REVISTA CEFAC
SPEECH, LANGUAGE, HEARING SCIENCES AND EDUCATION JOURNAL
Rev. CEFAC. 2016 Mar-Abr; 18(2):449-458 doi: 10.1590/1982-0216201618222115

Original articles

Nasalance at presence and absence of pharyngeal fricative

Nasalância na presença e ausência da fricativa faríngea

Thais Alves Guerra[1]
Viviane Cristina de Castro Marino[2]
Diana Conceição da Rocha[1]
Mahyara Francini Jacob[3]
Maria Inês Pegoraro-Krook[4]
Jeniffer de Cássia Rillo Dutka[4]

[1] Faculdade de Odontologia de Bauru, USP, Bauru, SP, Brasil.
[2] Departamento de Fonoaudiologia da Faculdade de Filosofia e Ciências da Universidade Estadual Paulista (UNESP), Marília, Brasil.
[3] Hospital de Reabilitação de Anomalias Craniofaciais, USP, Bauru, SP, Brasil.
[4] Departamento de Fonoaudiologia da Faculdade de Odontologia de Bauru e Hospital de Reabilitação de Anomalias Craniofaciais, USP, Bauru, SP, Brasil.

Source: FAPESP

Conflict of interest: non-existent

ABSTRACT

Purpose: to compare nasalance scores between speech samples with and without pharyngeal fricative and with and without hypernasality.

Methods: a total of 840 speech samples was analyzed in this study. The samples were rated by three experienced judges with consensus regarding the aspects of hypernasality and pharyngeal fricative. The ratings were distributed into 4 groups: **G1**: 255 samples rated as representative of presence of hypernasality; **G2**: 130 samples rated as representative of use of pharyngeal fricative and hypernasality; **G3:** 280 samples rated as representative of normal speech for speakers with history of cleft palate; **G4**: 175 samples rated as representative of normal speech for speakers without history of cleft palate. Satistical analysis involved the Kruskal-Wallis test and when significant difference was found Dunn's test was used to compared pairs of data.

Results: the ratings established with agreement between the 3 experienced judges allowed for the identification of the samples representative of use of pharyngeal fricative and hypernasal speech. Nasalance scores were establish for each group revealing a significant difference between groups G1+G2 (representative of speech errors) and groups G3+G4 (representative of normal speech). The difference between the group with hypernasality (G1) and the group with pharyngeal fricative (G2) was not significant.

Conclusion: the use of pharyngeal fricative did not significantly influence nasalance values for the studied sample.

Keywords: Cleft Palate; Velopharyngeal Insufficiency; Speech; Reproducibility of Tests

RESUMO

Objetivo: comparar os valores de nasalância em amostras de fala com e sem o uso de fricativa faríngea e, também, com e sem hipernasalidade.

Métodos: um total de 840 amostras de fala foi analisado neste estudo. As amostras foram julgadas por três juízas experientes por consenso quanto aos aspectos hipernasalidade e fricativa faríngea. Os julgamentos foram distribuídos em quatro grupos: **G1:** 255 amostras de fala julgadas como representativas de hipernasalidade; **G2:** 130 amostras julgadas como representativas do uso de fricativa faríngea e hipernasalidade; **G3:** 280 amostras julgadas como representativas de fala normal em falantes com história de fissura labiopalatina; **G4:** 175 amostras julgadas como representativas de fala normal em falantes sem história de fissura labiopalatina. Para análise dos dados foi utilizando o teste Kruskal-Wallis e quando houve diferença estatisticamente significante foi aplicado o teste Dunn's para comparar os grupos aos pares.

Resultados: os julgamentos aferidos por consenso pelas três juízas permitiram a identificação de amostras representativas do uso de fricativa faríngea e da presença e ausência de hipernasalidade. Foram estabelecidos valores de nasalância (média e desvio padrão) para cada grupo e observou-se que houve diferença estatisticamente significante entre os grupos com alteração de fala (G1 e G2) e aqueles sem alteração (G3 e G4). A diferença entre o grupo com hipernasalidade (G1) e o grupo com FF (G2) não foi significante.

Conclusão: o uso de FF não influenciou significantemente os valores de nasalância para a amostra estudada.

