The Effects of Muscle Exercises on Velopharyngeal Gap and Nasality

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The cleft palate literature is replete with statements recommending the use of muscle exercises for improving velopharyngeal functioning and speech. Proponents of these techniques (*2, 9, 12, 16, 17, 19, 24, 25*) have suggested exercises directed toward achieving voluntary control of muscle function and/or increasing muscle strength, bulk, and flexibility. Their proposals appear to be based on the assumptions that (a) velopharyngeal mechanisms function similarly to other neuromuscular mechanisms which have been modified through physical therapy procedures, and (b) improved velopharyngeal functioning for nonspeech activities will carry over into speech activities.

The validity of using muscle exercises to increase velopharyngeal movements has been questioned. Some investigators (*1, 3, 5, 6, 14, 15, 23*) have suggested that velopharyngeal function differs during speech, swallowing, gagging, blowing and sucking. Others (*8, 18, 21, 22*) have pointed out that neuromuscular processes responsible for speech may be dissimilar to other neuromuscular processes involving the same muscle groups.

Recent literature provides some support for muscle exercises. Yules and Chase (*26*) have described a muscle training program for developing pharyngeal wall movement during speech. Their procedures consisted of training 30 patients to bring under voluntary control movements elicited by electrical stimulation. Later these movements were shaped into spontaneous speech using operant conditioning techniques. They reported that 90 per cent of their patients either eliminated or decreased nasality during the course of treatment. Lubit and Larsen (*11*) have described an appliance which was developed to exercise the soft palate. They presented a case study suggesting that use of the exerciser may lead to desired changes in palatal function and speech. Massengill *et al.* (*13*) observed the influence of blowing, sucking, and swallowing exercises on velopharyngeal closure during the production of /i/ and /u/. Subjects were divided into three

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groups. Group A practiced sucking, group B blowing, and group C swallowing. Their data suggest that overall improvement in velopharyngeal gap was greatest for the swallowing group; however, beneficial changes were evident for individual subjects in the remaining two treatment groups.

Although the foregoing investigations are encouraging, interpretation of results is difficult. In the absence of control groups or baseline measures, one cannot be certain whether changes in performance were due to time or treatment. Also, in two of the treatment programs, the effects of nonspeech muscle exercises were confounded by speech training administered either concurrently (*13*) or as an integral part of the program (*26*). Thus, it is questionable whether muscle exercises alone were of value for improving velopharyngeal competence during speech, particularly during conversational speech.

The purpose of this study was to determine whether a concentrated management program consisting of voluntary nonspeech muscle exercises would result in an increase in palatal efficiency and/or a decrease in nasality for individuals with surgically repaired cleft palates.

Method

SUBJECTS. Selection of subjects (Ss) was guided by a number of considerations:

1. Evidence that Ss were nasal—This included (a) judgments by by the senior author (E) of degree of nasality (mild-moderate-severe); (b) clinical records indicating that nasality, as judged by other clinicians, had remained stable for at least six months immediately preceding the treatment program.

2. Evidence that velopharyngeal inadequacy was present—This included (a) a recommendation from the University of Minnesota Cleft Palate and Maxillofacial Clinic that an improved velopharyngeal mechanism was needed; (b) cephalometric head films showing that velopharyngeal closure was not accomplished during the sustained production of the vowel /i/.

3. Evidence that some potential for velopharyngeal closure existed—This included (a) judgments by E based on direct oral examination and cephalometric head films that palatal length was sufficient for closure; (b) oral manometer tests suggesting that velopharyngeal closure was accomplished during blowing; (c) cephalometric measurements obtained during the sustained production of /i/ indicating a velopharyngeal gap (VPG) of eight mm or less. (In Massengill's study (*13*) Ss with VPGs of eight mm or less demonstrated more improvement than Ss with larger VPGs.)

4. Evidence that Ss exhibited no problems preventing them from participating in the study—This included (a) school records indicating average intelligence and satisfactory achievement; (b) audiometric screening data indicating no hearing loss.

5. Evidence that there were no additional speech difficulties which might change during the period of the study and consequently influence ratings

of nasality—This included judgments by E of articulation, fluency, and voice (laryngeal).

6. Evidence that Ss were willing to participate in the study—This included interviews with Ss, parents, and school personnel.

Using the above criteria, three male Ss and one female S were selected. Ss ranged in age from eight to eleven years. All had palatal clefts which had been repaired before age two. None had had any subsequent pharyngoplasty or experience with speech appliances. Two Ss were judged by E to be midly nasal and two were considered moderately nasal. No articulation errors, other than weak plosives, were noted in three Ss while multiple errors were exhibited by the fourth S. Three Ss had been dismissed from speech therapy and the fourth was receiving therapy prior to the exercise program.

