants (18.2%) were smokers and 14 (18.2%) reported having reflux (Table I).

TABLE I

DEMOGRAPHIC INFORMATION for STUDY POPULATION (N = 77)

Age	
Mean ± SD	23.77 ± 4.295
Minimum	19
Maximum	40
Gender	
Male	39 (50.6%)
Female	38 (49.4%)
Smoking	
Yes	14 (18.7%)
No	61 (81.3%)
Reflux	
Yes	14 (18.7%)
No	61 (81.3%)

TABLE II

NASALANCE SCORES of the THREE PASSAGES for the TOTAL STUDY POPULATION

	Zoo Passage	Rainbow Passage	Nasal Passage
	Mean value ± SD [Range]		
Overall population (N = 77)	25.21 ± 11.07 [9-49]	34.04 ± 9.30 [14-56]	41.29 ± 9.87 [20-73]
Males (N = 39)	26.51 ± 11.66 [9-49]	34.05 ± 10.46 [14-56]	41.21 ± 12.08 [20-73]
Females (N = 38)	23.87 ± 10.42 [9-43]	34.03 ± 10.08 [24-48]	41.37 ± 7.08 [32-55]

SD: standard deviation

Nasal Values

The group mean nasalance scores for the Zoo passage, Rainbow passage and nasal sentences were 25.21 ± 11.07, 34.04 ± 9.30 and 41.29 ± 9.87, respectively. As expected, the mean nasalance score was highest for the nasal sentences and lowest for the Zoo passage. For the Zoo passage, the mean nasalance score was slightly higher in males compared to females (26.51 ± 11.66 *vs*. 23.87 ± 10.42), but the difference was not significant ($p = 0.30$). For the Rainbow passage and nasal sentences, the mean nasalance scores were comparable for the male and female groups (Table II).

Reliability Test

The difference in the mean nasalance scores within sessions and between sessions varied with the reading stimuli. For within-session variability, at least 86% of retests for all three passages were < 5 nasalance points different from the initial test. In the case of the Zoo passage and Rainbow passage, there was one outlier participant representing the remaining 14% whose retest was 8 nasalance points different for the Zoo passage and 7 points different for the Rainbow passage.

For across-session variability, at least 93% of retests for all three passages were < 5 nasalance points different, again with one test representing the remaining 7% in the case of the Rainbow passage and nasal sentences. For the Zoo passage, 100% of the retests resulted in a difference in mean nasalance score within 5 nasalance points (Table III).

DISCUSSION

Multiple instruments have been used to estimate or compute the extent of nasalance in normal English-speaking adults and children. These instruments and techniques have also been relied upon for the evaluation of hypernasality and hyponasality in subjects with velopharyngeal incompetence or cleft palate deformity. Since its introduction in 1986, the nasometer has been used as a research tool and as a noninvasive method for assessing nasal resonance related to velopharyngeal insufficiency [8,21] and nasal obstruction [22]. A nasalance score reflects the dispersion of nasal acoustic energy in the overall vocal tract. Its perceptual correlate is the perceived nasality in speech.

Several studies have evaluated the relationship between perceptual ratings of nasality and nasalance using correlation analysis and sensitivity and specificity measures. The correlation between nasalance and nasality has varied between 0.02 and 0.82 [8]. This range in variability has been attributed to differences in methodology related to variations in speech stimuli, rating scales and number of listeners. Speech stimuli loaded with nasal consonants tend to increase the correlation between perceptual rating and hyponasality whereas speech stimuli devoid of nasal consonants increase the correlation with hypernasality. Several studies indicate that nasalance scores vary across languages and dialects [17], an observation that mandates the presence of separate normative data to be used as cutoffs for what is normal and what is

TABLE III

CUMULATIVE FREQUENCIES in PERCENT of EACH of the SEVEN SUBJECTS' REPEATED READINGS WITHIN SESSION (7 MEASUREMENTS) and ACROSS SESSIONS (14 MEASUREMENTS).