Descritores: Fissura Palatina; Insuficiência Velofaringea; Fala; Reprodutibilidade dos Testes

Received on: December 23, 2015
Accepted on: February 27, 2016

Mailing address:
Jeniffer C. R. Dutka
Hospital de Reabilitação de Anomalias Craniofaciais–Universidade de São Paulo (HRAC-USP)
Rua Silvio Marchioni 3-20
Bauru, São Paulo, Brasil
CEP: 17043-900
E-mail: jdutka@usp.br

INTRODUCTION

Non-operated cleft lip and palate (CLP) and velopharyngeal dysfunction (VPD) after primary palatoplasty, can result in unwanted communication between the oral and nasal cavities causing speech disorders characterized by hypernasality, nasal air emission and weak intraoral pressure[1,2]. CLP and VPD may also lead some individuals to use atypical place of articulation known as compensatory articulations (CA), classified as pre-uvular and post-uvular[1] atypical production, by a group of authors. In the presence of post-uvular CA, manipulation of air pressure to generate plosion and frication needed for production of oral consonants occurs at pharyngeal or laryngeal areas of the vocal tract[3,4]. The pharyngeal fricative (PF) is one type of post-uvular CA produced when the base of the tongue approaches the posterior pharyngeal wall generating a fricative constriction[3]. PF can occur in the speech of individuals presenting CLP and VPD[4] and is often used to replace voiced and non-voiced fricatives[5]. When present, CA (including PF) may impair speech intelligibility, requiring speech therapy[4]. Identification of the presence and types of CA required an auditory-perceptual evaluation of speech[3,4].

The auditory-perceptual evaluation (APE) is considered the gold standard for the management of speech disorders related to CLP and VPD [1,2,6], however, taking into account APE's subjectivity, instrumental evaluation of speech can been employed to corroborate clinical findings, particularly nasalization of speech[5,7]. Among the instrumental methods available for assessment of speech and velopharyngeal function we find those that allow for visualization velopharyngeal structures and functioning such as nasoendoscopy and videofluoroscopy, and those that allow for assessment of speech features resulting from VPD such as pressure-flow techniques and nasometry [7].

Nasometry, more specifically, provides acoustic information about the speech signal which allows for an estimation the amount of speech nasality providing an index of the oral-nasal balance known as nasalance score. The nasalance score, therefore, is the physical correlate to the speech nasality perceived by listeners, and is calculated by the numerical ratio between the nasal energy divided by the sum of the oral plus the nasal acoustic energy during speech production[5,7]. Comparison of normative nasalance data with nasalance scores obtained for individuals with speech disorders such as hypernasality or hyponasality, for example, can corroborate perceptual fidings suggestive of VPD[5]. It is assumed that increased nasalance values, during production of oral speech stimuli, are suggestive of hypernasality, while decresed scores during production of nasal stimuli are suggestive of hyponasality[5]. The nasometric assessment, therefore, provides a quantitative measure of speech nasality which corroborates the perceptual assessment of nasality characteristics of speech, as broadly described in the literature [8,9].

The contribution of the nasometric assessment, to corroborate perceptual findings involving the use of atypical placeof articulation, however, has been discussed in a previous study [10]. Nasalance values were reported as varying according to gender, age, speaker´s language[7] and dialect[11], along with external variables, including, for example, the presence of audible turbulence during nasal air emission in the speech of an individual with CLP or VPD[12]. One of the limitations of nasometry consists of not making distinction between the type of acoustic energy captured, registering audible nasal air emission as vocal acoustic energy, leading to increased nasalance values. The acoustic energy associated with the production of speech sounds is modified according to the size and shape of supralaryngeal structures and according to the constriction points performed by the articulators during the production of different speech sounds. Speech nasality, in this sense, can be interpreted as an articulation phenomenon superimposed on the voice signal. Even though speech nasality is not registered without the existence of phonation, nasalization is theproduct of the articulation of the velopharynx which opens and closes for production of oral and nasal sounds[13]. Therefore, a very important relationship is assumed between nasality and nasalance.

Studies show reasonable agreement between nasalance values (obtained with the nasometer) and speech nasality (established with auditory-perceptual judgment)[8,9,14]. However, several factors can influence the relationship between nasality and nasalance, including the phonetic (target sounds) and linguistic (complexity of production) contexts of the speech stimuli[5] and the speaker's condition during sampling (for example, with or without the use of nasal decongestant, prior to nasometric evaluation[15] or pre or post-primary surgery[14]). The use of CA (such as pharyngeal fricative, for example) during speech production, has also become a factor to be studied, in order to verify its possible influences upon nasometry values [10,16].

Whereas nasalance value estimates the relative amount of nasal energy compared to the total acoustic energy (oral and nasal), vocalized in a given production, it is assumed that noise external to the glottal source, as the place where friction is generated may have an impact on nasalance values. An initial study[16] obtained nasalance values at the presence of glottal stop associated with moderate hypernasality, and the results suggested that the use of this type of CA did not influence the nasalance values. Another study[10] obtained nasalance scores during the use of post-uvular CAs, and compared the nasalance values between groups with and without hypernasality, and with and without CA. The results showed significant differences in nasalance values between the groups only with hypernasality and the group with hypernasality and pharyngeal fricative, particularly for stimuli with the sounds / f / and / s /. In reference to the findings, the authors[10] suggested that when evaluating patients using post-uvular CA, an increase in nasalance values could be expected, as compared to speakers presenting only with hypernasality. The presence of frication generated in the pharynx (such as the pharyngeal fricative CA) could justify the addition of acoustic energy to the speech signal which resonates throughout the vocal tract, and can be captured by the nasometer microphones. The authors[10], however, recommended caution when interpreting the data, since their study involved few speech samples with CA, and used only a single repetition of each stimuli. Further studies were recommendedby the authors[10].

