VELOPHARYNGEAL FUNCTION: SOME IMPORTANT DIFFERENCES

Sally J. Peterson

University of Iowa, Iowa City, Iowa

Although there is some evidence of differences in velopharyngeal function depending upon the type of subject and the nature of the task, many speech pathologists base clinical practice on a single model of that function. This project investigated patterns of velopharyngeal function on blowing and speech tasks performed by normal subjects, subjects with velopharyngeal competency for speech in the presence of palatal pathologies, and subjects with velopharyngeal incompetency for speech. Lateral cinefluorographic films were taken of each subject performing the designated tasks; measurements of velar height and velopharyngeal opening were derived from the steady-state portion of each task. Subjects with velopharyngeal incompetency for speech showed patterns of velar height and velopharyngeal opening which substantiated previous research indicating that the closure mechanisms of these speakers probably are not the same as those of speakers with velopharyngeal competency. The results are discussed with regard to (1) historically recommended nonspeech "exercises" for improvement of velopharyngeal closure and (2) a proposal that it may be misleading to view the speaker with incompetency simply as a case of "less-than-normal" velopharyngeal function. Such a speaker may, in fact, manifest an entire complex of neuromuscular patterns which is dissimilar from that of the normal speaker.

Since the advent of lateral cineradiography as a tool for studying the dynamic physiology of oral and pharyngeal structures, descriptions of velopharyngeal closure patterns have been reported for both normal and "non-normal" speakers performing a variety of speech and nonspeech tasks (Ashley et al., 1961; Bjork, 1961; Bzoch, 1968; Calnan, 1955; Fritzell, 1969; Lubker, 1968; Mazaheri, Millard, and Erickson, 1964; Moll, 1962, 1965; Warren and Hofmann, 1961). Conclusions drawn from cineradiographic studies have been predicted, substantiated and, in some cases, contradicted by information gleaned in cephalometric roentgenography (Benson, 1972; Buck, 1954; Calnan, 1952; Lubker and Morris, 1968; Pruzansky and Mason, 1969; Williams, 1948; Willis, 1952).

In a cineradiographic study reported in 1965, Moll found differences between normal speakers and speakers with velopharyngeal inadequacy on a number of speech and nonspeech tasks. His findings led him to conclude, ". . . the assumption that the closure mechanisms of normal subjects on various tasks are the same as those utilized by individuals with velopharyngeal inadequacy

is probably invalid." This conclusion was prompted primarily by differences Moll observed in the act of swallowing. The between-group differences observed on swallowing, plus the within-group differences he found among the various tasks of sucking, swallowing, and blowing, led Moll to seriously question the use of such activities as exercises to increase velopharyngeal closure for speech. He observed that such tasks may not require velopharyngeal closure, in that tongue-palate valving may be used. Further, even if such tasks were presumed to increase strength in the velopharyngeal musculature, the development of improved closure on nonspeech tasks may not generalize to speech, which involves a different mechanism (Kantner, 1947; Moll, 1963, 1965). Moll's findings suggested the need for further investigation and comparison of speech and nonspeech activities performed by normal speakers and speakers with velopharyngeal inadequacy, particularly because many clinicians persist in using blowing, sucking, swallowing, and other nonspeech tasks as exercises to increase velopharyngeal closure (Berry and Eisenson, 1956; Morley, 1970; Van Riper, 1971).

METHOD

As part of a larger study of the effects of electrical stimulation of the soft palate, lateral cinefluorographic films were taken of 21 subjects during four "behavior sample" conditions: (1) rest, (2) blowing on manometer with bleed (for a discussion of the oral manometer and its use, see Morris, 1966), and (3) repetition of the bisyllabic utterances /mɑmɑ/ and /fufu/. The bisyllable /mɑmɑ/ was chosen because the consonant is a nasal and Moll (1962) found the vowel /ɑ/ to be associated with greater velopharyngeal opening than vowels produced with higher tongue positions (when produced in association with a nasal consonant). The bisyllable /fufu/ was chosen to sample "maximum closure" in speech. The vowel /u/ has been found to be associated with maximum velopharyngeal closure in normals (Moll, 1962). The consonant /f/ was chosen because (1) fricatives are among those consonants requiring greater interaoral air pressure and thus greater velopharyngeal closure (Spriestersbach, Moll, and Morris, 1961); and (2) the labiodental articulation of /f/ facilitates identification of the consonant on cinefluorographic films.