Exercise Tasks. Four voluntary exercise tasks consisting of blowing, sucking, swallowing, and gagging were included in the management program. These particular tasks were chosen for the following reasons:

1. All are accompanied by velopharyngeal action and have been among those activities recommended by previous authors as a means of improving palatal functioning for speech. Experimental findings suggest that blowing and sucking exercises stress velar muscle activity (*3*, *6*, *23*) and that swallowing and gagging exercises stress pharyngeal wall muscle activity (*1*, *5*, *15*).

2. All can be structured so that elements deemed necessary to increase muscle strength, mass, and endurance can be controlled and monitored. Physiologists have suggested that muscle training to increase these parameters must emphasize force, duration, and repetition of efforts (*4*, *7*, *10*).

3. All can be designed to provide Ss with relatively objective goals concerning force, duration, and number of efforts in addition to some form of feedback regarding the successful attainment of these goals.

Blowing and Sucking Tasks. The blowing and sucking tasks were accomplished using the Hunter oral manometer (bleed valve open). Force of each effort was measured in ounces per square inch of pressure. Duration was defined as the length of time, in seconds, each effort was sustained at a predetermined force.

Swallowing Task. The swallowing task was similar to that outlined by Massengill *et al.* (*13*). S was directed to raise the larynx to its highest point maintaining this position as long as possible before completing the swallow. In order to insure proper execution of the task, he was directed to place his index finger on his neck superior to the thyroid cartilage to feel its upward motion. The duration of each effort was measured in seconds.

Gagging Task. A mirror provided visual feedback during the gagging task, which was performed voluntarily. Judgments concerning the adequacy of each effort were based on observations of upward movement of the soft palate and mesial movement of the posterior pillars. Duration of each effort was measured in seconds.

EXERCISE PROGRAM. In an attempt to design a suitable exercise program, the following guidelines were established.

1. Ss were to perform the exercise tasks four times a day, five days per week for six weeks.

2. The blowing and sucking exercises were carried out twice a day, once in the morning before school and again after school. The swallowing and gagging exercises were completed in the remaining two sessions which were scheduled during school hours.

3. Within sessions, Ss were to repeat each task a designated number of times at minimal criteria levels which were established weekly. Tasks were structured so that force and duration could be specified for blowing and sucking while duration was the only variable assessed for swallowing and gagging. Criteria for the first week were derived from Ss' performance in individual pre-program training sessions. Goals for weeks two through six were obtained on the basis of three or more randomly chosen sessions of each foregoing week. Thus, for any given week, the minimal force and/or duration required for each effort of the four tasks was clearly specified. Number of repetitions of each exercise was fixed so that no session was less than 10 or more than 20 minutes in length.

Prior to the study, Ss were informed that they would receive 50 cents daily for completing the exercise sessions and that the allowance would be doubled if they remained in the program for the full six weeks. Payments were made at the completion of treatment.

EXERCISE SUPERVISION. Design of the study prohibited E from monitoring all training sessions for each S and necessitated the enlistment of persons to assist in implementing the program. Ss' mothers agreed to supervise the blowing and sucking tasks in the home and a training session was scheduled with each of them. Similar training sessions were arranged with staff members employed in the Ss' schools who had volunteered to supervise the swallowing and gagging tasks. E acquainted supervisors with their role in the program and observed the first exercise session to insure that supervisors and Ss understood their assignments. Each supervisor was given a chart on which to record number of efforts per session, force and/or duration of each effort, and other relevant observations.

E made a minimum of one weekly visit to the home and school of each S to observe his performance on all tasks, readjust criteria for each task, and answer any questions which may have arisen.

MEASUREMENTS. Effects of the exercise program on palatal functioning and speech were assessed by analyzing VPG measurements and perceived nasality ratings.

Velopharyngeal Gap (VPG) Measurements. VPG measurements were made from lateral cephalometric head films obtained from each S during the sustained production of the vowel /i/. The films were taken approximately one second after the onset of phonation. Two x-rays were obtained immediately before the exercise program, two at the conclusion of the program, and two six weeks after the completion of the program. Each

film was traced on two occasions separated by at least one week. Extent of VPG, in mm, was assessed for each tracing using a micrometer and metric ruler. Measurements obtained at each of the aforementioned intervals were used to derive a VPG—score. A S's VPG—score was computed by averaging the four VPG measurements secured from two tracings of each of the two x-rays taken within a filming session.