This study aimed to replicate and expand Garcia`s findings[10], particularly regarding nasalance scores obtained during use of pharyngeal fricative. The hypothesis tested in this study is guided by the fact that fricative sounds produced with pharyngeal place of articulation (such as pharyngeal or laryngeal fricatives) can significantly raise nasalance scores in relation to productions deemed as hypernasal, without CA and also in relation to the typical productions (without CA and hypernasality). The objective of this study was to compare the nasalance values between samples with and without pharyngeal fricative, and with and without hypernasality.

METHODS

The research was conducted at the Experimental Phonetics Laboratory of the Craniofacial Anomalies Rehabilitation Hospital of the University of São Paulo (LAFO-HRAC-USP) and approved by the Human Research Ethics Committee at the research site (207 837).

Participants

This study comprised the analysis of 840 speech recordings and nasometric assessment of 24 females, from 15 to 53 years, whom agreed to participate. Nineteen participants were patients with operated cleft palate associated or not to cleft lip (operated), with or without VPD after primary palatoplasty. The remaining five participants did not present CLP history and / or VPD and had typical speech (control group). The included participants did not present syndromes or any other conditions which could affect their performance during the recording task. They did not present nasal snoring (audible nasal air / turbulence), dysphonia, nasal congestion (e.g. cold), nasal obstruction in both nostrils (identified by Glatzel mirror), or any other condition which could affect the speech signal recording.

Procedure

This study aimed to obtain representative speech samples, such as: 1) presence of hypernasality, 2) presence of CA (pharyngeal fricative "PF" type), and 3) absence of hypernasality and absence of CA. The stimuli used for sampling comprised a set of seven phrases consisting of obstruent consonants (six fricatives) and one constituted by the lateral approximant consonant (/l/) as described in Table 1. The phrases included in the study were constituted by the target sounds (for example, /f/) each with recurrence of a single target consonant at least three times in the same sentence (e.g. "Fafa foi a feira" - Fafa went to the fair). These phrases were selected to favor identification and characterization of the place and manner of target sound production, during the auditory-perceptual judgment of the recorded material. The phonetic composition of the speech stimulus was designed according to the literature recommendations[1]. It is noteworthy that a sentence containing the target lateral approximant (/l/) was included in the study in order to facilitate comparisons of nasalance values in case of speech samples are judged with presence of audible nasal air escape. The literature[12] recommends the use of low pressure sounds to evaluate and obtain nasalance values, in order to prevent noise derived from the audible nasal air escape from being captured by the nasometer. The set of seven phrases

Table 1. Speech stimuli used for obtaining recordings and nasometric evaluation

Brazilian Portuguese	Target*=n	Syllables **	Manner	Place	Pressure
Fafá foi a feira	f=4	6	Fricatives	Labiodental	High
Vovó viu a uva	v=4	6	Fricatives	Labiodental	High
Cecilia laçou o saci	s=5	8	Fricatives	Alveolar	High
A rosa lisa é azul	z=3	8	Fricatives	Alveolar	High
Xuxa achou o xale	ʃ=4	7	Fricatives	Postalveolar	High
Julia girou o gira-gira	ʒ=4	9	Fricatives	Postalveolar	High
Lalá olhou a lua	l=3	7	Lateral***	Alveolar	Low

* Number of targets with the potential to elicit PF
** Number of syllables in words (regardless of the target)
***Aproximante lateral

included in the study was repeated five times by each participant, totaling 35 repeated samples (7 phrases x 5 repetitions). Altogether, the 24 subjects produced 840 phrases (24 participants x 35 samples).

Audio recordings were captured simultaneously during nasometric evaluation.

Nasalance scores were obtained using Nasometer II (Kay PENTAX, NJ, USA). All nasalance measures and recordings took place in a quiet room. The nasometer ™ was calibrated prior to data collection, according to the manufacturer's instructions. The nasometer helmet which supports the sound separator was positioned between the nose and the upper lip of each participant, according to the manufacturer's instructions. The audio recordings were obtained using a microphone (AKG - C420) coupled in the nasometer plate. The examiner checked regularly the separator plate and the AKG microphone placement, in order to ensure proper positioning of the equipment throughout the evaluation.

