Training Voluntary Pharyngeal Wall Movements in Children with Normal and Inadequate Velopharyngeal Closure

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The older clinical speech literature recommended use of therapeutic exercises for improvement of palatopharyngeal closure (*1, 7, 9, 16*). However, little research was done to test the efficacy of the exercises and their use declined. Recently, Yules and Chase (*17*) reported successful development of pharyngeal wall movements and reduction of hypernasality in persons with minimal velopharyngeal incompetency. Their procedure involved electrical stimulation and training; however, they mentioned that other sources of stimulation might work equally well.

In an unpublished pilot study one of the authors developed procedures for training pharyngeal wall movements during phonation of /ɑ/. Stimulation with a cotton swab was used to elicit pharyngeal wall movements, and then training was directed toward voluntary production of the movements. Visual observations indicated that three of four young normal female adults learned to produce voluntary mesial movement of the lateral pharyngeal walls and anterior movement of the posterior pharyngeal wall during phonation of /ɑ/. Two of the subjects learned the task in less than 30 minutes. One subject learned in ten days. The fourth subject was given three weeks of training and was able to produce voluntary mesial movement of the lateral walls with phonation but not anterior movement of the posterior pharyngeal wall with phonation.

Tape recordings and color motion pictures were made of the subjects 1) phonating without voluntary pharyngeal wall movements, 2) phonating with voluntary pharyngeal wall movements, and 3) producing voluntary

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This paper is based upon a dissertation completed by Earlene L. Tash, Ph.D., under the direction of Ralph L. Shelton, Ph.D., The University of Kansas, 1970.

This study was supported in part by PHS Research Grant DE02204 and by the Audiology and Speech Pathology Laboratory and the Research Education Committee of the Veterans Administration Hospital, Kansas City, Missouri.

pharyngeal wall movements without phonation. Judges viewing the motion pictures were able to detect whether or not voluntary pharyngeal wall movements were made but could not differentiate between movements with phonation and movements without phonation. Judges listening to audio tapes were able to differentiate between phonations produced with and without voluntary pharyngeal wall movements. Although no measurements were undertaken, it was hypothesized that the judgments may have been made on the basis of some change in fundamental frequency, jitter (aperiodic laryngeal vibration), the perceived pitch of the signal, the duration of the signal, the intensity of the signal, or some combination of the foregoing.

The current study applied touch stimulation procedures and training trials procedures developed in the pilot work to both normal children and children with palatopharyngeal closure deficits. The following questions were studied:

1. Can children with adequate palatopharyngeal closure and children with inadequate palatopharyngeal closure learn to produce voluntary lateral and posterior pharyngeal wall movements during phonation of /ɑ/?
   a. Is there any generalization of these voluntary pharyngeal wall movements to other speech utterances?
   b. Does the training program have an effect on velopharyngeal closure as evaluated by nasal sound level measures, water manometer readings, or cinefluorographic films?
2. Are there perceptual and acoustical differences among phonations produced with and without voluntary pharyngeal wall movements?
3. Are there perceptual differences in nasal resonance when a sentence is spoken by children with velopharyngeal closure deficits before and after the training program?

The measures used will be discussed with reference to their adequacy for measuring changes in velopharyngeal closure.

Procedures

SUBJECTS. Six children between the ages of 4–6 and 6–8 served as subjects in this study. Four had normal palatopharyngeal closure and no history of speech or hearing problems. The remaining two subjects had inadequate palatopharyngeal closure but no palatal clefts. Cinefluorographic films of these two children showed a velopharyngeal gap on some non-nasal consonants, close approximation to closure on others, and probable contact on still others. Their closure patterns would fit category three, sometimes closed during the course of phonation, described by Shelton *et al.* (*11*). Letters identifying numbers of each subject pair are included in Table 1.

Several qualifying tests were administered to the subjects. The normal children were free from articulation errors whereas the pair with poor closure produced plosives, sibilants, and fricatives with audible nasal escape of air, inadequate oral breath pressure, or both. All six subjects had standard scores of 90 or higher on the Peabody Picture Vocabulary Test. They also passed a hearing screening test at 15 dB (ASA) for the frequencies 500, 1000, 2000, 4000, and 8000 Hz.

The six subjects were divided into three pairs. Pair one consisted of the two children with palatopharyngeal closure deficiency. Pairs one and two received the training program and pair three did not receive training.

