NORMATIVE NASALANCE SCORES IN THE PRODUCTION OF WORDS AND SYLLABLES FOR BRAZILIAN PORTUGUESE SPEAKERS

ABSTRACT

The objective of this study was to determine normative nasalance scores for non-cleft children, adolescents and adults, native speakers of Brazilian Portuguese, during the production of words and syllables, for cross-linguistic comparisons in populations with and without cleft palate. Nasalance was assessed in 62 individuals, aged 6-10 years (n=20), 11-17 years (n=20) and 18-35 years (n=22), using a nasometer II model 6450 (KayPENTAX), during production of one sequence of nine oral words (*pipa, bis, burro, tatu, pilha, cuca, gui, fila, luz)* and of sequences of isolated syllables (e.g. *pa, pa, pa, pa, pa, pa*) composed of plosive, fricative, liquid and nasal consonants with high and low vowels. In order to validate the new nasalance stimuli, nasalance scores for traditional oral and nasal stimuli (Trindade, Genaro, & Dalston, 1997) were also obtained. Differences were analyzed at a significance level of 0.01. Mean nasalance scores (±SD) during the production of the sequence of words were 18±5% (children), 18±7% (adolescents) and 21±5% (adults). Differences between age groups were not significant. During the production of syllables, adults had the highest mean nasalance scores (except for syllable /mi/); significant differences between age groups were observed only for /pa/, /sa/ and /la/. Nasalance scores were significantly higher in oral and nasal syllables with high vowels than with low vowels, and in nasal syllables than in oral syllables with high and low vowels. The nasalance scores obtained for the sentences were comparable to previously established norms. In conclusion, the nasalance scores defined for Brazilian Portuguese speakers, in different stimuli, may be adopted as normative values for local and cross-language comparisons in the identification of hypernasality related to conditions such as cleft palate, neurogenic disorders and syndromes.

Key Words: Cleft Palate. Hypernasality. Nasalance. Nasometry. Velopharyngeal Dysfunction.

INTRODUCTION

Hypernasality, related to velopharyngeal dysfunction (VPD), is a common resonance disorder in individuals with a cleft palate, even after surgical repair of the anatomical defect, and also among individuals with neurogenic disorders and syndromes (Goudy, Ingraham, & Canady, 2012). Perceptual assessment of speech is used to estimate hypernasality, the subjective perception of the nasal component in speech. In addition, nasometry has been used to measure nasalance, the ratio between the nasal acoustic energy and the total (nasal plus oral) acoustic energy generated during speech, expressed in percentage. Nasometry results suggest hypernasality when there is an increased nasalance in speech samples containing exclusively oral sounds. Studies have demonstrated that nasalance has good correlation with perceived nasality (Fletcher, 1976; Fletcher, Adams, & McCutcheon, 1989; Haapanen, 1991; Hardin, Van Demark, Morris, & Payne, 1992; Watterson, Lewis, & Deutsch, 1998). Nasalance may also be measured in speech samples containing nasal stimuli in order to estimate hyponasality such as that related to nasal obstruction frequently seen among individuals with cleft palate.

Nasalance norms for Brazilian Portuguese speakers without clefts have been established (Trindade, Genaro, & Dalston, 1997) and became the international reference for the language (Sweeney, Sell, & O'Regan, 2004). A score of 27% was considered as the upper limit of normality in the reading of sentences containing exclusively oral sounds, with scores above this limit suggesting hypernasality, and a score of 43%, as the lower limit in the reading of sentences containing nasal sounds, with scores under this limit suggesting hyponasality (Ribeiro, Oliveira, Trindade, & Trindade Junior, 1999).