Difference	Zoo Passage		Rainbow Passage		Nasal Passage	
(Nasalance points)	Within session	Across sessions	Within session	Across sessions	Within session	Across sessions
< 1	0	7	0	14	14	14
< 2	43	36	14	43	57	29
< 3	71	57	71	64	71	79
< 4	71	79	86	79	71	86
< 5	86	100	86	93	100	93
< 6	86		86	93		93
< 7	86		86	93		100
< 8	86		100	100		
< 9	100					

abnormal in different cultures, languages and even for speakers of the same language in different regions. The usage of pre-existing normative data derived primarily from Western countries may be misleading in the assessment and management of patients with nasalance problems in other contexts. Thus, having normative data for a given language or at least foreign-English-speaking individuals is necessary in order to better evaluate and manage speakers with resonance disorders. Very few studies have looked at the effect of dialect on nasalance scores in English-speaking adults [17]. Most of the studies have been done in North America. Dalston *et al*. reported different cutoff scores in different regions of North America [17]. Speakers of American English have been reported to have significant differences in their nasalance scores across different geographic regions in the United States [7]. Another study showed no significant differences between white and African American men in the mean nasalance scores for the Zoo passage [11]. The normative scores for the Zoo passage, Rainbow passage, and nasal sentences have been reported as 11.25 ± 5.63, 31.47 ± 6.65, and 59.55 ± 7.96, respectively, for American English-speaking adults [7]. In other English-speaking countries, Van Doorn and Purcell have reported normative data for Australian English-speaking children, and found that mean nasalance scores on the Zoo passage were 2 points lower in their population compared to American English-speaking children [12]. Sweeney *et al*. examined a group of Irish-speaking children and reported the normative scores for the total speech sample, high pressure consonant sentences, low-pressure consonant sentences and nasal consonant sentences to be 26%, 14%, 16% and 51%, respectively, with no significant differences among genders [13].

In our study, the mean nasalance score for the Rainbow passage was comparable to the scores reported in the literature for different English dialects, whereas scores for the Zoo passage and nasal sentences were quite different from the results of other studies. For the Rainbow passage, the nasalance score in English-speaking Lebanese adults (34.04 ± 9.30) was well within the range of 31.69 ± 5.47 to 35.2 ± 4.7 reported for Canadian adults [19] and American adults from various regions [7]. For the Zoo passage, the results differed by 4-12 points in comparison to the normative data reported for American English-Speaking adults from different regions [7], by almost 7 points in comparison to White Americans and 8 points compared to African Americans [11]. All differences for this passage were statistically significant, ($p = 0.032$ for study population compared to Mid-Atlantic U.S. adults, the group with the closest value). For the nasal sentences, the nasalance score was markedly lower than those reported by other studies (16-19 points). Similarly, all differences were statistically significant ($p < 0.0001$ for study population compared to any other group). Table IV displays the mean nasalance scores obtained in this study alongside with those from readings of the same passages in previously published studies [7,11-12,19].

TABLE IV

NASALANCE SCORES of the THREE PASSAGES for the STUDY POPULATION - FOREIGN ENGLISH-SPEAKING LEBANESE ADULTS, SEVERAL ENGLISH SPEAKING ADULT POPULATIONS in the U.S. and CANADA, and AUSTRALIAN CHILDREN

Population	N	Mean age ± SD [Range]	Zoo Passage	Rainbow Passage	Nasal Passage
Lebanon, Adults	77 (39 M;38 F)	23.77 ± 4.295 [19-40]	25.21 ± 11.07	34.04 ± 9.30	41.29 ± 9.87
*Mid-Western U.S., Adults[1]	148		15 ± 6	35 ± 5	62 ± 6
*Mid-Atlantic U.S., Adults[1]	148		21 ± 5	39 ± 6	65 ± 5
*Southern U.S., Adults[1]	148		13 ± 7	34 ± 6	61 ± 6
*Ontario, Canada, Adults[1]	148		12 ± 6	36 ± 7	61 ± 7
African American Adults[2]	80 (40 M;40 F)	23.2 ± 5.33	17.05 ± 5.2		57.74 ± 5.3
White American Adults[2]	80 (40 M;40 F)	23.2 ± 5.33	18.24 ± 4.2		60.89 ± 6.6
Toronto, Ontario, Adults[3]	76 (25 M;51 F)	26.5 ± 5.8	13.45 ± 5.9	31.69 ± 5.47	57.9 ± 6.69
Australian Children[4]	245 (122 M;123 F)	6.5 ± 1.5	13.1 ± 5.9		59.6 ± 8.1

For all the *subjects as one group, the mean age was 33.07 years with a range of 16.17-63.33 and the male (M) to female (F)ratio: 56 males and 92 females.
[1]Seaver *et al*., 1991, using Nasometer 6200. [2]Mayo *et al*., 1996, using Nasometer 6200. [3]Bressman, 2005, using Nasometer 6200.
[4]Van Doorn & Purcell, 1998, using Nasometer 6200.