DESCRIPTION OF TRAINING PROGRAM. The steps in the training program were as follows:

1. Teach positioning of the tongue, control of the gag reflex, and elevation of the soft palate.
2. Elicitation of mesial movement of the lateral pharyngeal walls with touch stimulation and without phonation.
3. Development of voluntary mesial movement of the lateral pharyngeal walls without phonation.
4. Development of mesial movement of the lateral pharyngeal wall with phonation.
5. Development of anterior movement of the posterior pharyngeal wall with phonation. During this step of the training program, lateral pharyngeal wall movement may also occur, but the main emphasis is on anterior movement of the posterior pharyngeal wall.
6. Development of voluntary mesial movement of the lateral pharyngeal walls and anterior movement of the posterior pharyngeal wall with phonation. Stimulation with a cotton swab was used initially to elicit reflexive movement of the pharyngeal walls. Training was then directed toward having the subject voluntarily produce the movement while observing in a mirror and then without observing in a mirror. A detailed description of the training program is presented elsewhere (*15*).

A subject advanced from one of the above steps to the next when his performance reached a pre-selected criterion. Generally, the criterion required successful performance of a training activity during each of ten consecutive trials. If a child regressed in his performance from the previous session, part of the training trials for a session were spent on the previous step of the training program.

Each of the four experimental subjects was to be seen individually on a daily basis, five days a week, until he had completed all steps in the training program or 30 sessions, whichever occurred first. The subjects were instructed not to practice outside the training sessions.

EXPERIMENTAL TRAINING SESSIONS. Each training session consisted of three sections: (1) ten pre-training trials, (2) thirty training task trials, and (3) ten post-training trials. The pre-training and post-training trials consisted of ten attempts to produce both voluntary lateral pharyngeal wall movement and voluntary posterior pharyngeal wall movement with phonation of /ɑ/. The subject was not allowed to observe in the mirror and did not receive touch stimulation or visual or auditory feedback as to the correctness of his response. Training trials and experimenter and observer judgments of the subject's responses during the training program were recorded by use of event recorders.

During the 30 training task trials, the subject generally made 30 attempts at a specific step of the training program. At other times, the subject made a specific number of attempts at one step and a specific number of attempts at another step for a total of thirty attempts. During this training, the subject observed himself in a mirror, and a signal light and verbal statements were used to inform him of successful performance.

Scheduling difficulties and illness prevented the administration of the post-tests immediately after each subject completed the training sequence or the thirtieth lesson. In order to maximize the possibility of detecting any effects of training on the post-tests, each subject was seen a few additional times either for training or testing trials.

Three persons were trained to observe and record pharyngeal wall movements. One observer assisted the experimenter during each training session. Observer-experimenter agreement across sessions ranged from 71 to 100 percent for judgments of lateral wall movements and from 84 to 100 percent for posterior wall movements.

PROCEDURES FOR CINEFLUOROGRAPHIC FILMS. Lateral cinefluorographic films were made of each of the six children before and after the training program. The equipment and procedures used are described elsewhere (*15*). The following events were filmed: 1) /ɑ/ produced normally without voluntary pharyngeal wall movements, 2) /ɑ/ produced with voluntary pharyngeal wall movements, 3) voluntary pharyngeal wall movements without phonation, 4) /i/, /u/, /sis/, /sɑs/, and 5) *The cars are parked on the arcade.* The first three samples were filmed in a random order using a table of random numbers.

The pre- and post-treatment cinefluorographic films were projected in a random order to four judges. The judges were to decide for each filmed event whether forward movement of the posterior pharyngeal wall took place. Forward movement was defined by the projection of two films that showed approximately 4 mm. of pharyngeal wall displacement during each of several utterances.

TAPE RECORDING SUSTAINED /ɑ/ PHONATIONS. (Each subject was tape recorded phonating /ɑ/ for five seconds. These phonations were produced five times normally and again five times accompanied by voluntary pharyngeal wall movement. The recordings were made with a Bruel and Kjaer (B and K) one inch condenser microphone (Model 4132), cathode follower Model 2612, and microphone amplifier (Model 2603). The microphone was positioned three inches from the subject's lips at a 45 degree angle to the subject's mouth. The signal was recorded on one channel of an Ampex AG-350 tape recorder operated at 7½ ips. A 10 kHz tone was recorded simultaneously on the second channel of the tape recorder.