Nasalance scores may vary according to language, as observed by several investigators (Abou-Elsaad, Quriba, Baz, & Elkassaby, 2012; Anderson, 1996; Brunnegård & van Doorn, 2009; Dalston, Neiman, & Gonzalez-Landa, 1993; El Kassabi et al., 2015;

Ibrahim, Reilly, & Kilpatrick, 2012; Ha & Cho, 2015; Karakoc, Akcam, Birkent, Arslan, & Gerek, 2013; Lee and Browne, 2013; Mayo, Floyd, Warren, Dalston, & Mayo, 1996; Okalidou, Karathanasi, & Grigoraki, 2011; Prathanee, Thanaviratananich, Pongjunyakul, & Rengpatanakij, 2003; Seaver, Dalston, Leeper, & Adams, 1991; Sweeney et al., 2004; Van der Heijden, Hobbel, Van der Laan, Korsten-Meijer, & Goorhuis-Brouwer, 2011; van Doorn & Purcell, 1998; van Doorn, Bergh, & Brunnegård, 2008; Van Lierde, Wuyts, De Bodt, & Van Cauwenberge, 2001; Watterson, Lewis, Murdock, & Cordero, 2013, and others).

Despite the significant number of studies done, the comparison between them has proved to be unfeasible due to the diversity of speech samples used. In this sense, the SCANDCLEFT trial represented a great advancement in standardizing comparable speech samples between different languages; in order to analyze the speech outcomes of the palate repair in children with a cleft, investigators from different European countries developed a method for cross-linguistic speech analysis, based on the analysis of consonants in speech units phonetically similar between languages, in audio and video recordings of standardized speech samples (Lohmander et al., 2009). This experience led to the development of the website CLISPI-Cleft Palate International Speech Issues (https://www.clispi.org), which provides training in utilization of the method for speakers of different languages. Training in Brazilian Portuguese is also available, using speech samples standardized by investigators of the present study (RPY, APF, IEKT), under supervision from the European team. More recently, the first nine words in a standard list, in different languages, has also been used as speech stimuli for nasometry evaluations in an ongoing investigation named *Timing of Primary Surgery for Cleft Palate* (TOPS), headed by Prof. William Shaw from the University of Manchester, UK (www.tops-trial.org.uk).

Thus, the present study had the primary goal of defining normative scores of nasalance using the standard words of the TOPS trial, and also isolated syllables, to be used as a new protocol for the Brazilian Portuguese language in cross-linguistic comparisons, in addition to the passages previously established by Trindade et al. (1997). The secondary objective was to analyze: 1) differences in nasalance between ages; 2) differences between syllables; and 3) differences between nasalance scores obtained in the present study and those of Trindade et al. (1997), as an approach to validate the method.

METHOD

The study was performed under the approval of the Institutional Review Board (protocol n. 10783412.8.0000.5441). A consent form was signed by the adult participants and by parents/caretakers of minors, who signed an assent form.

Participants

Nasometry data were acquired from 62 individuals of both genders, divided into three age ranges: 6-10 years (20 children), 11-17 years (20 adolescents) and 18-35 years (22 adults), who spoke Brazilian Portuguese as their first and only language, living since birth in a single city of the State of São Paulo, Southeast region of Brazil.

Upon invitation to the study, the participants or their caretakers responded to a questionnaire regarding their suitability for the study. Individuals with history or complaints of chronic nasal obstruction and of voice, speech or language disorders, who underwent or were currently receiving speech therapy, and those with obvious craniofacial anomalies, severe dentofacial deformities or using orthodontic appliances were not included in the study. Participants with speech disorders or delays not reported by them or by the caretakers, but identified during nasometry examination by the speech pathologist were excluded from the study.

Procedures

Nasometry

Nasalance was assessed using a Nasometer II, 6450-KayPENTAX Model, Montvale, NJ, USA. The system is composed of two microphones, positioned one on each side of a sound separation plate, which is positioned against the upper lip. The system is held in position by a headgear. The upper microphone captures the signals of the nasal component of speech, and the lower microphone captures the signals of the oral component, which are filtered, digitized and analyzed by a specific software. Nasalance is calculated by the numerical ratio between the amount of nasal acoustic energy and the sum of nasal and oral acoustic energies generated during speech, and is expressed as a percentage. In theory, it may range from 0%, meaning absence of sound through the nose, and 100%, meaning all the sound arising from the nose, respectively. The system was calibrated before each period of examination, following the manufacturer's instructions.