Each participant was asked to read a set of seven phrases, five times repeatedly at her usual pitch. The evaluator controlled the reading of the set of sentences by the participants, so that a two second interval could be established, from one sentence to another. When the participant made a mistake while reading a sentence, she was requested to read all the phrases, and the revised version of this set of sentences was used for data analysis. The order of presentation of the sentences was the same for all participants. The nasalance value of each sentence read by each participant was calculated individually, using the nasometer software. The audio recordings obtained simultaneously to the nasometric evaluation were edited for later perceptual evaluation by multiple judges. For editing the samples, an *Intel Pentium 4 computer* (504 MB RAM) and the Forge 8.0 program were used.

This study aimed to identify two speech characteristics: nasality (presence or absence of hypernasality) and the use of the post-uvular articulation place of friction (presence or absence of pharyngeal fricative). Identification of the use of atypical articulation place is favored by selecting phrases with recurrence of target sound. However, judgment of speech nasality requires the use of longer samples[17]. Therefore, for judging these two speech aspects, two groups of samples were prepared differently, using the same recorded samples, as follows: 1°) for judging nasality and 2°) for judginh the use of CA.

For judging nasality, five phrases repetitions, produced sequentially by the 24 participants were not cut out, ie, a single material for each speaker was prepared, resulting in 24 continuous recording files (about 2 minutes) for the judgement of this variable of interest. As for judging the use of CA, the samples were cut out and archived again, this time in seven different folders, each one related to a given stimulus (target sound) of interest for the study. Whereas each of the seven folders contemplated five repetitions of the same speech stimulus, recorded for each of the 24 participants, a total of 120 speech samples (24 participants x 5 replicates) were obtained for each of the seven target studied sounds, totaling 840 samples (120 samples x 7 stimuli / target sounds) for judging this variable of interest.

Three speech-language pathologists (SLPs) from the original institution of the study judged the speech samples. These SLPs perform speech evaluations of individuals with speech disorders resulting from CLP and / or VPD, for at least three years. The speech samples were judged simultaneously by them, using individual headphones, which are connected to a sound splitter and the same computer in which the recordings were made. Consensual judgment of speech nasality were initially made by the three judges, from the 24 files (of 2min), provided for this purpose. Subsequently, consensual judgments were obtained by the same judges as to the use or not of PF, on each target consonant, on each of the seven phrases presented, which are representatives of the target sounds of interest.

The 840 samples were distributed into four groups, according to the auditory-perceptual judgments:

- 255 (32.3%) samples with presence of hypernasality, without PF (G1);
- 130 (13.5%) samples with PF (and hypernasality) (G2);
- 280 (33.3%) samples without hypernasality and PF, with CLP history (G3);
- 175 (20.8%) samples without hypernasality and PF without CLP history (G4).

Data analysis

Nasalance values (mean and standard deviation) were obtained from each group for each speech stimulus of interest. Kruskal-Wallis test followed by Dunn's test for multiple comparisons between pairs of groups (G1 X G2, G1 X G3, G1 X G4, G2 X G3, G2 X G4; G3 X G4) were performed, with significance established at $p<0.05$.

RESULTS

The study included the judgement of SLPs concerning the nasality and presence of PF, and the judgments obtained were compiled. For nasality, from the 24 subjects enrolled in the study, 11 (46%) were judged as hypernasality, while 13 (54%) were judged as balanced resonance. For PF (variable of interest of this study) this type of production was identified in 9 subjects. As shown in Table 2, presence of PF was not consistently observed in fricative sounds produced by the subjects.

Table 2. PF occurrence in the recorded phrases according to targets for the 5 repetitions of each sentence to 9 participants who produced PF

Phrases produced with PF		N. of phases with PF/ N. total of repetitions					
Subjects	Targets	f	v	s	z	ʃ	ʒ
1	s	0/5	0/5	**4/5**	0/5	0/5	0/5
2	s, z	0/5	0/5	**1/5**	**1/5**	0/5	0/5
3	s, ʃ	0/5	0/5	**5/5**	0/5	**1/5**	0/5
4	s, ʃ, ʒ	0/5	0/5	**5/5**	0/5	**4/5**	**5/5**
5	f, s, z, ʃ	**3/5**	0/5	**5/5**	**5/5**	**5/5**	0/5
6	s, z, ʃ, ʒ	0/5	0/5	**5/5**	**5/5**	**5/5**	**5/5**
7	s, z, ʃ, ʒ	0/5	0/5	**5/5**	**5/5**	**5/5**	**5/5**
8	f, v, s, z, ʃ	**5/5**	**3/5**	**5/5**	**3/5**	**5/5**	0/5
9	v, s, z, ʃ, ʒ	0/5	**5/5**	**5/5**	**5/5**	**5/5**	**5/5**
Total Possible	f, v, s, z, ʃ, ʒ	8/45	8/45	40/45	26/45	28/45	20/45

The average nasalance values (and standard deviation) obtained for each phrase of each group are shown in Table 3. Nasalance values were not presented to speech stimuli comprising target sound / l / in G2. Speech samples judged with presence of PF in sentences consisting of / l / were not identified in this group.