FUNDAMENTAL FREQUENCY AND JITTER ANALYSES. To obtain measures of mean fundamental frequency and mean jitter, prototype equipment was used to generate a train of pulses corresponding to the frequency and periodicity patterns of the recorded phonations. This equipment and procedure has been described in detail by Johnson (*6*). To determine the time interval between the phonation pulses, a TMC pulse height analyzer was used to count the number of 100 kHz pulses that occurred between successive pairs of phonation pulses. This required use of a multivibrator synchronized by the 10 kHz signal previously recorded.

Once these interval values were obtained, they were analyzed by a G.E. 625 computing system programmed to provide for each phonation: 1) mean fundamental frequency in Hz, 2) mean period in msec., 3) mean period deviation (jitter) in msec., and 4) mean jitter ratio. Jitter ratio is defined by following formula:

$$\frac{\text{Mean jitter}}{\text{Mean period}} \times 1000$$

JUDGING PROCEDURES FOR DIFFERENTIATION BETWEEN VOWELS PRODUCED WITH AND WITHOUT VOLUNTARY PHARYNGEAL WALL MOVEMENTS. A tape was prepared for presentation to five judges to determine whether the judges could differentiate between two conditions. Condition 1 was phonation of /ɑ/ without voluntary pharyngeal wall movement, and condition 2 was phonation of /ɑ/ with voluntary pharyngeal wall movement. The tape included recordings of the experimenter producing the two conditions. These recordings served as standards. The tape also included ten practice examples and 48 samples to be categorized. Samples 25 through 48 were duplicates of the first 24. Instructions called for independent judgments. A contingency coefficient (*14*) computed between the first and second judgment made by each judge for each of the 24 samples was significant at the .001 level. Thus, the judgments were reliable.

RECORDING ORAL AND NASAL SL. Oral and nasal sound level (SL) measurements were made of each subject before and after the training program. The procedures have been described elsewhere (*2, 13*). A condenser microphone (B and K model 4134) was positioned ten inches from the subject's mouth. A probe attached to a second microphone (B & K model 3134) was positioned within one naris. The amplifier for the oral microphone was positioned within the subject's view. Throughout the study, each subject used the amplifier meter needle to help him produce each utterance at a comfortable SL identified during his first recording session. Except for the pre-treatment recordings of the two subjects with inadequate closure, the recordings were not made in a sound treated room.[1] The following utterances were tape recorded (Ampex AG-350) and graphically written out on a level recorder (B & K model 2305): /s, ʃ, so, ɝ/ each repeated in groups of three, three separate times, /sɑs/, /sis/, *The cars are*

[1] SPL was measured for the oral channel when recordings were made in the sound treated room.

parked on the arcade, each repeated three separate times, and /ɑ/, /i/, and /u/ each produced normally without voluntary pharyngeal movements, and /ɑ/ produced with voluntary pharyngeal wall movements. Each vowel phonation was produced for approximately five seconds. For all utterances except the vowels, SL values were obtained by averaging peaks associated with each utterance. The repetitions of a vowel by a subject were spliced together and processed through the B and K statistical distribution analyzer (Model 4420) to obtain the mean dB value for the vowel.

Water Manometer Recording Procedures. A U-tube water manometer similar to that described by Hess and McDonald (*4*) was used to measure nasal air pressure during the production of /s/, /ʃ/, /so/, and /ɝ/. The manometer was coupled to both nares by means of a Y tube and straight tubes with 7 mm bores. Maximum displacement for each utterance was read and reported to the nearest .5 cm. in one wing of the U tube. Readings for the three productions were averaged for each utterance. During the testing, subjects monitored the SL of their productions by means of the meter on a B and K microphone amplifier. Utterances were to be produced at a comfortable SL.

Judging Nasal Resonance. Utterances produced by the two subjects with closure deficits were judged for nasality. Eight samples of *The cars are parked on the arcade* were selected randomly from three days of pre-treatment recordings of each subject and eight more were selected from post-treatment recordings. A tape was prepared containing two standards—one a normal voice and one a cleft palate person speaking with her speech obturator removed—, ten practice examples, and 32 samples arranged in random order. The samples were duplicated and presented to twelve judges twice. The duplicates were identified as samples 33 through 64. The samples were played backwards to twelve judges who rated them by the method of equal appearing intervals. Agreement between first and second ratings by each judge was determined by use of the Pearson correlation coefficient. The ratings of five judges were dropped from the study because the ratings assigned the duplicate presentations were not significantly correlated ($p > .01$). Ratings assigned each sample by the remaining seven judges were averaged. Mean ratings for the first presentation of the 32 samples were found to be significantly correlated with ratings assigned the second presentation ($r = .86$; $p < .01$).

