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Original Article

Artigo Original

Nasalance during use of pharyngeal and glottal place of production

Nasalância durante produção de fricativa faríngea e oclusiva glotal

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Keywords

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ABSTRACT

Purpose: This study obtained nasalance scores during use of compensatory articulation (CA) and compared nasalance between groups with and without hypernasality and with and without CA. **Methods:** Speech samples were obtained from 43 individuals with and without velopharyngeal dysfunction during repetition of 20 phrases originating 860 audio recordings and their respective nasometric values. After excluding 143 recordings due to low quality, the remaining 717 samples were rated by three speech language pathologists (SLPs), independently, for presence or absence of hypernasality and CA. Nasalance scores for the 553 samples rated with 100% agreement among the SLPs were grouped according to the auditory-perceptual ratings: Group 1 (G1) - included samples without hypernasality and without CA (n=191); Group2 (G2) - included samples with hypernasality and without CA (n=288); Group 3 (G3) - included samples with hypernasality and with pharyngeal fricative (n=33); Group 4 (G4) - included samples with hypernasality and with glottal stop (n=41). **Results:** Analysis of variance (ANOVA) revealed significant difference nasalance scores which were significantly higher for G2, G3, and G4 (p<0.0001) when compared to G1. The use of pharyngeal fricative (G3), particularly during /f/ (p=0.0018) and /s/ (p=0.0017) productions resulted in nasalance scores significantly higher than scores found for G2. **Conclusion:** Significantly higher nasalance values where identified during use of pharyngeal fricative.

Descritores

Fala
Fissura Palatina
Distúrbios da fala
Medida da Produção da Fala
Fonoaudiologia

RESUMO

Objetivo: Este estudo obteve medidas de nasalância durante a produção de articulação compensatória (AC) e comparou a nasalância entre grupos com e sem hipernasalidade e com e sem AC. **Métodos:** As amostras de fala foram obtidas a partir de 43 indivíduos com e sem disfunção velofaríngea durante a repetição de 20 frases, originando um total de 860 gravações e respectivos valores nasométricos. Foram excluídas 143 gravações devido à baixa qualidade e as 717 amostras restantes foram avaliadas por três fonoaudiólogas, de forma independente, quanto à presença ou ausência de hipernasalidade e AC. As 553 amostras julgadas com 100% de concordância entre as fonoaudiólogas foram agrupadas de acordo com o julgamento perceptivo-auditivo: Grupo 1 (G1) - amostras sem hipernasalidade e sem AC (n=191); Grupo 2 (G2) - amostras com hipernasalidade e sem AC (n=288); Grupo 3 (G3) - amostras com hipernasalidade e com fricativa faríngea (n=33); Grupo 4 (G4) - amostras com hipernasalidade e com oclusiva glotal (n=41). **Resultados:** Análise de variância (ANOVA) revelou medidas de nasalância significativamente maiores para G2, G3 e G4 (p<0,0001) quando comparados ao G1. O uso de fricativa faríngea (G3), particularmente durante /f/ (p=0,0018) e /s/ (p=0,0017) resultou em valores de nasalância significativamente maiores que os valores encontrados para G2. **Conclusão:** Valores de nasalância significativamente mais elevados foram encontrados durante produção de fricativa faríngea.

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INTRODUCTION

Cleft lip and palate (CLP) is one of the congenital anomalies with an impact in the structures and function of the velopharyngeal mechanism. Primary palatoplasty does not always warrant adequate velopharyngeal function for speech for individuals who present with the CLP, resulting in velopharyngeal dysfunction (VPD) and related speech disorders. Besides hypernasality, audible nasal air emission and weak oral pressure consonants, speakers with CLP or VPD may use atypical place of production, resulting in a group of consonant production errors (CPE) described in the literature as compensatory articulation[1,2]. A group of authors[1] classified CPE related to CLP and VPD as pre-uvular and post-uvular place of production errors. Among the post-uvular errors, pharyngeal fricatives (PF) and glottal stops (GS) have been described as the most common atypical productions associated to CLP and VPD[3]. The use of CA can compromise intelligibility of speech, having an impact in socio-educational development and vocational placement of the speaker. Individuals with history of CLP and VPD may also experience bullying, due to the speech disorders involving CPE and hypernasality.