Speech samples

Nasalance assessment was performed during three contexts: 1. naming of nine one word-figures; 2. repetition of eight isolated syllables (composed of plosive, fricative, liquid and nasal sounds); and 3. reading of standardized sentences, as follows:

Words: pipa, bis, burro, tatu, pilha, cuca, gui, fila, luz (https://www.clispi.org)

The nine words were produced in a sequence, one after the other, in the same order presented above, at an approximate speed of one word every two seconds, and the recording time was set at 24 seconds (9 words per screen, 1 screen), in order to standardize production rate. The production of words was elicited using figures drawn on individual cards. Individuals who did not recognize or did not correctly name the figure were asked to repeat the word after verbal demonstration by the examiner.

Syllables: pa, pi, sa, si, ma, mi, la, li

Each syllable was repeated six times (e.g. pa, pa, pa, pa, pa, pa), at an approximate speed of one syllable per second, with the recording time set at 8 seconds in order to standardize production rate, so that each the series of syllables occupied a single screen. Overall, 48 syllables were produced (6 syllables per screen, 8 types of syllable, 8 screens).

Sentences (shown in Portuguese, followed by their literal translation in English)*:*

1. Nasal sentences with high pressure consonants (NASAL-BR): *Domingo tem neblina* (Sunday is foggy). *O passarinho comeu a minhoca* (The bird ate the worm). *Miriam lambeu o limão* (Miriam licked the lime). *O menino era bonzinho* (The boy was kind). *Flavinho chamou o João* (Flavinho called for João).

2. Oral sentences with high pressure consonants (ZOO-BR): *Papai caiu da escada* (Daddy fell from the stairs). *Fábio pegou o gelo* (Fabio caught the ice). *O palhaço chutou a bola* (The clown kicked the ball). *Tereza fez pastel* (Tereza made pasties). *A árvore dá frutos e flores* (The tree produces fruits and flowers).

3. Oral sentences with low pressure consonants (ZOO2-BR): *Louro ia olhar a lua* (Louro would look at the moon). *Laura lia ao luar* (Laura was reading under the moonlight). *A leoa é leal* (The lioness is loyal). *Lili era loira* (Lili was blond). *Lulu olha a arara* (Lulu look at the macaw).

In each category (NASAL-BR, ZOO-BR, ZOO2-BR), the sentences were read in one sequence, and the recording time was adjusted at 24 seconds (5 sentences per screen, 3 screens). Children who were unable to read, repeated each sentence after verbal demonstration by the examiner.

Only technically acceptable recordings were considered, produced without errors and within the acceptable intensity threshold of the instrument.

Data analysis

Mean nasalance scores and standard deviations were calculated for the sequence of words (one average score for the nine words), for the eight sequences of syllables composed of plosive, fricative, liquid and nasal consonants with high and low vowels (eight average scores obtained for the six repetitions of each syllable), and for each category of passage. Mean nasalance scores of the three age ranges were compared using ANOVA. When significance was detected, the Tukey test was applied for multiple comparisons with p adjusted to 0.003 by Bonferroni correction. The nasalance scores in the production of sentences, for each age range, were compared with the nasalance scores reported by Trindade et al. (1997) using the Student t test. All comparisons were performed at a statistical significance level of 1%.

RESULTS

Table 1 shows the mean nasalance scores, standard deviations and the minimum and maximum scores observed in children, adolescents and adults for the production of the sequence of the nine words. Table 2 shows the same variables for the eight syllable sequences, composed of plosive, fricative, nasal and liquid consonants. Comparison of mean nasalance scores between the age ranges revealed statistically significant difference only between oral syllables with the low vowel. The scores of the children and the adolescents were significantly lower than the adults for /pa/, /sa/ and /la/. In addition, the children scored lower than the adolescents for the syllable /la/.