Nasality Ratings. Nasality ratings were based upon ten-second connected speech samples obtained from each S. Two samples were secured from each of three recordings sessions—one immediately before the exercise program, one at the conclusion of the program, and one six weeks after the completion of the program. The 24 samples (6 per listener × 4 listeners) were re-recorded onto a master tape in random order. Ratings were made by a listening panel composed of twelve graduate students majoring in speech pathology. A nine-point equal-appearing interval scale was employed with a scale value of one designating "mild nasality" and a value of nine designating "severe nasality." For each S, nasality ratings of samples from each of the three recording sessions were used to equate a nasality score. A S's nasality score was derived by averaging the responses of the twelve listeners to the two samples taken from a particular recording session.

Results

It was hypothesized that the exercise program employed in this study would decrease VPG on sustained vowels and reduce hypernasality.

Data presented in Table 1 show that one S (S3) exhibited a decrease in VPG immediately following the exercise program. However, this decrease was not evident six weeks later. Two Ss (S2, S4) showed no immediate decrease, but a slight reduction appeared after six weeks. None of the differences was statistically significant.

Data presented in Table 2 show some nasality decrease for three Ss (S1, S2, S3) immediately after the exercise program and for two Ss (S2, S4) six weeks later. None of the differences was statistically significant.

Analysis of data in Tables 1 and 2 provides an additional observation. The Ss (S2, S4) who showed a decrease in VPG after six weeks also exhibited a decrease in nasality during the same period of time. Conversely, the S (S3) experiencing the largest decrease in VPG on the immediate follow-up measure showed essentially no accompanying change in his nasality ratings.

TABLE 1. VPG-scores obtained from X-rays of sustained /i/ taken before the exercise program, immediately after the program, and six weeks after the program.

Ss	*before program*	*after program*	*six weeks after program*
S1	7.81 mm	9.69 mm	8.75 mm
S2	7.63 mm	9.43 mm	7.06 mm
S3	3.56 mm	2.25 mm	4.81 mm
S4	4.06 mm	4.69 mm	3.00 mm

TABLE 2. Nasality scores obtained from listeners (N = 12) who rated speech samples taken before the exercise program, immediately after the program, and six weeks after the program. Ratings were made on a nine point equal-appearing interval scale.

Ss	*before program*	*after program*	*six weeks after program*
S1	7.50	6.88	8.04
S2	6.92	6.46	6.09
S3	3.79	3.75	4.09
S4	5.17	5.75	4.92

Reliability of VPG results was evaluated by comparing the measurements obtained from the two tracings of each x-ray. A Pearson correlation coefficient of .99 was found between the 24 sets of measurements and the mean of the difference between the sets (.28 mm) was not statistically significant.

Reliability of nasality ratings was evaluated by having the 12 original listeners re-rate all speech samples after an interval of one week. A Pearson correlation coefficient of .93 was found between the 24 sets of ratings and the mean of the difference between sets (.44) was not statistically significant.

Discussion

This study does not support the notion that voluntary muscle exercises improve velopharyngeal closure or decrease nasality. Failure to demonstrate improvement might be attributable to selection of Ss and exercises, to implementation of the exercise program, or to the choice of measurement techniques. However, techniques employed seem to be comparable to those advocated by some authors and with those reported to be successful in at least one other study (*13*). At this point in time, speech clinicians would probably do well to follow the lead of those investigators (*6*, *14*, *15*) who question the effectiveness of voluntary muscle exercises of the types employed here in programs designed to decrease nasality and improve speech.

The present investigation does not provide information regarding the effectiveness of speech oriented activities in influencing VPG and perceived nasality. It is interesting to note, however, that Shelton *et al.* (*20*) were unable to demonstrate changes in velopharyngeal function following approximately six months of articulation therapy.

Summary

Four Ss with surgically repaired cleft palates, inadequate velopharyngeal closure, and hypernasality were enrolled in an exercise program to study the effects of blowing, sucking, swallowing, and gagging on palatal functioning and speech. Four daily exercise sessions were scheduled, Monday through Friday, for six weeks at which time Ss completed a prescribed number of contractions at a designated force and/or duration. Lateral

cephalometric head films and speech samples were obtained from each subject before the exercise program, immediately following the program, and six weeks after the completion of the program. Measurements of VPG were made during the sustained production of the vowel /i/. Nasality of speech samples was rated on an equal-appearing interval scale by a panel of 12 trained listeners. The non-significant results reported in this study fail to support the use of voluntary muscle exercises to improve velopharyngeal closure or decrease nasality.

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