Many cleft palate teams around the world follow parameters established for evaluation and treatment of CLP and other craniofacial anomalies as proposed by ACPA[4]. Instrumental assessment of velopharyngeal function is recommended for adequate management of VPD and may involve the use of nasometry to corroborate findings of speech nasality. While nasometric assessment provide a quantifiable measure of speech nasality and has been extensively studied and described in the literature[5-7], the recommendation for not conducting nasometric assessment during use of CA is based on clinical impressions.

During our clinical practice, we observe that the use of post-uvular place of production leads to impaired velopharyngeal movements during nasoendoscopic and videofluoroscopic assessments. Making decision regarding the management of VPD at the presence of CA is difficult and some cleft palate teams delay surgical procedures for correcting velopharyngeal insufficiency until after speech therapy is conducted to resolve CPE involving use of post-uvular CA. Since nasometry has clinical applications during evaluation and treatment of speech disorders related to VPD, we questioned the possibility of using nasalance scores to corroborate auditory-perceptual findings of acoustic events happening at atypical places in the vocal tract. As reported in the literature[8], the use of GS surrenders velopharyngeal function once the valving of airflow to generate air pressure for plosion is obtained before the flow reaches the level of the velopharyngeal mechanism. Nasometric scores have been shown to vary according to several aspects including language, age and gender of the speaker, as well as the phonetic context and the length of the speech stimuli[9-13]. One article[14] also reported that, besides nasal acoustic energy related to voiced resonance, nasometric assessment can also reflect acoustic events related to unvoiced aerodynamic turbulence occurring within the vocal tract.

This study assumes that, besides corroborating auditory-perceptual findings of voiced resonance related to speech nasality, nasometric assessment can also provide information related to other acoustic events occurring within the vocal tract. The hypothesis to be tested is whether the production of frication and plosion at a post uvular place of production may significantly increase or reduce nasalance scores. Finding whether the use of CA can affect nasalance scores, however, will not bring direct useful information for management of VPD, since it is known that the use of pharyngeal place of frication (such as in PF) or laryngeal place of plosion (such as in GS) may minimize (or completely surrender) velopharyngeal activity. Further information about the impact of CA on nasalance scores, however, may provide clinician with a tool for measuring outcome of behavioral management of CPE. This study compares nasalance scores between speakers with and without hypernasality and use of PF and GS.

METHODS

This study was approved by the Human Research Ethics Committee at the research site. Sampling was conducted during a period of three months in which a group of 43 patients, with operated CLP, accepted to participate in the study. To control for some factors that could affect listeners' ratings and nasalance scores recording from participants with dysphonia, nasal obstruction on both nares and nasal snort (turbulent audible nasal air emission) were not included in the study. Patients with syndromes or other conditions that could affect performance or compliance during speech recording were not recorded. A series of 20 phrases was used for audio and nasometric recordings (Table 1). The stimuli are currently used for speech recordings at the research site and the phonetic composition was designed according to the recommendations of Henningsson et al.[1]. To favor identification of CPE, 20 phrases (12 loaded with high pressure sounds, 8 loaded with low pressure sounds, each with recurrence of a single target consonant) were repeated once by the participants. Nasalance scores were obtained using Nasometer model 6400 (Kay PENTAX). An audio-recording was captured simultaneously during nasometric assessment using an AKG – C420 microphone attached to the Nasometer's separator plate.

A total of 860 audio and nasometric samples (Table 2) were recorded (43 participants *versus* 20 stimuli = 860 phrases). Using Sound Forge 8.0, the audio samples were edited into a material for listeners' ratings of speech production. During editing, 143 samples (17%) presented with external noise and were excluded due to low quality for auditory-perceptual ratings. The remaining 717 recordings were grouped according to the stimuli and presented to three experienced speech language pathologists (SLPs) for ratings of speech nasality and use of PF and GS. The SLPs worked daily in the assessment of speech disorders related to CLP for over five years. They were instructed to listen to each phrase, independently, as many times needed until they were able to indicate the presence or the absence of hypernasality and use of PF or GS. During identification of PF and GS, listeners had to indicate which targets in each stimulus were substituted or co-produced with the use of PF and GS. All ratings were compiled into a Microsoft Excel© table and only the samples rated with 100% agreement among