The significant differences in nasalance scores for the Zoo passage and nasal sentences may be attributed to several factors. First and foremost is the known difference in vowels and consonants across different dialects in English, as previously discussed. This provide the most reasonable explanation for why mean nasalance scores in this Lebanese English-speaking population showed such a smaller range (i.e. were significantly higher for the Zoo passage and significantly lower for the nasal sentences) compared to other English dialects. A second potential factor is the difference in the mean age group in the reported studies. Mean age in the studies by Seaver *et al*. (1991), Bressman (2005) and Van Doorn and Purcell (1998) [7,12,19] were all significantly different from the mean age in this study (Table IV). The possible effect of such differences is unclear. Trindade *et al*. (1997) found that children, compared to adults, had significantly lower nasalance scores for non-nasal passages [23]. At the same time, other studies that have compared adults and children have found no significant differences in nasalance scores between the two groups [4,7], concluding that factors such as language or dialect more directly influence nasalance than does age [13]. A third potential effect relates to the nasometer used; the Nasometer 6450 was used in this study while the version used in all comparison studies was the Nasometer 6200. In a comparison of the Nasometer 6400 series and Nasometer 6200 series, Watterson *et al*. (2005) found that the former tends to yield slightly higher means than the latter [19]. This difference was statistically significant, but probably due mostly to within-participant performance inconsistency and variation in headgear placement [19]. While this machine variation might help explain some of the discrepancy in our findings related to the Zoo passage, we would have anticipated such an (elevating) effect for all three passages. Aside from the variations of mean nasalance scores in relation to language- and dialect-specific stimuli, gender may have an impact as well. Gender's effect has been attributed to physiological differences, among other methodological discrepancies [24-25]. Whether female speakers have significantly higher nasalance scores than male counterparts has been an issue of debate, with no clear consensus on whether such a difference exists or if it is significant [7,23,26]. Many authors have indicated that women have higher nasalance scores for language-specific stimulus material [7,26]. These differences were more pronounced on passages containing nasal consonants, as reported by Van Lierde *et al*. (2001) [26] and Seaver *et al*. (1991) [7]. Others have reported the opposite, indicating that men have higher mean nasalance scores than women [24,27]. Even when statistically significant differences in the mean nasalance scores were present between genders, these were in the range of only 2 scalar points and thus carry little clinical significance. Reflecting the equivocal literature, there was no considerable difference based on gender in our study. Scores were roughly equal between males and females for the Rainbow passage and the nasal sentences, and there was a slight but insignificant difference ($p = 0.3$) for the Zoo passage.

CONCLUSIONS

This study helps fill a gap in clinical knowledge by providing normative data for nasalance scores in a Lebanese English-speaking population. Our data can subsequently be employed to direct the use of then nasometer as a clinical assessment tool in this population. Compared to normative data from other English-speaking populations, the overall range of mean nasalance scores in this population was smaller, with significantly higher values for the Zoo passage and significantly lower values for the nasal sentences. This is most likely due to differences in vowels and oral and nasal consonants across different dialects. No significant difference in nasalance scores was found between males and females. Similar studies could be done in the future in order to corroborate our study findings in the Middle East population.

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This manuscript has no actual or potential conflict of interest.

Please note that Dr. Abdul Latif Hamdan had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