Two types of subjects were selected: normal subjects and subjects with palatal pathologies. The latter group included both subjects with velopharyngeal competency for speech and subjects with velopharyngeal incompetency for speech, as judged by three experienced speech pathologists. Five subjects, aged 10 to 16, were selected who demonstrated velopharyngeal closure for speech in the presence of repaired palatal clefts. Five subjects, aged seven to 15, were selected who demonstrated velopharyngeal incompetency for speech. Two of the latter group had unrepaired submucous clefts and bifid uvulas, two had unrepaired congenital palatopharyngeal incompetency due to inadequate palatal length, and one had a repaired unilateral cleft of the lip and

palate. (For purposes of the larger study dealing with the effects of electrical stimulation of the soft palate, the group of subjects demonstrating velopharyngeal incompetency was intentionally selected to be heterogeneous.) Eleven subjects without palatal pathologies and without speech defects were selected from the age groups of preadolescent, adolescent, and adult, as one-to-one age match with the palatal pathology subjects was not possible.

The cinefluorographic equipment and the technique for analyzing the films were similar to those used by Moll (1960). The procedure for analyzing the films involves the frame-by-frame projection of a life-size image of selected frames. The structures of interest are traced for each of the selected frames, and measurements are made to the nearest 0.5 mm. For this study, three consecutive frames were selected from the steady-state portion of each condition of the behavior sample for tracing and measurement. Velar height (VH) and velopharyngeal opening (VPO) values were established for each condition by averaging the values obtained on the three frames.

Illustrated in Figure 1 are the two film analysis measurements used in this study: (1) velopharyngeal opening (VPO), the shortest distance between the velum and the posterior pharyngeal wall (during the steady-state portion of the designated task); and (2) velar height (VH), the height of the velum above a line drawn from the inferior border of the base of the skull through the tip of the upper central incisor. Because several subjects did not exhibit a definite "knee action" in velar elevation on one or more conditions, the point from which velar height was measured differed slightly from that used in previous

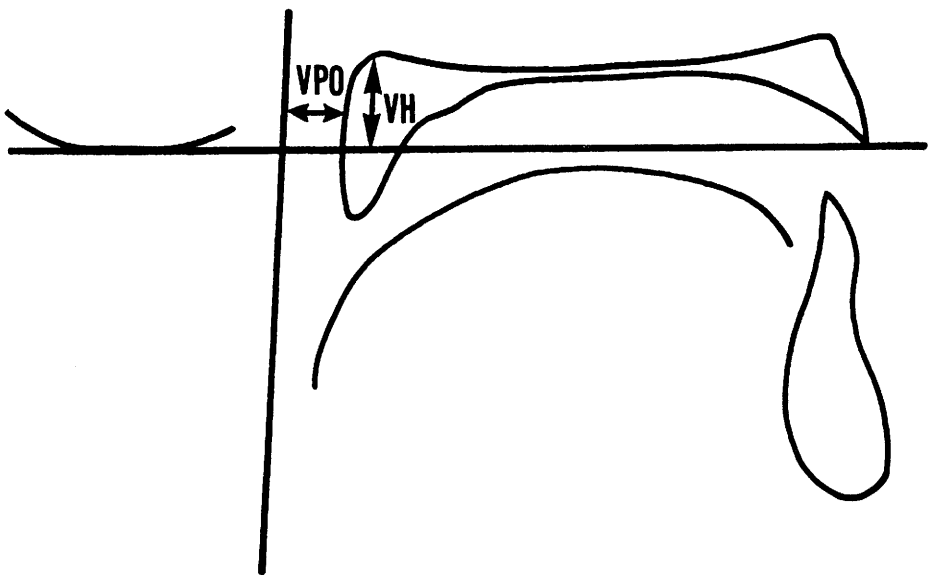

Figure 1. **Sample tracing of a cinefluorographic film showing the measures of velar height (VH) and velopharyngeal opening (VPO).**