Table 1. Target sound and stimuli in Portuguese, approximate translation to English and phonetic transcription

Target	Brazilian Portuguese	Approximate Translation	Phonetic Transcription
/p/	O piu-piu piou	The chick chirps	[ʊ pii̯ʊ̯ˈpiʊ̯ piˈoʊ̯]
/b/	O bebê babou	The baby drooled	[ʊ beˈbe baˈboʊ̯]
/t/	O tatu é da Talita	Talita's armadillo	[ʊ taˈtu ɛ də taˈlitə]
/d/	O dedo da Duda doeu	Duda's finger hurt	[ʊ ˈdedʊ də ˈdudə duˈeʊ̯]
/k/	A Cuca correu e caiu	Cuca ran and fell	[ə ˈkukə koˈxeʊ ɪ kaˈiʊ̯]
/g/	O Gugu é gago	Gugu stutters	[ʊ guˈgu ɛ ˈgagʊ]
/f/	Fafá foi à feira	Fafa went to the market	[faˈfa foɪ̯ a ˈferə]
/v/	A vovó viu a uva	Grandma saw the grape	[ə voˈvɔ ˈviʊ əˈuvə]
/s/	Cecília laçou o Saci	Cecilia got the Saci	[seˈsilɪ̯ə laˈso ʊ saˈsi]
/z/	A rosa azul é da Zezé	Zeze's rose is blue	[ə ˈxɔzə aˈzu ɛ də zeˈzɛ]
/ʃ/	Xuxa achou o xale	Xuxa found the blouse	[ˈʃuʃə əˈʃo ʊ ˈʃalɪ]
/ʒ/	Júlia ralou o joelho	Julia hurt her knee	[ˈʒuλə xaˈlo ʊ ʒuˈeλʊ]
/l/	A leoa é leal	The Lion is loyal	[ə leˈoə ɛ leˈaʊ̯]
/l, λ/	Lalá olhou a lua	Lala saw the moon	[laˈla oˈλoʊ͜ə ˈluə]
/l, r/	Lili era loira	Lili was blond	[liˈli ɛɾə ˈloɪ̯ɾə]
/l, r/	Laura lia ao luar	Laura read at moonligth	[ˈlaʊ̯ɾə ˈliəʊ͜luˈar]
/l, λ, r/	Lulu olha a arara	Lulu saw the bird	[luˈlu ˈɔλə[1]ˈɾaɾə]
/l, r, λ/	A orelha da Laura	Laura's ear	[ə oˈɾeλə da ˈlaʊ̯ɾə]
/l. λ. r/	O louro ia olhar a lua	The bird saw the moon	[ʊ ˈloɾʊ ˈiə oˈλa[1] ˈluə]
/R/	Rui é o rei	Rui is the king	[ˈxuɪ ɛ ʊˈxeɪ̯]

the three SLPs were kept. A total of 164 (23%) samples were rated with less than 100% agreement among the listeners and were excluded.

The remaining 553 samples were distributed into four groups according to the auditory-perceptual ratings: G1 included samples without hypernasality and without CA; G2 included samples with hypernasality and without CA; G3 included samples with hypernasality and with pharyngeal fricative; and G4 included samples with hypernasality and with glottal stop. Nasalance scores for the 553 samples were calculated. Mean nasalance scores and standard deviations were identified for each group in each of the 20 stimuli. Analysis of variance (ANOVA) was used to compare means between the groups, followed by Tukey's test with significance established at $p<0.05$.

RESULTS

This study initially established a data bank of speech recordings representative of presence and absence of hypernasality, PF and GS. To assure representativeness of the samples, all audio recordings with adequate quality for auditory-perceptual ratings were presented to three listeners who rated the samples independently. Only the samples with 100% agreement between the raters (consensus) were grouped for comparison of nasalance findings. PF or GS were identified with consensus by the SLPs when all targets within the stimuli were produced with the CA and when co-productions were not used. Review and discussion of ratings with less than 100% agreement during independent ratings were not pursued in this study. In the group of samples excluded due to lack of consensus between the raters, 27% involved phrases produced with fricative targets, 24% plosive targets and 18% liquid targets.

