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Hypernasality in singing among children with cleft palate: a preliminary study

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S. Peter, Z.A. Abdul Rahman, S. Pillai: Hypernasality in singing among children with cleft palate: a preliminary study. Int. J. Oral Maxillofac. Surg. 2019; 48: 1317–1322.

Abstract. The aim of this study was to document differences in hypernasality during speaking and singing among children with cleft palate and to compare nasality score ratings of trained and untrained listeners. Twenty subjects with cleft palate aged between 7 and 12 years participated in this study. Audio recordings were made of the children reading a passage and singing a common local song, both in the Malay language. The degree of hypernasality was judged through perceptual assessment. Three trained listeners (a speech therapist, a classical singer, and a linguistic expert – all academicians) and two untrained listeners (a cleft volunteer worker and a national high school teacher) assessed the recordings using a visual analogue scale (VAS). Inter-rater and intra-rater reliability for hypernasality in both speaking and singing were verified using the intra-class correlation coefficient (ICC). A significant reduction in hypernasality was observed during singing as compared to speaking, indicating that hypernasality reduces when a child with cleft palate sings. The act of singing significantly reduces hypernasality. The outcome of this study suggests that children with cleft palate would benefit from singing exercises to ultimately reduce hypernasality. However, future research is needed to objectively measure nasality in singing compared to speaking.

Key words: hypernasality; cleft; palate; singing.

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Hypernasality is a common problem encountered by most children with cleft palate and is due to excessive nasal resonance experienced during speech. It is defined as ‘‘any abnormal increase in nasal resonance during speech production, which is easily perceived on vowels and voiced consonants’’[1]. Most children with a surgically repaired cleft palate will experience frequent hypernasality due to an inadequacy of their velopharyngeal (VP) function, despite a satisfactory palate repair with the absence of a fistula. As a result of the presence of a short velum and extensive scarring, children with cleft palate often produce a hypernasal sound due to the incompetency of their VP complex. This problem leads to low intelligibility during speech and thus compromises the child’s social well-being. Speech therapy to treat hypernasality among these children is advocated once the structural defect has been treated adequately[2].

Singing is a pneumatic activity in which the physiological movement can be considered similar to speaking. It is a form of connected speech comprising different pitches and glissandos[3]. Gramming et al. discovered that singers change their velum position to determine pitch in order to achieve targeted formant frequencies or pitch[4]. In addition, Tanner et al. discovered that trained sopranos do permit nasal airflow through the VP port during classical singing, but the airflow through the VP port is controlled through a small gap and is within normal limits for VP adequacy[5]. Thus, singers are never perceived as hypernasal.

Previous studies performed on classically trained singers and non-cleft palate individuals, with comparison of velum movement in speaking and singing, have indicated that the VP port closes longer and tighter during the act of singing than during speaking, thus reducing hypernasality[6,7]. The aim of this study was to document differences in hypernasality during speaking and singing among children with cleft palate and to compare nasality score ratings of trained and untrained listeners. The hypothesis of this observational study was that hypernasality would be reduced during the act of singing compared to speaking among children with cleft palate, based on the perceptual judgement of trained as well as untrained listeners.

Materials and methods

Twenty children aged between 7 and 12 years (mean age 9 years), randomly selected from the Cleft Lip and Palate Association Malaysia (CLAPAM) database, responded positively to participate in this study. The selected subjects included 13 boys and seven girls who had been treated surgically with only one primary palatal repair, performed before the age of 2 years. All subjects were currently undergoing speech therapy (minimum duration of 8 months) due to VP incompetence and were able to sing and read in the Malay language. Subjects who were syndromic, had any hearing impairment, or who had undergone VP space surgeries such as adenoidectomy and pharyngoplasty, as well as subjects with an existing hard palate fistula, were excluded. The most common cleft type in this cohort was left unilateral complete cleft (45%, $n = 9$), followed by right unilateral cleft lip/palate (30%, $n = 6$), isolated cleft palate (15%, $n = 3$), and bilateral complete cleft lip/palate (10%, $n = 2$). All participants presented with clearly audible hypernasal speech.