Comparison between syllable scores showed statistically significant nasalance differences as follows: nasal syllables with high vowel > oral and nasal syllables with low vowel; nasal syllables with low vowel > oral syllables with low and high vowel; nasal syllables with high vowel > oral syllables with high vowel; oral syllables with high vowel > oral syllables with low and high vowel (Table 3).

Table 4 shows the mean nasalance scores, standard deviation and the minimum and maximum scores observed in children, adolescents and adults, for the production of nasal sentences with high pressure consonants (NASAL-BR), oral sentences with high pressure consonants (ZOO-BR) and oral sentences with low pressure consonants (ZOO2-BR). The upper limit of normality of 27%, defined by Ribeiro et al. (1999) for the ZOO-BR passage, was not exceeded by any of the participants. Statistical comparison with nasalance scores published by Trindade et al. (1997) revealed the results observed for children, adolescents and adults did not differ significantly between the studies ($p<0.01$).

DISCUSSION

The present study defined normative nasalance scores for Brazilian Portuguese speakers, provided by children, adolescents and adults of both genders. The importance of this approach lies in the need to establish normative data for diagnostic purposes in cases of nasality deviations, as well as for the results comparison of international studies. Considering the latter, this study included two speech samples which might be comparable to samples of other languages in future studies. The first was composed of a series of nine words, designed for the aforementioned TOPS trial (www.tops-trial.org.uk) and defined by a team of speech therapists and linguists to allow cross-linguistic evaluation of speech, based on the analysis of consonants in speech units that are phonetically similar between languages (Lohmander et al., 2009) and the second sample comprised the repetition of syllables. In addition, a third sample comprised three passages used by Trindade et al. (1997). Comparison of nasalance scores from the present study and those reported by Trindade et al (1997) showed similar values, indicating that present data are reliable and may be used as norms for the Brazilian

Portuguese language. It is important to note that all participants lived in a single city of the Southeast of Brazil; therefore, dialectical influences could have impacted on nasalance results. However, a recent study from Maturo et al. (2017), comparing nasalance scores of Brazilian Portuguese-speaking individuals from two different states, using the same nasal and oral sentences from Trindade et al. (1997), indicated a minimal difference, and only for the oral sentences.

As expected, data showed that nasalance of children is around 10% in the production of an oral syllable as /pa/, while in the production of the nasal syllable /ma/ it is much higher, around 58%. Similar differences were observed in adolescents and adults, validating the method as well. The study also revealed that nasalance is increased in syllables composed of nasal or oral consonants and the high vowel /i/, compared to samples composed of nasal or oral consonants with the low vowel /a/. This is understandable because high vowels are produced with the tongue positioned toward the roof of the oral cavity, which yields higher impedance for sound transmission, differently from low vowels, which are produced with the tongue positioned low in the oral cavity, resulting in a less nasalized sound. These findings corroborate those of other investigators (Abou-Elsaad et al., 2012; Ha & Cho, 2015; Lee & Browne, 2013; Lewis, Watterson, & Quint, 2000; Marino, Cardoso, Ramos, & Dutka, 2016; Oliveira et al., 2017). It should be noted that for many of the syllables, the standard deviations were higher than that of the 9-words or the passages, so that their suitability for cross-linguistic comparisons and clinical aplication may be questioned. However, considering that the syllables are produced more easily than the other stimuli, we would recommend using the repetition of syllables /pa/ and /ma/ as an alternative approach, in case of unsuccessfully production of the words or sentences. Ultimately, due to the high standard deviations observed for /li/, this syllable should be excluded from clinical investigation.