After the auditory-perceptual ratings, 191 (35%) samples were identified as representative of absence of hypernasality and absence of CA (G1), 288 (52%) as representative of presence of hypernasality and absence of CA (G2), 33 (6%) as representative of presence of hypernasality and use of PF (G3), and 41 (7%) as representative of presence of hypernasality and use of GS (G4). As indicated in Table 2, 182 samples targeting plosive sounds were rated with consensus: 62 (34%) in G1, 94 (52%) in G2, and 26 (14%) in G4. No samples using pharyngeal fricatives (G3) were identified during repetitions of stimuli loaded with plosive sounds. A total of 165 samples targeting fricative sounds were rated with consensus: 63 samples (38%) in G1, 54 (33%) in G2, 33 (20%) in G3, and 15 (9%) in G4. A total of 206 samples targeting liquid sounds were rated with consensus: 66 (32%) in G1 and 140 (68%) in G2. No samples using pharyngeal fricatives (G3) or glottal stops (G4) were identified for the stimuli loaded with liquid sounds. Table 2 also indicates that 288 samples (52%) were rated with presence of hypernasality and absence of CA, while 74 (13%) samples were rated as representative of hypernasal speech and

Table 2. Summary of targets, recorded samples, number of samples not included due to low quality (No Quality), number of samples included and rated by listeners (Included), number of samples excluded due to lack of consensus by listeners (Excluded), sample used in this study (Samples), and number of recordings in each group (G1, G2, G3, G4)

Target	Recorded	No Quality	Included	Excluded	Samples	G1	G2	G3	G4
	n	n	n	n	n	n	n	n	n
/p/	43	3	40	8	32	12	14	0	6
/b/	43	2	41	4	37	12	24	0	1
/t/	43	4	39	11	28	11	14	0	3
/d/	43	3	40	9	31	9	17	0	5
/k/	43	3	40	14	26	10	9	0	7
/g/	43	5	38	10	28	8	16	0	4
Subtotal plosives					182	62	94	0	26
/f/	43	12	31	8	23	7	10	4	2
/v/	43	3	40	10	30	12	13	2	3
/s/	43	5	38	9	29	12	5	9	3
/z/	43	0	43	12	31	11	9	8	3
/ʃ/	43	4	39	12	27	10	8	6	3
/ʒ/	43	7	36	11	25	11	9	4	1
Subtotal fricatives					165	63	54	33	15
/l/	43	7	36	7	29	9	20	0	0
/l, λ/	43	6	37	8	29	11	18	0	0
/l, r/	43	15	28	3	25	8	17	0	0
/l, r/	43	12	31	4	27	10	17	0	0
/l, λ, r/	43	16	27	5	22	7	15	0	0
/l, r, λ/	43	13	30	8	22	6	16	0	0
/l. λ. r/	43	16	27	2	25	9	16	0	0
/R/	43	7	36	9	27	6	21	0	0
Subtotal liquids					206	66	140	0	0
Total	860	143	717	164	553	191	288	33	41

use of CA, 33 (6%) pharyngeal fricative and 41 (7%) glottal stops. That is, for all samples rated as representative of PF or GS, listeners also identified hypernasality. Furthermore, glottal stops were observed during production of stimuli loaded with plosive and fricative targets while pharyngeal fricatives were observed only during production of fricative targets.

Table 3 presents mean nasalance and standard deviations for all samples grouped according to nasality and CA findings (G1, G2, G3, and G4). During production of stimuli with plosive targets, an overall mean nasalance of 9.4% (±1.1) was found for G1, 44.4% (±2.5) for G2, and 56.2% (±4.9) for G4. No samples were identified with pharyngeal fricative (G3) during productions targeting plosive stimuli. During production of fricative targets an overall mean nasalance of 9.3% (±2.1) was found for G1, 35.9% (±3.9) for G2, 52.3% (±3.8) for G3, and 49.7% (±5.5) for G4. For liquid targets, an overall mean nasalance of 12.3% (±4.0) was found for G1 and 43.1% (±4.3) for G2. No samples were identified with pharyngeal fricatives (G3) or glottal stops (G4) for stimuli using liquid targets. ANOVA revealed a significant difference in mean nasalance between the four groups ($p<0.005$). Table 4 presents the difference between nasalance means for G1 when compared to G2, G3 and G4, respectively. Means for samples in G1 were significantly lower than means for samples in G2, G3, and G4.