Results

Tabulation of Training Program Events. The subjects with adequate velopharyngeal closure who received training were able to produce voluntary lateral wall movement and learned voluntary posterior wall movement with phonation during training according to the criteria set forth in the training program. One subject with velopharyngeal closure deficiency learned only inconsistent mesial movement of the lateral pharyngeal

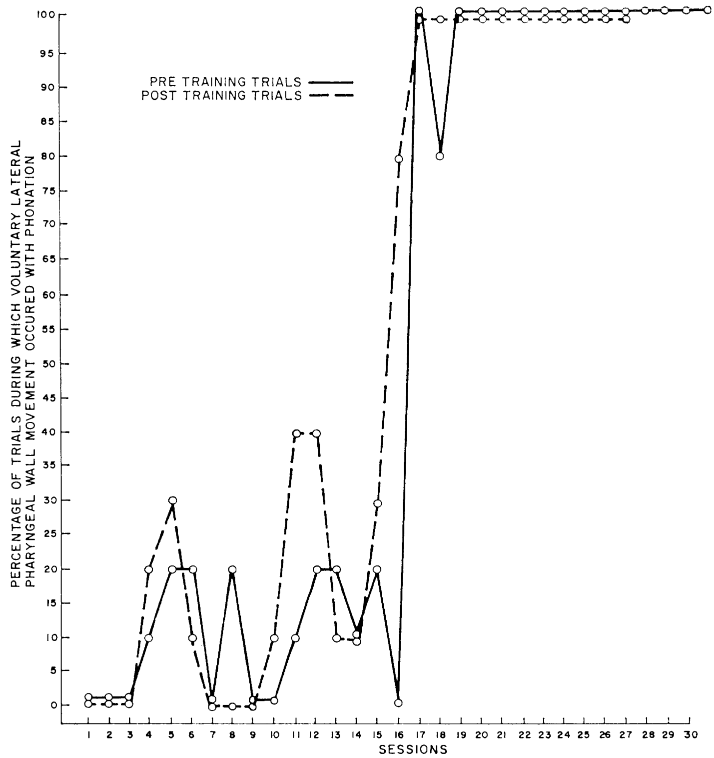

FIGURE 1. Percentage of pre- and post-training trials during which Subject BS produced medial movement of the lateral pharyngeal walls with phonation. This subject did not produce the pharyngeal wall movement simultaneously with phonation of /α/. He began phonating, ceased phonating while producing the pharyngeal wall movement, and with the termination of the movement resumed phonation.

walls. The other subject with a velopharyngeal closure deficit learned to produce voluntary pharyngeal wall movements, but never produced the movements simultaneously with phonation. Figures 1 and 2 are illustrative of subject performance during the training program. The data are from subjects with palatopharyngeal incompetency. Figure 1 shows Subject BS's production of mesial movement of the lateral pharyngeal walls with phonation during the pre- and post-training trials for each session. This subject was inconsistent in production of the movement during the first 17 sessions. From session 18 until termination of his training program, he consistently produced voluntary lateral wall movement.

Figure 2 shows Subject SZ's performance on the training trials for each session. This subject was very inconsistent in her performance. She showed a period of progress followed by a period of regression.

Cinefluorographic Film Analysis. The training did not result in wall movements of sufficient magnitude to be observed in the x-ray films. Of