Changes in nasalance with age were also investigated in the present study. In general, statistically significant differences were observed with the increase in age for oral syllables with low vowel /pa/, /sa/, /la/), yet not for the other stimuli, even though a trend of smaller nasalance in children, intermediate in adolescents and greater in adults was observed. Similar results were obtained by Abou-Elsaad et al. (2012), who observed statistically significant differences between children, adolescents and adults for the syllables /pa/, /pi/, /sa/, /si/ and /ma/, with consistent increase in adults. These findings also agree with the reports of Hirschberg et al. (2006) and El-Kassabi et al. (2015), who investigated Hungarian and Arabian populations, respectively, and reported increased nasalance with age, which may be explained by changes in the size and shape of resonance structures in the vocal tract, caused by growth (Preston, Tobias, & Salem, 2004). Conversely, in the present study, no differences between ages were observed for the sentences, which are more representative of habitual speech. The same was observed by Karakoc et al. (2013), who also reported nasalance scores close to those observed in the present study (15% for oral and 49% for nasal sentences in children, and 13%, for oral and 50% for nasal sentences in adults).

To validate the present results, nasalance scores obtained in the sentences were compared with those obtained in an earlier study (Trindade et al., 1997), in which nasalance was also analyzed during the reading of NASAL-BR, ZOO-BR and ZOO2-BR passages. The authors reported mean values very close to those observed in the present sample, validating the normative scores presently established for the sentences and also, indirectly, for the syllables and words.

The present findings may also be compared to others reported for Brazilian speakers using similar methodology (Marino, Dutka, de Boer, Cardoso, Ramos, & Bressmann, 2015; Maturo, Pirola, Ricz, & Trawitzki, 2017). In the reading of NASAL-BR, ZOO-BR and ZOO2-BR passages, Marino et al. (2015) obtained mean scores which differed from the present scores less than 6% points, which corresponds to the minimum of day-to-day score variation (6-8%) according de Boer & Bressmann (2014). Even smaller differences were seen when comparing our nasalance scores in adults with those of Maturo et al. (2017) in the reading of NASAL-BR and ZOO-BR sentences, further reinforcing the present findings.

CONCLUSION

Normal nasalance scores for Brazilian Portuguese speakers were defined using speech samples of different characteristics and degrees of complexity, providing objective data for the diagnosis of hypernasality caused by VPD in individuals with cleft palate, neurogenic disorders and syndromes, and allowing cross-linguistic comparisons.

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REFERENCES

Abou-Elsaad, T., Quriba, A., Baz, H., & Elkassaby, R. (2012). Standardization of nasometry for normal Egyptian Arabic speakers. *Folia Phoniatrica et Logopaedica, 64*(6), 271-277.

Anderson, R. T. (1996). Nasometric values for normal Spanish-speaking females: a preliminar report. *Cleft Palate-Craniofacial Journal, 33*(4), 333-336.

Brunnegård, K., & van Doorn, J. (2009). Normative data on nasalance scores for Swedish as measured on the Nasometer: influence of dialect, gender, and age. *Clinical Linguistics & Phonetics*, *23*(1), 58-69.

Dalston, R. M., Neiman, G. S., & Gonzalez-Landa, G. (1993). Nasometric sensitivity and specificity: a cross-dialect and cross-culture study. Cleft Palate-Craniofacial Journal, *30*(3), 285-291.

de Boer, G., & Bressmann, T. (2014). Comparison of nasalance scores obtained with the nasometers 6200 and 6450. *Cleft Palate-Craniofacial Journal*, *51*(1), 90-97.

El-Kassabi, R. M., Hassan, S., Mesallam, T. A., Malki, K. H., Farahat, M., & Alfaris, A. (2015). Standardization of nasalance scores in normal Saudi speakers. *Logopedics Phoniatrics Vocology*, *40*(2), 77-85.

Fletcher, S.G., Adams, L.E., & McCutcheon, M.J. (1989). Cleft palate speech assessment through oral-nasal acoustic measures. In K.R. Bzoch (Ed.), *Communicative disorders related to cleft lip and palate*. (pp. 246-257). Boston: Little-Brown.