Table 5 presents the difference between nasalance means for G2 and G3. Scores identified for /f/ and /s/ targets where significantly higher for G3 (productions with pharyngeal fricatives and hypernasality) when compared to /f/ and /s/ targets in G2 (productions only with hypernasality). For some stimuli, the sample size was too small for inferential statistics (No size).

DISCUSSION

Identifying speech samples representative of use of PF and GS was the first task addressed in this study. Representativeness of a sample was established with consensus auditory-perceptual ratings obtained with three SLPs. With the objective of testing the hypothesis that the use of PF or GS would have a significant impact in nasalance scores, only samples for which the judges agreed 100% regarding presence or absence of hypernasality, PF and GS were maintained in the study. Obtaining similar sample size for the four groups of interest, however, was not possible and only 13% of the samples in the overall data bank were rated as representative of use of PF (6%) and use of GS (7%). These findings, however, cannot be interpreted as

Table 3. Mean nasalance scores and standard deviations for all groups and all stimuli

Target	G1 (Mean±SD)	G2 (Mean±SD)	G3 (Mean±SD)	G4 (Mean±SD)
/p/	8.8±7.0	41.9±15.1	No samples	58.0±8.1
/b/	9.7±8.4	47.3±13.6	No samples	58.0*
/t/	9.3±4.2	45.215.6	No samples	61.3±9.5
/d/	10.1±10.9	47.4±15.6	No samples	59.2±12.2
/k/	7.8±3.6	43.7±14.6	No samples	47.614.4
/g/	11.3±9.6	41.5±14.4	No samples	53.3±11.2
All plosives	9.4±1.1	44.4±2.5	No samples	56.2±4.9
/f/	6.7±4.1	30.3±10.1	54.3±8.0	48.0±4.2
/v/	8.8±4.7	35.9±13.4	55.5±6.4	43.3±16.3
/s/	12.2±6.7	33.6±3.8	56.2±11.7	52.3±9.2
/z/	9.5±5.4	34.8±11.9	47.4±12.9	50.0 ±9.8
/ʃ/	7.6±3.7	41.0±16.9	48.0±15.0	45.7±17.2
/ʒ/	11.3±7.6	39.9±13.1	52.5±3.7	59.0*
All fricatives	9.3±2.1	35.9±3.9	52.3±3.8	49.7±5.5
/l/	14.6±10.7	38.3±12.3	No samples	No samples
/l. λ/	11.2±8.6	42.5±12.7	No samples	No samples
/l. r/	20.3±16.7	52.9±12.1	No samples	No samples
/l. r/	11.9±7.9	42.4±11.8	No samples	No samples
/l. λ. r/	10.9±4.7	41.9±13.3	No samples	No samples
/l. r. λ/	8.7±5.5	40.3±9.9	No samples	No samples
/l. λ. r/	14.3±13.3	43.3±13.7	No samples	No samples
/R/	7.2±6.9	43.8±13.2	No samples	No samples
All liquids	12.3±4.0	43.1±4.3	No samples	No samples
All targets	10.61±3.1	41.40±5.0	52.32±3.5	52.98±5.8

*Standard deviation was not calculated because this group had a single participant

Caption: SD = standard deviation

Table 4. Difference in nasalance scores between the group without hypernasality (G1) and the three groups with hypernasality (G2, G3, G4) with p-value indicative of significance when <0.05

