The Relationship Between Three Oral Breath Pressure Ratios and Ratings of Severity of Nasality for Talkers With Cleft Palate

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Oral manometer ratios and perceptual judgments of speech frequently are used clinically to assess velopharyngeal function. Barnes and Morris (*1*) recently noted that there is not yet sufficient information about the relationship between these measures for meaningful interpretation of obtained clinical observations. The purpose of this research was to provide information about the relationship between each of three manometer ratio measures and perceptual judgments nasality. Specifically, the following question was asked: to what extent can oral manometer ratios differentiate speakers with hypernasal speech from patients with normal voice quality?

Method

Subjects. One hundred (100) persons with histories of velopharyngeal inadequacy were studied. They were selected from a series of patients receiving treatment at the Cleft Palate Clinic, Indiana University Medical Center. Subjects ranged in age from 3 years to 20 years ($\bar{X} = 9.65$ years) and demonstrated a variety of physical management procedures for cleft palate.

Perceptual Judgments. Two experienced speech pathologists independently rated each talker for presence or absence of hypernasality. In each case where hypernasality was judged to be present, hypernasality was rated on two degrees of severity: mild or moderate-severe. Perceptual judgments were based on vowels /i/ and /u/ sustained and in sentences: "Who are you" and "We see three geese." Judgments were made during the initial stage of clinical evaluation of each patient. Thus, live speech samples rather than tape recorded samples were rated.

This paper was presented at the 1970 meeting of the American Cleft Palate Association, April, 1970, in Portland, Oregon.

This research was funded in part by a grant from the James Whitcomb Riley Memorial Association, Indianapolis, Indiana. Computations for this project were performed at the Indiana University Medical Center Research Computation Center which is supported in part by Public Health Service Research Grant RR00162.

TABLE 1. Means and standard deviations of positive and negative manometer ratios and manometer difference scores for the three talker groups.

groups	*N*	*conditions*					
		positive		*negative*		*positive minus negative (MDS)*	
		$\overline{X}$	*S.D.*	$\overline{X}$	*S.D.*	$\overline{X}$	*S.D.*
(1) normal voice	38	.989	.03	.942	.15	.05	.15
(2) mild hypernasality	52	.894	.21	.487	.20	.40	.25
(3) mod-severe hypernasality	10	.471	.25	.437	.16	.03	.28

Subjects were included in this study only when (1) both judges agreed that the talker was or was not hypernasal on all tasks and (2) both judges agreed on the severity of hypernasality of each task. In this way, three subject groups were formed: (1) 38 individuals demonstrating normal voice quality, (2) 52 exhibiting mild hypernasality and (3) 10 exhibiting moderate to severe hypernasality.

Manometer Procedures. Readings of maximum, sustained, positive and negative pressure with bleed and with nostrils occluded and open were obtained from each subject using a Hunter oral manometer.[1] Positive and negative manometer ratios were computed by expressing the open-nose reading as a percentage of the closed-nose reading.

Subjects were instructed to practice each manometer task prior to recording readings. To increase validity and reliability, each individual had to achieve three pre-set criteria. (*1, 3, 5*). A. Each patient was required to sustain maximum pressure for two (2) seconds on three consecutive trials during sustained exhalation and inhalation. B. Among trials, each subject's maximum sustained pressure could not differ by more than 1 oz./sq. in. C. Under closed-nose conditions, each subject had to generate minimum pressures of 8 oz./sq. in. during sustained exhalation and 5 oz./sq. in. during sustained inhalation. The readings for each trial were recorded and a mean computed.

Three pressure ratio measures were derived: positive, negative, and positive minus negative (called Manometer Difference Score).