Fletcher, S. G. (1976). "Nasalance" vs. listner judgements of nasality. *Cleft Palate Journal, 13*, 31-44.

Goudy, S., Ingraham, C., & Canady, J. (2012). Noncleft velopharyngeal insufficiency: etiology and need for surgical treatment. *International Journal of Otorhinolaryngology, 2012:296073*, 3 pages.

Ha, S., & Cho, S. H. (2015). Nasalance scores for normal Korean-speaking adults and children: effects of age, vowel context, and stimulus length. *International Journal of Pediatric Otorhinolaryngology, 79*(8), 1235-1239.

Haapanen, M. L. (1991). A simple clinical method of evaluating perceived hypernasality. *Folia Phoniatrica et Logopaedica, 43*(3), 122-132.

Hardin, M. A., Van Demark, D. R., Morris, H. L., & Payne, M. M. (1992). Correspondence between nasalance scores and listener judgments of hypernasality and hyponasality. *Cleft Palate-Craniofacial Journal, 29*(4), 346-351.

Hirschberg, J., Bók, S., Juhász, M., Trenovszki, Z., Votisky, P., & Hirschberg, A. (2006). Adaptation of nasometry to Hungarian language and experiences with its clinical application. *International Journal of Pediatric Otorhinolaryngology, 70*(5), 785-798.

Ibrahim, H. M., Reilly, S., & Kilpatrick, N. (2012). Normative nasalance scores for the Malay language. *Cleft Palate-Craniofacial Journal, 49*(5), e61-63.

Karakoc, O., Akcam, T., Birkent, H., Arslan, H. H., & Gerek, M. (2013). Nasalance scores for normal-speaking Turkish population. *Journal of Craniofacial Surgery, 24*(2), 520-522.

Lee, A., & Browne, U. (2013). Nasalance scores for typical Irish English-speaking adults. *Logopedics Phoniatrics Vocology, 38*(4), 167-172.

Lewis, K. E., Watterson, T., & Quint, T. (2000). The effect of vowels on nasalance scores. *Cleft Palate-Craniofacial Journal, 37*(6), 584-589.

Lohmander, A., Willadsen, E., Persson, C., Henningsson, G., Bowden, M., & Hutters, B. (2009). Methodology for speech assessment in the Scandcleft project-an international randomized clinical trial on palatal surgery: experiences from a pilot study. *Cleft Palate-Craniofacial Journal, 46*(4), 347-362.

Marino, V. C., Cardoso, V. M., Ramos, R. G., & Dutka, J. e. C. (2016). Nasalance values for syllables produced by Brazilian Portuguese speakers. *Codas, 28*(3), 278-283.

Marino, V. C., Dutka, J. e. C., de Boer, G., Cardoso, V. M., Ramos, R. G., & Bressmann, T. (2015). Normative nasalance scores for Brazilian Portuguese using new speech stimuli. *Folia Phoniatrica et Logopaedica, 67*(5), 238-244.

Maturo, D. S., Pirola, M. N. C. P., Ricz, L. N. A., & Trawitzki, L. V. V. (2017). Nasalance of Brazilian Portuguese-speaking populations from two different states. *Codas, 29*(2), e20160041.

Mayo, R., Floyd, L. A., Warren, D. W., Dalston, R. M., & Mayo, C. M. (1996). Nasalance and nasal area values: cross-racial study. *Cleft Palate-Craniofacial Journal, 33*(2), 143-149.

Okalidou, A., Karathanasi, A., & Grigoraki, E. (2011). Nasalance norms in Greek adults. *Clinical Linguistics & Phonetics, 25*(8), 671-688.

Oliveira, D. N., Sampaio-Teixeira, A. C. M., Alvarenga, B. G., Fukushiro, A. P., Yamashita, R.P., & Trindade, I. E. K. (2017). Nasalance scores of Brazilian Portuguese speakers at 5 years of age. *Codas, 29*(3), e20160197.