studies (Moll, 1962, 1965). There were several instances in which the superior surface of the velum, even at maximum elevation, took the form of a smooth, curved line. In such cases, velar height was measured from the most superior-posterior point on the superior surface of the velum. In subjects showing the knee-action type of elevation, this point corresponded to that from which velar height was measured in previous studies (Moll, 1962, 1965).

Reliability. In the larger study dealing with the effects of electrical stimulation (Peterson, 1971), a standard error of measurement was derived for each of the two measures of VPO and VH. These standard errors were 0.36 mm and 1.02 mm for velopharyngeal opening (first and second tracing units) and 0.11 mm and 0.52 mm for velar height (first and second units).

FINDINGS

The VPO and VH values for each subject on the four conditions of the behavior sample are reported in Table 1. Values for the normal subjects are given in *a,* for the subjects with velopharyngeal competency in the presence of repaired clefts in *b,* and for subjects with velopharyngeal incompetency in *c.* Intersubject comparisons based on actual millimeter values cannot be made because of individual differences in dimensions of the structures measured.) Velar height values are not given for the rest condition, as the presence of velar elevation would contradict identification of the frames as representing the rest condition. In addition, one subject (LC) with a repaired cleft and velopharyngeal competency showed no identifiable velar elevation on /mɑmɑ/.

Velar Height. In Table 1, the normal subjects (a) and the subjects with velopharyngeal competency for speech in the presence of palatal pathologies (b) showed a consistent pattern of velar height values not observed in any of the subjects with velopharyngeal incompetency for speech. Specifically, the subjects in the first two groups exhibited a consistent rank order of velar height values over the three conditions of the behavior sample (in addition to rest). This rank order, from least to greatest VH value, was as follows: /mɑmɑ/—/fufu/—blowing, the latter yielding the highest VH value for each subject. The one exception to this pattern was subject LC, who, as noted previously, showed no identifiable velar elevation on /mɑmɑ/.

In contrast, none of the five subjects with velopharyngeal incompetency for speech showed this consistent rank order in VH values. Three subjects (CD, MB, LSch) did not show velar elevation in blowing. CD showed tongue-palate contact on blowing, with the posterior tongue markedly elevated and appearing to push the soft palate up and back against the posterior pharyngeal wall. MB and LSch also failed to show identifiable velar elevation on the speech samples. One subject (KH) showed greater velar height on /fufu/ than on blowing and no identifiable velar elevation on /mɑmɑ/. (Although this subject did obtain closure on /fufu/, her conversational speech was markedly hypernasal, and she was thus placed in the velopharyngeal incom-

petency group.) One subject (BP) obtained velopharyngeal closure on blowing and on the first three repetitions of the syllable /fu/, but did not maintain closure on the remaining repetitions of the syllable. During that portion of the speech sample in which closure was maintained, the VH value exceeded that on blowing.

TABLE 1. Velopharyngeal opening (VPO) and velar height (VH) values on rest, blowing, and speech tasks.