Results

Positive Manometer Ratios. The means and standard deviations for positive manometer ratios for each group are presented in Table 1. A preliminary Bartlett test demonstrated group heterogeneity of variance for positive manometer ratios. Specifically, speakers with normal voice quality had a significantly smaller variance associated with positive manometer ratios than either of the two hypernasal groups. Thus, individuals with normal voice quality exhibited small variation in their production of

[1] Hunter Manufacturing Company, Iowa City, Iowa

TABLE 2. t′ test results for evaluating group differences for positive manometer ratios.

group comparisons	*means*	*t′*	*p*
1–2	.989 − .894	3.19	< .005
1–3	.989 − .471	6.48	< .001
2–3	.894 − .471	5.63	< .001

near-unity positive breath pressure ratios, while subjects with hypernasal voice quality exhibited significantly more variation in positive intra-oral breath pressure ratio productions.

The differences between the mean positive manometer ratios for the three groups were evaluated with t′ tests. Subjects with normal voice quality produced significantly higher positive breath pressure ratios than either hypernasal group (Table 2). This statistical result, however, is highly misleading and is subject to considerable clinical misinterpretation. For example, the mean positive manometer ratio for the group of mildly hypernasal speakers was .89. Obviously, a large number of talkers exhibiting mild hypernasality achieved positive manometer ratios approximating unity ($\geq .90$). In fact, approximately three out of every four patients with mild hypernasality produced positive manometer ratios $\geq .90$. Thus, positive manometer ratios provided considerable false-positive clinical information: that is, adequate oral breath pressure ratios during forced, sustained exhalation were associated with perceptual evidence of hypernasality.

Negative Manometer Ratios. The means and standard deviations for negative manometer ratios for the three groups are also found in Table 1. A preliminary Bartlett test demonstrated group homogeneity of variance for negative manometer ratios. Subsequent one-way analysis of variance revealed that mean negative manometric ratios were significantly different among the three speaker groups. Specifically, t test results (Table 3) show that the group of speakers with normal voice quality achieved significantly higher mean negative manometer ratios than either hypernasal group. Moreover, patients with mild hypernasality could not be differentiated from those with severe hypernasality.

Negative manometer ratios provided highly significant clinical informa-

TABLE 3. t test results for evaluating group differences for negative manometer ratios.

group comparisons	*means*	*t*	*p*
1–2	.942 − .487	12.01	< .001
1–3	.942 − .437	8.01	< .001
2–3	.487 − .437	.82	<N.S.

TABLE 4. t′ test results for evaluating group differences for manometer difference scores.

group comparisons	*mean difference scores*	t'	p
1–2	.05 − .40	8.47	< .0001
1–3	.05 − .03	0.13	N.S.
2–3	.40 − .03	4.28	< .0001

tion. Namely, they more clearly differentiated two significant speaker groups: those with normal voice quality from patients with hypernasal voice quality. Negative manometer ratios also decreased the rate of false-positive identification of speakers with potential velopharyngeal inadequacy. For example, only 3 percent (N = 2) of the patients with mild hypernasality achieved negative manometer ratios $\geq .90$, while 77 percent (N = 40) of these same talkers achieved positive manometer ratios $\geq .90$.

Manometer Difference Score (*MDS*). To evaluate the difference in performance between forced, sustained exhalation and inhalation, a Manometer Difference Score was computed for each individual. This was accomplished by subtracting the negative manometer ratio from the positive manometer ratio. The means and standard deviations for Manometer Difference Scores of the three groups are presented in Table 1. As expected, group heterogeneity of variance for the MDS measure was found. Therefore, t′ tests were used to evaluate group differences for MDS. The mean MDS for patients with normal voice quality was not significantly different from the mean MDS for those with severe hypernasality (Table 4). This finding would be expected since subjects with normal voice quality achieved oral breath pressure ratios near unity during both exhalation and inhalation, while speakers exhibiting moderate-severe hypernasality achieved low breath pressure ratios during both tests. Hence, the average difference scores for both of these groups was small.

By comparison, speakers exhibiting mild hypernasality had a significantly higher mean MDS than either of the other two groups (Table 4). In short, high MDS scores appear to provide an additional useful clinical measure for identifying children with mild hypernasality associated with inadequate valving mechanisms for speech.