Recordings of each of the subjects were made in a soundproof room. Subjects were asked to read a pre-determined passage, 'the *Kampung* passage', which is a speech assessment tool developed by a speech therapist in the Malay language. Their voices were digitally recorded using a Sony D100 Linear PCM recorder with a microphone placed at a fixed distance of 3 cm away from the subject's mouth. Following the speech recording, the subjects were asked to sing a common local Malay song consisting of nasal and oral sounds. The digital recordings were then transferred to a computer and saved in MP3 format using Audacity software (Version 2.1.1, Audacity Team, 2015); the file was renamed with a specified number to mask the identity of the patient.

Untrained and trained individuals assessed the recordings to detect hypernasality and its severity. This was done through perceptual judgement, with just the human ear. The untrained listeners were individuals who interact with children with cleft palates and are aware of this abnormality but are not involved in its assessment and grading. Trained listeners were professionals involved in speech and singing assessment and the detection of abnormalities of speech in daily life.

The untrained listeners were two lay persons: the secretary of the CLAPAM society (listener 1) and a high school Malay language teacher (listener 2). The trained listeners were three professionals: a classical singer and music lecturer at the University of Malaya (listener 3), a language and linguistic expert who is a Professor of the Language and Linguistics Faculty at the University of Malaya (listener 4), and a speech therapist (listener 5). All of the trained professionals are academicians with more than 10 years of experience and have a special interest in hypernasality.

A listening session was conducted in the Department of Music. At the beginning of the ratings session, information was disseminated by the main investigator about the rating procedure and rating scale. A brief introduction was given to explain normal resonance and hypernasality in order to improve consistency. A standard pair of earphones was provided to all listeners. The blinded audio samples were used in a randomized sequence to exclude any order and ratings. Each individual listener was asked to rate the degree of hypernasality of the random speech and singing recordings using a 100-mm visual analogue scale (VAS). For each sample, a 1–100 mm bar was provided, which included the label 'normal' at the left end and 'severe' at the right end, and the listener placed a mark on the bar according to their assessment of the recording[8]. Each sample could be listened to as often as needed; however, once the listener had moved on to the next sample, they were asked not to return to a previous one. All listeners worked at their own pace and could pause whenever they wanted to. All questions were answered by the main investigator throughout the rating procedure. The two untrained listeners (listener 1 and listener 2) repeated the assessment 1 month later.

Statistical analysis

Data were gathered and analysed using IBM SPSS Statistics software, version 23 (IBM Corp., Armonk, NY, USA). All data were subjected to the Shapiro–Wilk *W* test, and the paired samples *t*-test was used to compare the mean hypernasality ratings of all listeners and in the speaking and singing tasks. The level of significance was set at $P < 0.05$.

Prior to analysis, intra-rater reliability tests were conducted for the untrained listeners, and inter-rater reliability tests were conducted for the ratings of all listeners in comparison to the speech therapist's ratings. The intra-class correlation coefficient (ICC) was calculated to determine intra-rater and inter-rater reliability. Intra-listener and inter-listener reliability was verified by two-way fixed model with consistency agreement (ICC (3, 1)) using IBM SPSS Statistics software, version 23.0. The level of agreement was categorized based on Cicchetti[9], as follows: excellent, 0.75–1.00; good, 0.60–0.74; fair, 0.40–0.59; poor, <0.40. The nasality ratings for speaking and singing were compared among all listeners individually and between the groups of trained and untrained listeners.

Results

Intra-rater reliability test for the untrained listeners

As can be seen in Table 1, the ICCs for the level of agreement between the two assessments (1 month apart) made by listener 1 and listener 2 were found to

Table 1. Intra-rater ICC values for the assessment of hypernasality by listener 1 and listener 2.

		ICC	95% CI	Level of agreement
Listener 1	Speaking	0.90	0.77–0.96	Excellent
	Singing	0.95	0.88–0.98	Excellent
Listener 2	Speaking	0.85	0.63–0.94	Excellent
	Singing	0.92	0.81–0.97	Excellent

CI, confidence interval; ICC, intra-class correlation coefficient.

Table 2. Inter-rater ICC values for the assessment of hypernasality by listeners 1–4 in comparison with listener 5.