Target	% Difference: G2-G1	% Difference: G3-G1	% Difference: G4-G1
	G2-G1=Diff; p-value	G3-G1=Diff; p-value	G4-G1=Diff; p-value
/p/	41.9-8.8=33.1; p=0.0001	No samples	58.0-8.8=49.2; p=0.0001
/b/	47.3-9.7=37.6; p=0.0001	No samples	58.0-9.7=48.3; No Size*
/t/	45.2-9.3=35.9; p=0.0001	No samples	61.3-9.3=52.0; p=0.0001
/d/	47.4-10.1=37.3; p=0.0001	No samples	59.2-10.1=49.1; p=0.0001
/k/	43.7-7.8=35.9; p=0.0001	No samples	47.6-7.8=39.8; p=0.0001
/g/	41.5-11.3=30.2; p=0.0003	No samples	53.3-11.3=42.0; p=0.0003
/f/	30.3-6.7=23.6; p=0.0002	54.3-6.7=47.6; p=0.0001	48.0-6.7=41.3; No Size*
/v/	35.9-8.8=27.1; p=0.0001	55.5-8.8=46.7; No Size*	43.3-8.8=34.5; p=0.0018
/s/	33.6-12.2=21.4; p=0.0029	56.2-12.2=44.0; p=0.0002	52.3-8.8=40.1; p=0.0002
/z/	34.8-9.5=25.3; p=0.0002	47.4-9.5=37.9; p=0.0004	50.0-9.5=40.5; p=0.0002
/ʃ/	41.0-7.6=33.4; p=0.0003	48.0-7.6=40.4; p=0.0076	45.7-7.6=38.1; p=0.0002
/3/	39.9-11.3=28.9; p=0.0001	52.5-11.3=41.2; p=0.0002	59.0-11.3=47.7; No Size*
/l/	38.3-14.6=23.7; p=0.0004	No samples	No samples
/l. λ/	42.5-11.2=31.3; p=0.0001	No samples	No samples
/l. r/	52.9-20.3=32.6; p=0.0002	No samples	No samples
/l. r/	42.4-11.9=30.5; p=0.0001	No samples	No samples
/l. λ. r/	41.9-10.9=31.0; p=0.0002	No samples	No samples
/l. r. λ/	40.3-8.7=31.6; p=0.0002	No samples	No samples
/l. λ. r/	43.3-14.3=29.0; p=0.0003	No samples	No samples
/R/	43.8-7.2=36.6; p=0.0002	No samples	No samples

*Sample size in this group was too small and inferential statistics were not computed

Caption: Diff = Difference; No samples = no recordings available

Table 5. Difference in nasalance scores between the groups with hypernasality and with CA with p-value indicative of significance when <0.05

Target	% Difference: G3-G2	% Difference: G4-G2	% Difference: G4-G3
/p/	No samples	58,0-41,9=16,1; p=0.0533	No samples
/b/	No samples	58,0-47,3=10,7; No size*	No samples
/t/	No samples	61,3-45,2=16,1; p=0.1035	No samples
/d/	No samples	59,2-47,4=11,8; p=0.3861	No samples
/k/	No samples	47,6-43,7=3,9; p=0.8033	No samples
/g/	No samples	53,3-41,5=11,8; p=0.3972	No samples
/f/	54,3-30,3=24,0; p=0.0018**	48,0-30,3=17,7; No size*	48.0-54.3=6.3; No size*
/v/	55,5-35,9=19.6; No size*	43,3-35,9=7,4; p=0.6817	43.3-55.5=12.2; No size*
/s/	56,2-33,6=22,6; p=0.0017**	52,3-33,6=18,7; p=0.0571	52.3-56.2=4.2; p=0.9435
/z/	47,4-34,8=12,6; p=0.0872	50,0-34,8=15,2; p=0.2815	50.0-47.4=2.6; p=0.9889
/ʃ/	48,0-41,0=7,0; p=0.7845	45,7-41,0=4,7; p=0.9704	45.7-48.0=2.3; p=0.9961
/ʒ/	52,5-39,9=12,6; p=0.1844	59,0-39,9=19,1; No size*	59.0-52.2=6.5; No size*

*Sample size in this group was too small and inferential statistics were not computed; **significant

Caption: No samples = no recordings available

indicative of frequency of use of PF and GS in the population with CLP since participants' selection was biased to identification of samples representative of the four groups of interest in the study.