To compare the nasalance values among the four groups and for testing the hypothesis that presence of PF would have a significant impact on the scores the statistical test was employed. Significant statistical difference between the nasalance values in the seven studied phrases ($p < 0.0001$) was found. Multiple comparisons between groups in six pairs (G1 X G2, G1 X G3, G1 X G4, G2 X G3, G2 X G4, G3 X G4) were then performed. Statistically significant difference was found for all tested targets between G1 X G3; G1 X G4; X and G2 x G3 x G4. There was no statistically

Table 3. Nasalance average for 7 stimuli (fricative and liquid) according to the 4 groups

	Portuguese Estimulu	G1	G2	G3	G4
	Fricatives	**X̄ (±DP)**	**X̄ (±DP)**	**X̄ (±DP)**	**X̄ (±DP)**
/f/	**F**a**f**á **f**oi à **f**eira	41,0 (12,1)	47,1 (06,2)	11,9 (07,4)	09,4 (04,2)
/v/	**V**o**v**ó **v**iu a u**v**a	48,1 (12,3)	45,4 (04,3)	13,0 (08,4)	09,1 (03,4)
/s/	**Ce**cília la**ç**ou o **s**aci	52,1 (08,8)	52,6 (12,0)	16,0 (11,5)	01,4 (03,4)
/z/	A ro**s**a li**s**a é a**z**ul	46,2 (11,2)	50,8 (08,4)	16,6 (10,4)	13,0 (03,8)
/ʃ/	**X**u**x**a a**ch**ou o **x**ale	41,1 (11,2)	43,0 (10,4)	12,9 (09,2)	11,2 (04,0)
/ʒ/	**J**ulia **g**irou o **g**ira-**g**ira	50,2 (12,3)	45,6 (14,9)	17,9 (12,9)	13,2 (06,5)
	Todos os Fricativos	**45,9 (12,3)**	**48,2 (11,5)**	**14,7 (10,3)**	**11,2 (4,6)**
/l/	**L**a**l**á o**lh**ou a **l**ua	**43,2 (09,8)**	**NS**	**16,3 (09,5)**	**10,7 (05,6)**

NS= No samples; **G1**= hiper; **G2**= FF; **G3**= regular with cleft; **G4**= regular without cleft

significant difference in nasalance values for the stimuli investigated while comparing G3 X G4 and G1 X G2. Data obtained for group comparison are summarized in Table 4. Data obtained do not support the hypothesis that fricative sounds produced with pharyngeal articulation place (PF) can significantly raise nasalance values, as shown in the comparison between G1 x G2, Table 4.

Table 4. Comparison between group pairs

Stimuli	G1 x G2	G1 X G3	G1 X G4	G2 X G3	G2 X G4	G3 X G4
Fa**f**á **f**oi à **f**eira	41,0 x 47,1	41,0 x 11,9*	41,0 x 09,4*	47,1 x 11,9*	47,1 x 09,4*	11,9 x 09,4
Vo**v**ó **v**iu a u**v**a	48,1 x 45,4	48,1 x 13,0*	48,1 x 09,1*	45,4 x 13,0*	45,4 x 09,1*	13,0 x 09,1
Cecília la**ç**ou o **s**aci	52,1 x 52,6	52,1 x 16,0*	52,1 x 01,4*	52,6 x 16,0*	52,6 x 01,4*	16,0 x 01,4
A ro**s**a li**s**a é a**z**ul	46,2 x 50,8	46,2 x 16,6*	46,2 x 13,0*	50,8 x 16,6*	50,8 x 13,0*	16,6 x 13,0
Xu**x**a a**ch**ou o **x**ale	41,1 x 43,0	41,1 x 12,9*	41,1 x 11,2*	43,0 x 12,9*	43,0 x 11,2*	12,9 x 11,2
Julia **g**irou o **g**ira-**g**ira	50,2 x 45,6	50,2 x 17,9*	50,2 x 13,2*	45,6 x 17,9*	45,6 x 13,2*	17,9 x 13,2
La**l**á o**lh**ou a **l**ua	SA	43,2 x 16,3*	43,2 x 10,7*	NS	NS	16,3 x 10,7

NS= No sample; **G1**= hyper; **G2**= PF; **G3**= no hyper with cleft; **G4**= no hyper without cleft
Dunn´s p< 0,05*