Discussion

A number of clinical investigations employing the oral manometer have studied the ability of subjects to create forced, sustained, positive intra-oral breath pressure (*3, 6, 7*). By contrast, only a few investigators have studied the ability of individuals to create and sutain negative intra-oral breath pressure (*1, 2*). This discrepancy exists despite evidence that velopharyngeal function during forced, sustained exhalation is not similar to that observed during speech (*4, 5*). Moreover, comparable data indicates that velopharyngeal function during forced, sustained inhalation is remarkably similar to that observed during speech (*5*).

The authors recognize that velopharyngeal function associated with speech may not be identical with that observed during non-speech respiratory maneuvers. Indeed, velopharyngeal activity during these contrasting activities has not been fully specified. However, the findings of this investigation suggest that a more comprehensive clinical examination of patients with potential velopharyngeal inadequacy can be obtained by deriving several manometer ratio measures under carefully controlled test conditions. In short, the oral manometer can be a valuable clinical tool, particularly in situations where complex instrumentation such as cinefluoroscopy and air pressure-air flow devices are not available.

The results of this research show that considerable clinical error may be incurred by using only positive manometer ratios during diagnostic workups of patients with potential velopharyngeal inadequacy. Apparently, there is a high probability that high, sustained, positive intra-oral breath pressures (in association with factors such as Bernoulli effects, increased respiratory effort, and the advantageous configuration of the soft palate) contribute to the forcing of the velum toward or against the pharyngeal wall. The results of this study suggest that low, sustained, positive intra-oral pressure ratios are associated with marked impairment of palatal integrity or gross inadequacy of velopharyngeal function.

By comparison, there appears to have been limited discussion in the literature (*1, 5*) regarding the use of negative oral manometer ratios. Unfortunately, some investigators (*1*) have used the term "sucking" to describe patient activity during negative manometric testing. Moll (*5*) has carefully pointed out that sucking refers to a pre-swallow performance and that an essential feature of sucking is tongue valving. By contrast, during negative manometric testing with bleed, the patient performs a respiratory maneuver designed to assess his ability to generate and sustain negative intra-oral breath pressure. Therefore, we suggest the term "inhaling" (i.e. "breathing in"), rather than "sucking", as a more accurate term to describe the respiratory maneuver performed during negative manometer testing.

Theoretically, the production of a high, sustained, negative intraoral breath pressure ratio requires a palate that is anatomically intact, sufficiently long, and neurologically sound. The present findings suggest that the achievement of high negative manometer ratios generally preclude even marginal velopharyngeal inadequacy as evidenced by hypernasal speech. The anatomical configuration of the palate would not appear to offer mechanical advantage toward the achievement of velopharyngeal closure during forced, sustained, open-nose inspiration. The direction of air flow is opposed to the direction of palate movement. In fact, during negative manometer testing, velopharyngeal closure must be maintained against high negative intra-oral pressures.

The reported results support the observation by Chase (*2*) that inspiratory intra-oral pressure measures provide more sensitive indices of velopharyngeal inadequacy as evidenced by hypernasal voice quality. An original contribution of the present study is the potential contribution of the Manometer Difference Score as an additional diagnostic measure for evaluating velopharyngeal competence for speech.

Summary

This research investigated each of three oral manometer ratio measures and perceptual judgments of nasal voice quality in 38 speakers with normal voice quality, 52 with mild hypernasality, and 10 exhibiting moderate to severe hypernasal voice quality. The major question of this study was: to what extent can oral manometer ratios differentiate patients with hypernasal voice quality from those with normal voice quality?

Significant group differences were found with respect to mean positive and negative manometer ratios and mean Manometer Difference Scores. The results of this study show that considerable clinical error may be incurred by using only positive manometer ratios. For example, approximately three out of every four (77%) patients with mild hypernasality achieved positive manometer ratios $\geq .90$. Mean negative manometer ratios more clearly differentiated talkers with normal voice quality from those with hypernasal voice quality. This research suggests that a high Manometer Difference Score may provide a useful clinical measure for identifying children with potential velopharyngeal incompetency evidenced by mild hypernasality.

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