Prathanee, B., Thanaviratananich, S., Pongjunyakul, A., & Rengpatanakij, K. (2003). Nasalance scores for speech in normal Thai children. *Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery, 37*(6), 351-355.

Preston, C.B., Tobias, P.V., & Salem, O.H. (2004). Skeletal age and growth of the nasopharynx in the sagittal plane: a cephalometric study. In: C.B. Preston (Ed.), *The Upper Airway in Orthodontics*. (pp. 16-38). Elsevier, vol. 10.

Ribeiro, A.C., Oliveira, A.C., Trindade, I.E.K., & Trindade Junior, A.S. (1999, December). Valores normativos de nasalância para identificação de desvios de nasalidade. [Normative values of nasalance for the identification of nasal deviations]. *Proceedings of the 3º Encontro Científico da Pós-Graduação do HRAC-USP (*pp. 32-33*)*, Bauru, Brasil: Hospital de Reabilitação de Anomalias Craniofaciais, Universidade de São Paulo.

Seaver, E. J., Dalston, R. M., Leeper, H. A., & Adams, L. E. (1991). A study of nasometric values for normal nasal resonance. *Journal of Speech Hearing Research, 34*(4), 715-721.

Sweeney, T., Sell, D., & O'Regan, M. (2004). Nasalance scores for normal-speaking Irish children. *Cleft Palate-Craniofacial Journal, 41*(2), 168-174.

Trindade, I.E.K, Genaro, K.F., & Dalston, R.M. (1997). Nasalance scores of normal Brazilian portuguese speakers. *The Brazilian Journal of Dysmorphology and Speech-Hearing Disorders,1*(1), 23-34.

Trindade, I.E.K., Yamashita, R.P., & Gonçalves, C.G.A.B. (2007). Diagnóstico instrumental da disfunção velofaríngea. In I.E.K. Trindade, & O.G. Silva Filho (Eds.), *Fissuras labiopalatinas: uma abordagem interdisciplinar* (pp. 123-143). São Paulo: Santos.

Van der Heijden, P., Hobbel, H. H., Van der Laan, B. F., Korsten-Meijer, A. G., & Goorhuis-Brouwer, S. M. (2011). Nasometry normative data for young Dutch children. *International Journal of Pediatric Otorhinolaryngology, 75*(3), 420-424.

van Doorn, J., Bergh, I., & Brunnegård, K. (2008). Optimizing stimulus length for clinical nasalance measures in Swedish. *Clinical Linguistics & Phonetics*, *22*(4-5), 355-361.

van Doorn, J., & Purcell, A. (1998). Nasalance levels in the speech of normal Australian children. *Cleft Palate-Craniofacial Journal*, *35*(4), 287-292.

Van Lierde, K. M., Wuyts, F. L., De Bodt, M., & Van Cauwenberge, P. (2001). Nasometric values for normal nasal resonance in the speech of young Flemish adults. *Cleft Palate-Craniofacial Journal*, *38*(2), 112-118.

Watterson, T., Lewis, K. E., & Deutsch, C. (1998). Nasalance and nasality in low pressure and high pressure speech. *Cleft Palate-Craniofacial Journal, 35*(4), 293-298.

Watterson, T., Lewis, K. E., Murdock, T., & Cordero, K. N. (2013). Reliability and validity of nasality ratings between a monolingual and bilingual listener for speech samples from English-Spanish-speaking children. *Folia Phoniatrica et Logopaedica*, *65*(2), 91-97.

Table 1 - Mean nasalance scores (%), standard deviations (SD), ranges, F and p-values of children, adolescents and adults for the sequence of the nine words (*pipa, bis, burro, tatu, pilha, cuca*, *gui*, *fila*, *luz*).

	Children (n=20)		**Adolescents (n=20)**		**Adults (n=22)**			
Stimuli	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**	**F**	**p-value**
Words	18 (5)	8 - 27	18 (7)	9 - 30	21 (5)	14 - 31	2.09	0.133

Tukey Test (p > 0.01).