Authors point to the importance of conducting a careful sampling once the goal is to obtain listeners' perceptual ratings of the recordings[1,15,16]. From the initial pool of 860 recordings, 17% were lost due to poor recording quality, indicating the importance of listening the recordings during or immediately after the data collection. While clinical demands may require a quick process of sampling, special care with the recording procedures as well as with the length and phonetic context of the stimuli are needed to document speech outcome accurately. Sell[16] and Henningsson et al.[1] suggested the importance of using speech stimuli involving recurrence of a single consonant target to identify the use of CPE related to CLP. Balancing the phonetic context of the speech stimuli to maximize identification of both, hypernasality and CPE, however, is a complex task. While ratings of speech nasality may be facilitated with the use of longer stimuli (such as short passages instead of short phrases), the use of shorter stimuli (short phrases, words, syllable repetitions) with recurrence of a single target may favor the identification of CPE and may be applied at an earlier age.

For multiple listeners' ratings, care must be taken with listeners experience and preparation. The judges in this study had extensive experience in evaluating speech disorder related to CLP and have a history of over five year of daily work with management of CLP and VPD in a large craniofacial team. Extensive training was not provided but samples representative of presence and absence of hypernasality, PF and GS were played to the SLPs prior to the task and could be used by the listeners as reference if needed. For this study, all ratings were done independently and after all listeners finished the ratings, only samples for which the listeners agreed 100% (consensus) regarding the presence or the absence of the variables of interest were maintained in the study. The findings of this study support prior literature that indicates that PF is commonly observed for fricative targets while GS were used for both, plosive and fricative targets[3]. PF and GS were not used for liquid targets, as commonly observed[17].

While it is recommended that cut-off values should be stimuli specific, findings for G1 support prior studies which suggest that a cut-off value of 27% or lower can be used for clinical interpretation of nasalance scores obtained for Brazilian Portuguese language[18,19]. Within the groups with hypernasal speech, mean nasalance for stimuli with high pressure sounds (plosive and fricative) were similar to mean nasalance obtained for stimuli targeting low pressure sounds (liquids). This was an expected finding since the presence of audible turbulent nasal air emission was controlled to avoid increase in the scores due to nasal snort[14,20].

Looking into the hypothesis tested in this study, we observed a significant difference in nasalance score between the group with hypernasality and the group with hypernasality and use of PF, for the stimuli targeting /f/ and /s/ sounds. The current finding, therefore, does not support Ferreira et al.[21], who suggested that the use of CA has no impact in nasalance scores. Still this finding must be interpreted with care. The sample sizes for the stimuli were limited once ratings were distributed across the four groups, as indicated in Table 2. This study suggests that, while evaluating a patient that uses backing of fricative targets into post-uvular place of production, one can expect even higher nasalance measures than observed for speakers who are hypernasal but use no PF. Because only samples with PF showed significantly higher nasalance values when compared to samples with hypernasality and use of GS, the presence of frication generated at the pharynx appears to add acoustic features to the speech signal that resonates into the upper vocal tract and can be pick-up by the microphones of the Nasometer. These findings point towards a trend for higher nasalance scores when frication is produced at the pharynx; however, interpretation is limited due to small sample sizes, single repetition of each stimuli, unbalanced vowel distribution and unbalanced number of syllables among the stimuli. Further studies involving larger and better-controlled speech samples are needed for a better understanding of this finding.

Nasometric evaluation involving speech produced during use of CA is not recommended to corroborate speech nasality and velopharyngeal function findings. But when we consider that not all articulatory gestures used by speakers with VPD and history of CLP are captured by human ears[22,23], higher nasalance findings during use of PF may suggest presence of pharyngeal articulatory gestures and may help corroborating clinical identification of PF. Finally, considering that use of biofeedback of the speech signal with nasometry is a behavioral therapeutic strategy useful with speakers when addressing nasal snort, one can also explore the use of nasometric feedback when addressing CPE involving PF.

CONCLUSION

This study established nasalance scores for speech samples with and without hypernasality and with and without use of pharyngeal fricative and glottal stop. In general, the nasalance values for the samples with hypernasality were higher than the scores for samples without hypernasality. More specifically, however, when pharyngeal fricatives were used in substitution of oral targets /f/ and /s/, the scores where significantly higher than those obtained for speech with hypernasality but without the use of CA.

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