Subjects	*Rest* *VPO*	*Blowing* *VPO*	*Blowing* *VH*	/mama/ *VPO*	/mama/ *VH*	/fufu/ *VPO*	/fufu/ *VH*
a. Normal subjects.							
1 BM	12.1 mm	–	28.6	7.1	20.5	–	24.6
2 WL	13.5	–	21.0	4.3	14.1	–	19.0
3 GM	8.0	–	22.0	4.1	17.0	–	19.3
4 SM	8.5	–	22.6	6.3	12.8	–	21.3
5 DM	14.5	–	23.5	8.0	9.1	–	18.5
6 LM	10.6	–	28.1	5.1	16.0	–	25.4
7 ED	11.5	–	20.8	2.5	12.8	–	19.5
8 LS	7.5	–	25.5	3.0	13.6	–	23.3
9 AS	14.5*	–	23.5	5.3	14.6	–	20.6
10 AL	12.0*	–	24.1	4.3	15.6	–	21.3
11 LY	17.1	–	22.1	6.1	14.0	–	17.5
b. Subjects with palatal pathologies and velopharyngeal competency for speech.							
1 JB	5.5	–	26.0	1.8	18.6	–	24.5
2 LC	10.5	–	21.3	10.6	–	–	20.3
3 KG	8.0	–	22.8	6.1	20.0	–	22.6
4 EL	12.1	–	25.0	2.0	18.0	–	24.1
5 CR	15.0	–	29.8	7.0	21.5	–	27.1
c. Subjects with palatal pathologies and velopharyngeal incompetency for speech.							
1 MB	10.0	13.6	–	5.8	–	7.6	–
2 BP	10.5*	–	19.0	5.8	18.0	– †	19.5
3 LSch	16.0	17.0	–	14.6	–	17.5	–
4 KH	12.5*	–	24.8	9.3	–	–	26.0
5 CD	18.5*	3.5*	–	16.6	17.0	8.0	22.5

*Tongue-palate contact
†Closure on first 3 /fu/'s only

Velopharyngeal Opening. Two subjects in the velopharyngeal incompetency group (MB and LSch) also showed an aberrant pattern of VPO values in the behavior sample. They showed greater velopharyngeal opening during blowing than during the rest condition. Two judges experienced in viewing cinefluorographic films independently recorded the subjective impression, on view-

ing the films of these two subjects, that the posterior pharyngeal wall moved back as the subject went from the rest condition to the blowing condition. For both subjects, the greater VPO values during the blowing condition were verified on the reliability tracings. These were the same subjects who failed to show identifiable velar elevation in the speech samples.

With the exception of subjects MB and LSch of the velopharyngeal incompetency group and subject LC of the velopharyngeal competency group, the VPO values on /mamɑ/ fell between those at rest and those on /fufu/. MB and LSch showed greater VPO values on /fufu/ than on /mamɑ/, while the VPO value on /mamɑ/ for subject LC was virtually identical to that at rest.

In summary, examination of the VPO and VH measures obtained during the behavior sample yielded the following results: (1) With the exception of one subject with velopharyngeal competency, all subjects with palatal pathologies and velopharyngeal competency and all normal subjects showed a consistent rank order, from least to most, in VH values: /mamɑ/—/fufu/—blowing (highest VH value). (2) Velar height values for the five subjects with velopharyngeal incompetency for speech did not demonstrate the rank order found in the normal subjects and subjects with velopharyngeal competency for speech, in that two subjects showed greater elevation on /fufu/ than on blowing, three did not show any identifiable velar elevation on blowing, and two failed to show any identifiable velar elevation on the speech samples. (3) Two subjects with velopharyngeal incompetency for speech showed greater velopharyngeal opening in the blowing condition than at rest. (4) VPO values on /mamɑ/ fell between those at rest and those on /fufu/ for all but the two subjects with velopharyngeal incompetency who showed no elevation on the speech samples and the one subject with competency who showed no velar elevation on /mamɑ/.

DISCUSSION

Patterns of Velopharyngeal Function Found in Speakers with Velopharyngeal Competency

The results obtained on the normal speakers and the speakers with velopharyngeal competency for speech in the presence of repaired palatal clefts are generally in agreement with data reported in previous studies. Both Moll (1965) and Warren and Hoffman (1961) have reported that normal speakers show greater velar elevation on blowing than on phonation. Bzoch (1968) found greater velar elevation on /u/ than on /ɑ/ in CV syllables where these vowels were combined with /p/. His findings suggest that the markedly lower VH values on /mamɑ/ than on /fufu/ in this study may not have been entirely due to the nasal consonant /m/. Lubker (1968) found minimal velar elevation on sustained /m/ in normal speakers. He also found greater velar height (and less velopharyngeal opening) on /u/ than on /ɑ/ in his speakers.