REFERENCES

1. Bradford LJ, Brooks AR, Shelton RL Jr. Clinical judgment of hyper-nasality in cleft palate children. Cleft Palate J 1964; 1: 329-35.
2. Fletcher SG. Theory and instrumentation for quantitative measurement of nasality. Cleft Palate J 1970; 7: 601-9.
3. Fletcher SG. "Nasalance" vs. listener judgements of nasality. Cleft Palate J 1976; 13: 31-44.
4. Fletcher SG, Adams LE, McCucheon MJ. Cleft palate speech assessment through oral-nasal acoustic measures. In: Bzoch KR, ed. Communicative Disorders Related to Cleft Lip and Palate. Boston: Little, Brown 1989: 246-57.
5. Kay Elemetrics. Nasometer II Model 6450 Instruction Manual. Lincoln Park, NJ: Kay Elemetrics, 1994.
6. Dalston RM, Warren DW, Dalston ET. A preliminary investigation concerning the use of nasometry in indentifying patients with hyponasality and/or nasal airway impairment. J Speech Hearing Res 1991a; 34: 11-18.
7. Seaver EJ, Dalston RM, Leeper HA, Adams LE. A study of nasometric values for normal nasal resonance. J Speech Hear Res 1991; 34: 715-21.
8. Nellis JL, Nieman GS, Lehman JA. Comparison of nasometer and listener judgments of nasality in the assessment of velopharyngeal functions after pharyngeal flap surgery. Cleft Palate Craniofac J 1992; 29: 157-63.
9. Dalston RM, Warren DW. Comparison of Tonar II, pressure flow, and listener judgments of hypernasality in the assessment of velopharyngeal function. Cleft Palate Craniofac J 1986; 23: 108-15.
10. Hardin MA, Van Demark DR, Morris HL, Payne MM. Corrrespondence between nasalance scores and listener judgments of hypernasality and hyponasality. Cleft

Palate Craniofac J 1992; 29: 346-51.
11. Mayo R, Floyd LA, Warren DW, Dalston RM, Mayo CM. Nasalance and nasal area values: cross-racial study. Cleft Palate Craniofac J 1996; 33: 143-9.
12. Van Doorn J, Purcell A. Nasalance levels in the speech of normal Australian children. Cleft Palate Craniofac J 1998; 35: 287-92.
13. Sweeney T, Sell D, O'Regan M. Nasalance scores for normal-speaking Irish children. Cleft Palate Craniofac J 2004; 41: 168-74.
14. Leeper HA, Rochet AP, Mackay IRA. Characteristics of nasalance in Canadian speakers of English and French. International Conference on Spoken Language Processing, Banff, Alberta, Canada, October 1992: 49-52. Abstract.
15. Anderson RT. Nasometric values for normal Spanish-speaking females: a preliminary report. Cleft Palate Craniofac J 1996; 33: 333-6.
16. Van der Heijden P, Hobbel HH, Van der Laan BF, Korsten-Meijer AG, Goorhuis-Brouwer SM. Nasometry normative data for young Dutch children. Int J Pediatr Otorhinolaryngol 2011; 75: 420-4.
17. Dalston RM, Neiman GS, Gonzalez-Landa G. Nasometric sensitivity and specificity: a cross-dialect and cross-culture study. Cleft Palate Craniofac J 1993; 30: 285-91.
18. Fletcher SG: Diagnosing Speech Disorders from Cleft Palate, New York: Grune and Stratton, 1978: 92-157.
19. Bressman T. Comparison of nasalance scores obtained with the Nasometer, the NasalView, and the OroNasal System. Cleft Palate Craniofac J 2005; 42: 423-33.
20. Watterson T, Lewis K, Brancamp T. Comparison of nasalance scores obtained with the Nasometer 6200 and the Nasometer II 6400. Cleft Palate Craniofac J 2005; 42: 574-9.
21. Dalston RM, Warren DW, Dalston ET. Use of nasometry as a diagnostic tool for identifying patients with velopharyngeal impairment. Cleft Palate Craniofac J 1991b; 28: 184-9.
22. Dalston RM, Warren DW, Dalston ET. The identification of nasal obstruction through clinical judgments of hyponasality and nasometric assessment of speech acoustics. Am J Orthod Dentofac Orthop 1991c; 34: 11-18.
23. Trindade IEK, Genero KF, Dalston RM. Nasalance scores of normal Brazilian Portuguese speakers. Braz J Dysmorphol Speech Hear Disord 1997; 1: 23-34.
24. Litzaw LL, Dalston RM. The effect of gender upon nasalance scores among normal adult speakers. J Commun Disord 1992; 25: 55-64.
25. Zajac D, Lutz R, Mayo R. Microphone sensitivity as a source of variation in nasalance scores. J Speech Hear Res 1996; 39: 1228-31.
26. Van Lierde KM, Wuyts FL, De Bodt M, Van Cauwenberge P. Nasometric values for normal nasal resonance in the speech of young Flemish adults. Cleft Palate Craniofac J 2001; 38: 112-18.
27. Kavanagh JL, Fee EJ, Kalinowski J, Doyle PC, Leeper HA. Nasometric values for three dialectal groups within the Atlantic Provinces of Canada. J Speech Lang Pathol Audiol 1994; 18: 7-13.