Table 2 - Mean nasalance scores (%), standard deviations (SD), ranges, F and p-values of children, adolescents and adults for the syllable sequences.

Stimuli	Children (n=20)		Adolescents (n=20)		Adults (n=22)		F	p-value
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range		
pa, pa, pa, pa, pa, pa	10 (3)	5 - 19	13 (6)	6 - 24	22[b,c] (10)	6 - 38	16.80	<0.001
pi, pi, pi, pi, pi, pi	22 (10)	8 - 44	22 (8)	10 - 37	27 (7)	12 - 37	2.75	0.072
sa, sa, sa, sa, sa, sa	11 (4)	6 - 20	16 (9)	6 - 36	28[b,c] (12)	9 - 50	22.45	<0.001
si, si, si, si, si, si	23 (9)	10 - 41	26 (9)	13 - 44	29 (9)	12 - 53	2.43	0.096
ma, ma, ma, ma, ma, ma	58 (8)	42 - 70	58 (8)	42 - 76	60 (7)	48 - 71	0.37	0.689
mi, mi, mi, mi, mi, mi	76 (8)	60 - 88	75 (8)	53 - 87	75 (8)	60 - 87	0.21	0.809
la, la, la, la, la, la	12 (4)	7 - 22	20[a] (7)	9 - 33	27[b,c] (9)	7 - 45	25.64	<0.001
li, li, li, li, li, li	29 (16)	12 - 75	33 (11)	15 - 51	36 (11)	17 - 59	5.26	0.072#

Tukey Test (p < 0.01); a = statistically significant difference (adolescents x children); b = statistically significant difference (adults x children); c = statistically significant difference (adults x adolescents); # Kruskall-Wallis (p < 0.01).

Table 3 - Comparison between the syllable nasalance scores.

	/pa/	**/pi/**	**/sa/**	**/si/**	**/ma/**	**/mi/**	**/la/**	**/li/**
/pa/								
/pi/	S							
/sa/	NS	NS						
/si/	S	NS	S					
/ma/	S	S	S	S				
/mi/	S	S	S	S	S			
/la/	NS	NS	NS	S	s	s		
/li/	S	S	S	S	s	s	S	

Tukey Test ($p < 0.01$); S - statistically significant difference (vertical > horizontal data); s - statistically significant difference (vertical < horizontal data); NS - non-significant difference.

Table 4 - Comparison between mean nasalance scores and standard deviation (SD), expressed in percentage (%), ranges, t-values with degrees of freedom (df), and p-values in the production of nasal sentences with high pressure consonants (NASAL-BR), oral sentences with high pressure consonants (ZOO-BR) and oral sentences with low pressure consonants (ZOO2-BR) of the present study and the reported by Trindade et al. (1997).

Stimuli	**Mean (SD)**	**Range**	**Mean (SD)** Trindade et al. (1997)	t (df)	**p-value**
CHILDREN	(n=20)		(n=24)		
NASAL-BR	49 (4)	44-56	48 (7)	- 0.74 (42)	0.463
ZOO-BR	12 (4)	5-20	10 (6)	- 1.27 (42)	0.210
ZOO2-BR	13 (5)	6-22	12 (9)	- 0.52 (42)	0.607
ADOLESCENTS	(n=20)		(n=24)		
NASAL-BR	52 (5)	43-60	51 (6)	- 0.36 (42)	0.721
ZOO-BR	12 (4)	8-21	14 (8)	0.87 (42)	0.387
ZOO2-BR	14 (5)	8-30	16 (9)	0.75 (42)	0.460
ADULTS	(n=22)		(n=51)		
NASAL-BR	52 (4)	44-59	48 (7)	- 2.24 (71)	0.028
ZOO-BR	15 (4)	7-26	16 (8)	0.55 (71)	0.583
ZOO2-BR	17 (5)	8-24	19 (9)	0.99 (71)	0.327

t *Student* Test ($p < 0.01$); df = degree of freedom.