Aberrant Patterns Found in Speakers with Velopharyngeal Incompetency: Clinical Implications

The aberrant, highly variant patterns of velopharyngeal function found among the subjects in the velopharyngeally incompetent group in this study should be of crucial interest to the clinical speech pathologist. The failure of any of the subjects in this group to show the pattern of VPO and VH values among the four behavior sample conditions shown by the normal speakers and speakers with velopharyngeal competency in the presence of repaired clefts lends support to Moll's suggestion (1965) that "the assumption that the closure mechanisms of normal subjects on various tasks are the same as those utilized by individuals with velopharyngeal inadequacy is probably invalid." Moll noted that individuals with inadequate closure may develop compensatory mechanisms which allow them to perform some nonspeech activities adequately. In his films on subjects with velopharyngeal inadequacy, he observed that tongue-palate contact persisted throughout the entire time that the velopharyngeal port was closed. One subject in the current study (CD) showed this pattern while blowing on the manometer, although the bleed valve was open. As would be expected, the flow of air into the manometer could not be sustained with the velopharyngeal port occluded using tongue-palate contact. This subject showed the same tongue-palate contact on repeated trials with the manometer.

More remarkable in the blowing task was that two subjects with velopharyngeal incompetency showed greater velar elevation on repetition of /fufu/ than in blowing, and two showed greater velopharyngeal opening on blowing than at rest. Both of these findings appear to render highly suspect the practice of encouraging patients with velopharyngeal incompetency to use blowing exercises to achieve maximum velopharyngeal closure. Such time-honored practices as asking patients to blow up balloons or inflate the cheeks to increase activity of the velopharyngeal musculature must be seriously questioned in light of these data.

The Need for a Different Viewpoint

Also rendered suspect by the results of this study is the practice of generalizing from muscular behavior patterns observed in normal experimental subjects to the speech or nonspeech velopharyngeal function patterns of persons with velopharyngeal incompetency. For instance, we can no longer assume that a speaker with velopharyngeal incompetency will show greater velar elevation on /u/ than on /ɑ/ simply because this pattern has been demonstrated in normal subjects. Neither can we assume that speakers with velopharyngeal incompetency will achieve greater velopharyngeal closure on blowing tasks than in speech.

The aberrant patterns observed in the speakers with velopharyngeal incom-

petency for speech in this study suggest that we may be guilty of viewing such speakers from a much too narrow, and perhaps distorted, viewpoint. We have habitually viewed these speakers "through" our studies of normal speakers. The custom has been to view the speaker with incompetency as a case of insufficient, inadequate, or simply not enough of the kind of function seen in the normal speaker. While the value of studying the normal mechanism cannot be disputed, these results indicate that we cannot study the speaker with incompetency as representing a simple case of "less-than-normal" velopharyngeal function. Rather, we must shift our viewpoint to include the possibility that the speaker with velopharyngeal incompetency may manifest an entire complex of neuromuscular patterns which is dissimilar from that of the normal speaker.

ACKNOWLEDGMENT

This paper is based on a doctoral dissertation completed at the University of Iowa in 1971, under the direction of Hughlett L. Morris and Patrick J. Carney. The research was supported by U.S. Public Health Service Research Grant DE-00853, from the National Institute of Dental Research. The author is currently affiliated with the Center for Craniofacial Anomalies at the University of Illinois. Requests for reprints should be addressed to Sally J. Peterson, Center for Craniofacial Anomalies, Abraham Lincoln School of Medicine, University of Illinois at the Medical Center, P.O. Box 6998, Chicago, Illinois 60680.

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