	Listener 1 and listener 5			Listener 2 and listener 5			Listener 3 and listener 5			Listener 4 and listener 5		
	ICC	95% CI	Level of agreement	ICC	95% CI	Level of agreement	ICC	95% CI	Level of agreement	ICC	95% CI	Level of agreement
Speaking	0.63	0.06–0.85	Good	0.76	0.39–0.90	Excellent	0.78	0.44–0.91	Excellent	0.63	0.06–0.85	Fair
Singing	0.59	0.04–0.84	Fair	0.60	0.02–0.84	Good	0.81	0.53–0.93	Excellent	0.59	0.04–0.84	Good

CI, confidence interval; ICC, intra-class correlation coefficient.

be excellent, for both the speaking and singing task hypernasality assessments.

Inter-rater reliability test

Table 2 shows the inter-rater reliability test results for the trained and untrained listeners in comparison with listener 5, the speech therapist. ICCs ranged between 'fair' and 'excellent'.

Comparison of mean hypernasality among all subjects

All subjects showed a mean reduction in hypernasality rating on singing as compared to speaking, as seen in Fig. 1. There was a highly significant difference between the scores for speaking (mean 49.1 ± 21.7) and singing (mean 38.1 ± 19.7). These results suggest a reduction in hypernasality score during singing (mean 10.1 ± 5.9; $P < 0.001$), specifically indicating that when a child with cleft palate sings, their hypernasality reduces. There was no statistically significant difference in the mean hypernasality rating for speaking or singing between the trained and untrained listeners ($P > 0.05$), as seen in Table 3. Both the trained and untrained listeners gave lower hypernasality ratings for singing as compared to speech, as shown in Table 4.

Discussion

The primary purpose of this study was to determine whether there is a reduction in hypernasality among individuals with cleft palate when they are singing as compared to speaking, and this outcome was found. The statistical analysis indicated a highly significant difference in hypernasality among children with repaired cleft palate during singing compared to speaking; therefore the null hypothesis is rejected. Nasality ratings were lower when singing compared to speaking among these children. A few theories reported in the literature can be used to explain this phenomenon.

In a dual endoscopy study by Yanagisawa et al. involving nine professional singers, it was found that regardless of the singer's voice range in the highest fundamental frequency, the lateral pharyngeal walls contracted significantly towards the midline forming an ''upside down V shape'', creating a very narrow pharyngeal tube, lifting the soft palate and narrowing the VP port considerably[3]. Movement of the lateral pharyngeal wall compensates for the limited movement of the often scarred, fibrosed and short velum in a child with cleft palate, as highlighted by Woo[10]. Through this study, it can be cautiously assumed that this mechanism from the act of singing itself produces a desirable effect in reducing hypernasality.

Another postulated theory for the decrease in hypernasality during singing compared to speech is in accordance with the results of a recent study by Nair et al.[11]. Through magnetic resonance imaging (MRI), their study demonstrated that the act of the low mandible manoeuvre performed during singing, increases resonance and maintains a more sustained as well as closer contact of the velum with the posterior and lateral pharyngeal walls.

As the speech rate increases, vowel height decreases and the closure of the VP port becomes less firm, as it is difficult to achieve closure of the VP with inadequate height[12]. This is known as velar fatigue, and speakers will start to sound hypernasal. Singing exaggerates consonants and sustains vowels at a greater height for a longer duration as compared to speaking[13]. According to a theory by Finkelstein et al., as more effort is placed on achieving a tighter VP closure, there is progressive muscle recruitment to obtain a better seal at the VP complex, which in turn reduces hypernasality[14].

Singing naturally occurs at a higher tone compared to speaking. Previous studies have reported that velar elevation increases as the frequency of the pitch increases[3,6,15]. Austin mentioned that by increasing the fundamental frequency (F0), nasal resonance is removed and the sound produced is of greater quality[6]. Fowler and Morris suggested that untrained singers should lift their velum higher whenever they cannot achieve the targeted musical tone, in an effort to reduce nasality[16].

As a person sings, they learn to control their breath to sing the lyrics following the variable pitches in a song. Singing involves rapid and forceful inspirations, followed by extended expirations to sustain notes, leading to higher vocal intensity and vocal control than when speaking[17,18]. This could explain the reduction in hypernasality as postulated in the present study. Singing also stimulates the musculature involved in phonation, respiration, and articulation, as well as resonance[19]. By singing songs at different tempos and by exaggerating consonants, abnormal speech rates as well as speech intelligibility improve[13].