DISCUSSION

Nasometry, during clinical practice, has an important role in corroborating auditory-perceptual findings, particularly with regard to speech nasality. Higher nasalance values than the normative values established for a particular language, suggest hypernasality[5]. The relationship between nasality judgement and nasalance values can be assessed establishing the sensitivity and specificity of nasometry, in order to identify a cut-off value that best distinguishes the range of normal scores from scores indicatives nasality disorders[18]. A previous study including Brazilian Portuguese speakers[19] indicated that nasalance values higher than 27% for oral stimuli, should be considered as an indicator of excessive nasal acoustic energy in speech (hypernasality). Values at or below 27%, for oral stimuli, were considered as an indicator of normal speech resonance [19]. It is recommended that cut-off values, are established for each specific speech stimuli. When interpreting the nasalance values obtained in this study using 27% as cut-off, it was observed the groups with speech disorders (G1 and G2) showed a mean nasalance value indicative of hypernasality, while the groups without speech disorders (G3 and G4), showed a mean nasalance value, indicative of normal nasality. These findings were expected and corroborate prior literature which reports higher nasalance values for subjects with speech disorders [14,19,20].

The degree of nasality, as well as nasalance values, can be affected by several factors, including the presence of nasal turbulence (nasal snort). One study, particularly, reported that the inability of the nasometer to distinguish between acoustic energy arising from the vocal source and acoustic energy arising from a noise source elsewhere in the vocal tract (such as in the velopharynx, for example, during marginal velopharyngeal closure), can be reflected in the nasogram. The nasogram, therefore, can provide a biofeedback of nasal snort and audible nasal emission which may be used during speech therapy[12]. In the present study, among the groups with hypernasal speech, mean nasalance values for sentences with fricative sounds were similar to the mean nasalance scores obtained for sentences with liquids sounds. This finding corroborates a previous study[10] and was expected since the presence of nasal snort and audible nasal air emission was controlled in order to avoid increased nasalance values due to noise external to the vocal source.

The nasalance value identifies the amount of nasal energy relative to the total acoustic energy (oral and nasal) in a specific production. Thus, it is assumed that noises external to the glottal source, such as frication generated at the pharynx for example may have an impact on nasalance values. Realizing that previous studies[10,16] contradicted each other, in reference to the impact of the use of the atypical place of production used during pharyngeal fricative, and anticipating a possible use of nasalance values to distinguish between samples with and without this type of CA, the present study aimed to identify if the use of PF compensatory articulation would have an impact upon nasalance values, increasing these values. The current findings, however, did not confirm its hypothesis since the difference between nasalance scores for the group with hypernasality (G1) and the group with PF (G2), was not significant, corroborating a prior study[16], which reported that presence of CA did not affect nasalance values.

Data obtained from the current study, however, did not agree with the findings of a recent study[10] which reported significant differences in nasalance between a group with hypernasality without PF (similar to G1 in this study) and a group with hypernasality with PF (similar to G2 in this study). One of the hypotheses raised by the authors[10] to justify higher values of nasalance only for certain speech stimuli, was based on a study[21] reporting that stimuli with less than six syllables may limit the reliability of nasalance values. Even though the number of syllables in each phrase in the current study was controlled, assuring at least six syllables, there was no significant difference between the groups with hypernasality (G1) and with PF (G2).

The procedures for listeners` ratings in this study, however, may have been a source of limitation. During ratings of nasality, the judges heard all recorded samples prior to making a judgment regarding presence or absence of hypernasality, while during ratings of PF the judges listened to each syllable to identify presence or absence of CA for each consonant target. Finally, the nasalance value was calculated for each phrase, and not for every syllable used for identification of PF, neither for all recorded samples, used to establish the nasality judgement. This dilemma is present during clinical practice, involving the perceptual evaluation of nasality and identification of CA. While, in one hand, it is very difficult to obtain a nasality judgment using short samples, on the other hand it is more complex to elicit, or even identify CA using long speech samples involving more than the target more consonant. A group of researchers[1] has already proposed universal parameters for documentation of speech of speakers with CLP and VPD, suggesting the use of different samples to evaluate nasality and articulatory production. While the sample of this study was based on prior literature[1], the different stimuli regarding complexity and phonetic context of the samples may have been a source of limitation in the current study.

As reported in a prior study[10] it was difficult to establish a speech sample representative of atypical articulatory productions such as PF for this study. That is, only a small number of recordings involving the use of CAs and only a single production of each speech sample were available. To control this variable partially and to increase the samples with PF in the current study, each subject produced each sample five times. However, from the 24 subjects included in the study, only nine (37.5%) presented with PF, and when considering all samples produced by the nine participants only 13% were judged with presence of PF. The occurrence of CA, as reported in the literature varies between 18% and 25% for the population with CLP or VPD, however the use of PF, even in this population, is not as common as the use of the glottal stop. Additionally, as reported in the literature[4], even when PF is used, not all fricative sounds may be substituted by this CA in a single sample. Considering the samples identified by the judges with PF in this study, 110 (84.6%) presented with substitutions by this CA in all target syllables, particularly for the consonants / ʃ / and / ʒ /. In this study, therefore, despite the limited number of samples with PF, when this CA was found it consistently affected all target consonants of each phrase.

In the present study the use of speech stimuli involving short phrases with recurrence of a single pressure consonant may have facilitated the identification of the atypical articulatory place of production, at the same time that it may have minimized the production of PF by the speaker due to the reduced complexity of the phonetic context of the sample. Studies like this present with a dilemma, at the same time that a chosen speech stimuli may facilitate listeners' task of identification of a target[1,] it may reduce the production of the target by the speaker. In the current study, while the use of a controlled phonetic context (short phrases with recurrence of the target) may have facilitated the identification of the CA it may have compromised its use by the speakers. As reported in prior literature[10], a speaker may use PF and other CA during a more complex context but will resume to the oral place of production when repeating words and phrases.

The methodological procedures for establishing consensus regarding ratings of presence or absence of PF in this study may have affected the results. While each rating was established individually initially with the use of individual headphones, it cannot be ruled out the possibility of one judge influencing the rating of another. That is, for the samples with disagreement regarding the presence or absence of PF, the judges listened to the recordings together and discussed the ratings as long as they needed until establishing consensus. Future studies involving only the use of speech samples with the agreement regarding the use of CA only during individual judgments, as performed in a previous study[10]. Limiting the inclusion of samples to those rated individually with 100% agreement regarding presence or absence of CA, however, may further reduce the available number of samples representative of the disorder of interest. The judgments, in the current study, were reliable, and misjudgments, if present, had the same incidence in both groups of samples, those with the presence of PF and those with absence of this CA. That is, the probability that the judges did not identify the PF when PF was present (false negative), was considered the same, as the probability the judges to identify the use of PF when the PF was absent (false positive).

Another aspect that cannot be rule out while interpreting the current findings, is the possibility of listeners missing the use of co-productions involving the use of PF simultaneously produced with oral place of articulation during ratings of the audio recordings. Video recordings (not available in this study) may favor the identification of some co-productions of this nature, since the visual context of place of articulation can be combined to the auditory-perceptual information[22]. Some productions which may not be observed, even when combining the auditory-perceptual to the visual-perceptual ratings, still may be captured by the equipment[23].

At the same time that results of the current study disagree with Garcia's et al.[10] regarding the impact of PF on nasalance values, the current findings agree with Ferreira's et al.[16] that the use of PF did not result in significantly higher nasalance values even though the use of PF adds new acoustic events to the speech signal. Furthermore, the information concerning the possible influence of PF in nasalance values would not bring significant contributions to VPD management, since the use of atypical place of articulation, particularly post-uvular CAs as PF, could trigger velopharyngeal hypodynamism. As reported in the literature, the velopharyngeal valve may not be elicited when CAs are produced, since the pressure required to generate friction (or plosion) is obtained before the sound (air) reaches the velopharynx[24]. Thus, the clinical use of nasometry to infer adequacy of velopharyngeal function for speech is not recommended while at presence of post-uvular place of articulation. The possible use of nasometry during speech therapy to provide clinicians with more information regarding increased nasality due to the use of PF (which may be detected by the Nasometer and not necessarily by the ear) has been one of the reasons to replicate Garcia's et al.[10] study. The current findings, however, do not support the clinical use of nasometry for this purpose. Future studies involving procedures that optimize the use of the CA are warranted in order to expand the samples with PF and may contribute to the understanding of the current findings and prior literature, expanding knowledge in the field of communication disorders.

CONCLUSION

The difference between nasalance values at presence of pharyngeal fricative CA and nasalance values obtained at presence of hypernasal speech without pharyngeal fricative was not statistically significant and did not prove the hypothesis postulated in this study stating that presence of pharyngeal fricative would increase nasalance values.