Another possible explanation for the study findings is based on a study by Warren et al., who discovered that subjects with cleft palate compensate for the

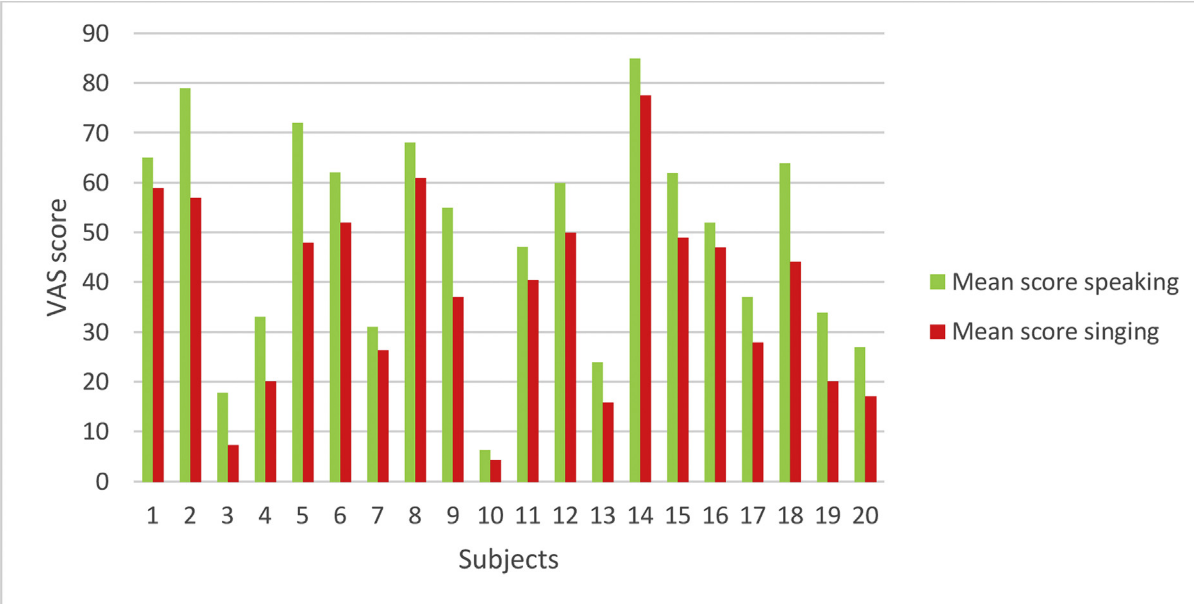

Fig. 1. Individual mean hypernasality VAS scores for speaking and singing, for all subjects.

Table 3. Comparison of the assessment of hypernasality between the trained and untrained listeners; paired samples test.

	Listener	Mean	SD	MD (95% CI)	*P*-value
Speaking assessment	Untrained	48.2	29.5	−1.4 (−10.4 to 7.6)	0.745
	Trained	49.7	18.7		
Singing assessment	Untrained	33.2	27.4	−8.1 (−17.2 to 0.9)	0.076
	Trained	41.4	17.5		

CI, confidence interval; MD, mean difference; SD, standard deviation.

Table 4. Comparison of the mean hypernasality ratings for speaking and singing, for all listeners; paired samples test.

		Mean	SD	MD (95% CI)	*P*-value
Listener 1	Speaking	46.1	29.1	11.3 (7.4–15.2)	<0.001
	Singing	34.8	26.2		
Listener 2	Speaking	50.4	31.8	18.8 (10.3–27.3)	<0.001
	Singing	31.6	30.0		
Listener 3	Speaking	55.5	22.9	12.0 (7.0–10.3)	<0.001
	Singing	43.6	21.8		
Listener 4	Speaking	57.4	25.1	3.8 (1.1–6.6)	1.008
	Singing	53.6	23.4		
Listener 5	Speaking	36.1	23.8	9.1 (4.5–13.8)	0.001
	Singing	26.9	20.0		

CI, confidence interval; MD, mean difference; SD, standard deviation.

loss of pressure through the VP orifice by increasing the intraoral pressure through increasing their lung output[20]. This helps improve speech intelligibility. Singing utilizes great respiratory pressure, which is produced by diaphragmatic-intercostal breathing. This expands the lower back ribs to aid the diaphragm to produce the required tone[21].