REFERENCES

1. Henningsson GE, Kuehn DP, Sell D, Sweeney T, Trost-Cardamone JE, Whitehill TL. Speech parameters group. universal parameters for reporting speech outcomes in individuals with cleft palate. Cleft Palate Craniofac J. 2008;45(1):2-17.
2. Kummer AW. Speech evaluation for patients with cleft palate. Clin Plast Surg. 2014;41(2):241-51.
3. Trost-Cardamone JE. Diagnosis of specific cleft palate speech error patterns for planning therapy or physical management needs. In: Bzoch KR (edit). Communicative disorders related to cleft lip and palate. 5. ed. Austin: Pro-Ed; 2004.p. 463-91.
4. Marino VCC, Dutka JCR, Pegoraro-Krook MI, Lima-Gregio AM. Articulação compensatória associada à fissura de palato ou disfunção velofaríngea: revisão de literatura. Rev CEFAC. 2012;14(3):528-43.
5. Kummer AW. Velopharyngeal dysfunction (VPD) and resonance disorders. In: Kummer AW. Cleft palate and craniofacial anomalies: the effects on speech and resonance. 2nd. ed. San Diego: Singular Thomson Learning; 2008. p. 45-76.
6. Brunnegård K, Lohmander A. A cross-sectional study of speech in 10 year- old children with cleft palate: results and issues of rater reliability. Cleft Palate Craniofac J. 2007;44(1):33-44.
7. Mayo CM, Mayo R. Normative nasalance values across languages. ECHO. 2011;6(1):22-32.
8. Sweeney T, Sell D. Relationship between perceptual ratings of nasality and nasometry in children/adolescents with cleft palate and/or velopharyngeal dysfunction. Int J Lang Commun Disord. 2008;43(3):265-82.
9. Brancamp TU, Lewis KE, Watterson T. The relationship between nasalance scores and nasality ratings obtained with equal appearing interval and direct magnitude estimation scaling methods. Cleft Palate Craniofac J. 2010;47(6):631-7.
10. Garcia AF, Marino VCC, Guerra TA, Lauris JRP, Dutka JCR. Nasalance during use of pharyngeal and glottal place of production. CoDAS. 2014;26(5):395-401.
11. Awan SN, Bressmann T, Poburka B, Roy N, Sharp H, Watts C. Dialectical effects on nasalance: a multicenter, cross-continental study. J Speech Lang Hear Res. 2015;58(1):69-77.
12. Karnell MP. Nasometric discrimination of hypernasality and turbulent nasal airflow. Cleft Palate-Craniofacial J. 1995;32(2):145-8.
13. Baken RJ. Clinical measurement of speech and voice. Boston: College-Hill Press; 1997.
14. Ferreira DBP. Nasalidade e nasalância após palatoplastia primária [dissertação]. Bauru (SP): Hospital de Reabilitação de Anomalias Craniofaciais, Universidade de São Paulo; 2011.
15. Pegoraro-Krook MI, Dutka-Souza JCR, Williams WN, Magalhães LCT, Rossetto PC, Riski JE. Effect of nasal decongestion on nasalance measures. Cleft Palate Craniofac J. 2006;43(3):289-94.
16. Ferreira DBP, Yamashita RP, Fukushiro AP. Influência do distúrbio articulatório compensatório sobre a nasalância da fala em indivíduos com insuficiência velofaríngea. 17º Congresso Brasileiro de Fonoaudiologia; 2009 out 21-24; Salvador, Brasil. Anais do 17º Congresso Brasileiro de Fonoaudiologia (Salvador): Sociedade Brasileira de Fonoaudiologia; 2009. p. 2628.
17. Kuehn DP, Moller KT. Speech and language issues in the cleft palate population: the state of the art. Cleft Palate Craniofac J. 2000;37:1-35.
18. De Boer G, Bressmann T. Application of linear discriminant analysis to the nasometric assessment of resonance disorders: apilot study. Cleft Palate Craniofac J. 2015;52(2):173-82.
19. Ribeiro AC, Oliveira AC, Trindade IEK. Valores normativos de nasalância para identificação de desvios de nasalidade. 3º Encontro Científico da Pós-Graduação do HRAC-USP; 1999 dez Bauru, Brasil. Anais do 3º Encontro Científico da Pós-Graduação do HRAC-USP: Hospital de Reabilitação de Anomalias Craniofaciais, Universidade de São Paulo; 1999. p. 32-3.
20. Gonçalves TF, Silva ASC, Yamashita RP, Fukushiro AP. Correlação entre nasalidade e nasalância da fala de indivíduos com fissura labiopalatina. 17º Congresso Brasileiro de Fonoaudiologia e 1ºCongresso Ibero-Americano de Fonoaudiologia; 2009 Salvador Brasil. 17º Congresso Brasileiro de Fonoaudiologia e 1ºCongresso Ibero-Americano de Fonoaudiologia; Salvador, 2009, 2828.
21. Lewis KR, Watterson T, Quint T. The effect of vowels on nasalance scores. Cleft Palate Craniofac J. 2000:37(6);584-9.
22. Howard SJ, Heselwood BC. Learning and teaching phonetic transcription for clinical purposes. Clin Linguist Phon. 2002;16(5):371-401.
23. Marino VCC, Berti LC, Lima-Gregio AM. Características acústicas da oclusiva glotal

associada à sequência de Pierre Robin: estudo de caso. Rev CEFAC. 2013;15(2):466-77.

24. Henningsson GE, Isberg AM. Velopharyngeal movement patterns in patients alternating between oral and glottal articulation: a clinical and cineradiographical study. Cleft palate J. 1986;23(1):1-9.