During singing, similar to speech, movements have to be precise, quick, and accurate, as discussed by Hardin-Jones et al.[22]. The actions of each muscle, structure, and phoneme are influenced by another muscle, structure, and phoneme, which form a continuum[23]. Therefore, there must be good synchronization between every component involved. Songs are led by tunes and melodic schema, which require harmonization in maintaining rhythm as well as accurate pronunciations of the lyrics. Thus, the integrity of the VP in singing cannot be overemphasized.

When a listener listens to a speech sample, their internal standards, which have developed through experience and exposure to similar conditions, are used to make comparisons and analyse the severity of a given condition. These internal standards, which develop over time, are preserved in the memory of each individual and differ from one listener to another[24]. Listener 4, a linguistic expert, disagreed with the speech therapist in the analysis of hypernasality during speaking. Listener 4's assessment also did not show a statistically significant change in hypernasality of children with cleft palate during singing when compared to speaking. This could be due to her internal standards, which could have been influenced by external factors such as articulation, vocal intensity, and phonetic context, which were not in accordance with the speech therapist's internal standards. As stated in the literature, listeners often use their personal criteria and standards in the auditory perceptual assessment of hypernasality[24]. Therefore, their ratings are occasionally not in consensus[25].

This study found no significant difference between the ratings of the trained and untrained listeners, which is similar to the findings of Brunnegard et al., who reported agreement in these two groups of listeners[24]. In the present study, untrained listeners tended to give lower ratings in all components of assessment compared to the trained listeners. This is probably because of their lack of exposure and training in this field of speech; therefore their level of acceptability tends to be lower since they are inclined to be lenient in their assessment. Although they did not agree on the nasality ratings, they did agree on the ranking of the severity of the speakers, similar to the findings of Brunnegard et al.[25].

The VAS scoring system used in this study is beneficial since it gives flexibility to the listeners. This system has led to a wider range of statistical analysis options with higher power and reliability[26,27]. The VAS was found to be easy to use by the untrained lay person and managed to yield abundant information.

This study has several limitations related to time constraints, patient compliance, and the lack of a control population of normal children for comparison. The cohort was also not categorized according to the different cleft phenotypes, the child's cognitive development, and the child's dentition due to the limited sample size. The issue of patient compliance was due to the various commitments regarding school attendance, which was a hindrance in obtaining a larger sample. Listener training, which was not provided in this study due to time constraints, could have been done to calibrate the ratings among the trained and untrained listeners. Intra-rater listener reliability testing for trained listeners could also have been conducted to produce more accurate and reliable ratings in the assessment of hypernasality. As no imaging tools such as radiographs or videofluoroscopy were used in this study, the patterns of closure of the VP complex of these children while they were singing compared to when they were speaking could not be determined.

In conclusion, this study demonstrated a reduction in hypernasality when a subject with cleft palate sings as compared to speaks. However, the theories behind the reduction in hypernasality and the actual mechanism involved can only be speculated upon, as this study was based only on auditory-perceptual judgement. Nevertheless, there is still much to be learned regarding hypernasality and the VP complex system in singing. A thorough understanding of its movements and coordination system would be beneficial in managing this clinical problem.

This study suggests that children with cleft palate would benefit from singing exercises to ultimately reduce hypernasality. Singing could be used as a form of therapy in the treatment of VP dysfunction. Future studies involving an MRI assessment of the function of individuals with cleft palate would be invaluable for visualization of the VP in function and comparison of measurements of the velar stretch as well as amounts of constriction of the pharyngeal walls during singing as compared to speaking. The use of objective quantitative acoustic measurement tools such as one-third octave spectral analysis and vocal low tone to high tone ratio, could also be considered as a supplement to perceptual judgement in the assessment of hypernasality[28].

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Ethical approval

Ethical approval was obtained (reference number: DF OS1513/0048 (P)).

Competing interests

None.

Patient consent

All patients consented to this study.

Author Statement

All authors have agreed and consented for submission.

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