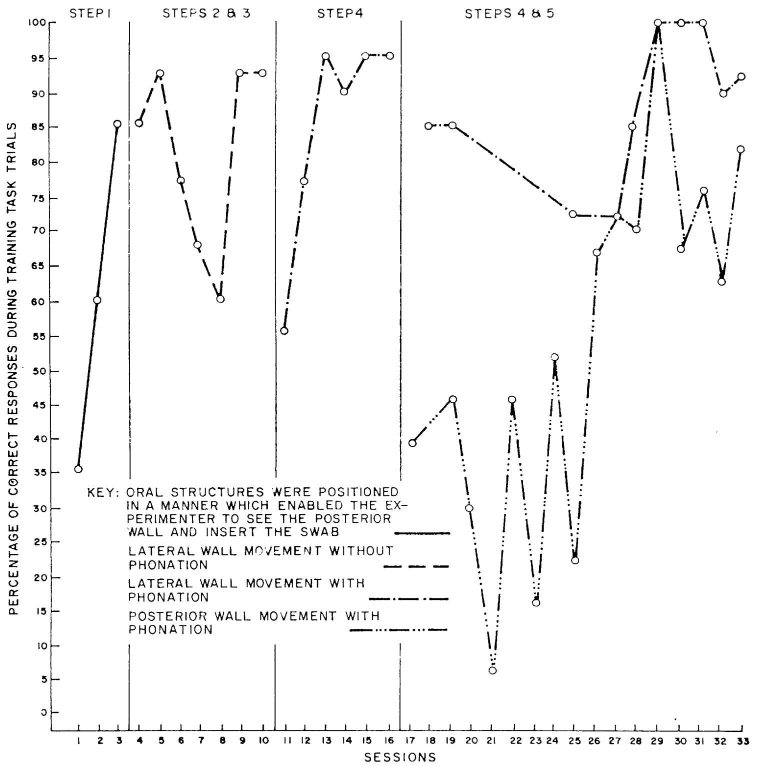

FIGURE 2. Performance on training task trials by Subject SZ.

the 119 utterances filmed, for only three did as many as two of the four judges agree that they observed forward movement of the posterior pharyngeal wall. This conflicts with an experimenter's intraoral observation of movements during the filming. Apparently the observed movements were either too slight or too low in location to be identified in the film. Some of the films were of poor quality, but movements comparable to those that occurred in the standards films would have been observed. While the directions called for the judges to identify movements comparable to those observed in the standards, the judges probably reported any movement they observed even though the magnitude was less than the standard.

The post-treatment cinefluorographic film of one subject with a closure deficit (Subject BS) showed marked elevation of the larynx and occlusion of the entire pharynx as he attempted to produce the pharyngeal wall movements. Phonation was terminated during this elevation and occlusion. The elevation of the larynx suggests training procedures may contribute to the development of laryngeal abuse in some persons.

Nasal SL Value. Because nasal SL is variable within subjects across testing days (*10, 13*), it was necessary to specify how much of a decrease in nasal SL must occur before the decrease could be attributed to the training. The criterion selected required the highest post-treatment SL value to be lower than the lowest pre-treatment value for the speech sample. Of the eleven speech samples tested, only the /ʃ/ for Subject SZ and the /s/ for Subject BS decreased sufficiently after the treatment to meet the criterion indicating a treatment effect.

MANOMETRIC RECORDINGS. The two subjects with velopharyngeal closure deficits displaced more water on all three sound samples /sss/, /ʃʃʃ/, and /sososo/ after the treatment than before the treatment. The four subjects with adequate velopharyngeal closure produced little or no water displacement on any of the sounds during either pre- or post-treatment tests.

JUDGE CLASSIFICATION OF SUSTAINED /ɑ/ PHONATIONS PRODUCED WITH AND WITHOUT VOLUNTARY PHARYNGEAL WALL MOVEMENTS. Table 1 reports the percentage of judge classifications that agreed with the directions given to the subjects. The results indicate that judges could not systematically differentiate between phonations produced normally and those produced with voluntary pharyngeal wall movements. This was true for phonations produced by all six subjects. This is a perplexing result for two reasons. First, in the pilot study listeners were able to differentiate systematically between the two types of phonation produced by normal speaking adults. Second, during the training program the investigator and the observers noted a perceptual change in the vowel sound when the phonation was produced with the pharyngeal wall movements. The child who produced the laryngeal elevations described above, Subject BS, always interrupted his post-treatment production of /ɑ/ in trials requiring voluntary pharyngeal wall movements. His data involved voicing that preceded or followed the voluntary movement.

FUNDAMENTAL FREQUENCY ANALYSIS OF SUSTAINED /ɑ/ PHONATIONS. The mean fundamental frequency for each phonation produced with and without voluntary pharyngeal wall movement attempts pre- and post-treatment is presented in Table 1. The largest post-treatment difference between the two types of phonations for any subject was 18.9 Hz. Some subjects showed small increases in fundamental frequency and some showed small decreases. Comparable variability was observed in the pre-treatment phonations. There does not appear to be any consistent difference in fundamental frequency between the phonations produced with the voluntary movements and those produced without the movements.

JITTER ANALYSIS OF SUSTAINED /ɑ/ PHONATIONS. The mean period deviation or jitter for each phonation produced with and without voluntary pharyngeal wall movement attempts before and after the treatment is presented in Table 1. The jitter differences between the two types of phonations ranged from 0 to .05. The jitter for the pathological subjects was lower after the treatment period than before the treatment period.

Jitter ratios for all pre- and post-treatment phonations produced with and without voluntary pharyngeal wall movements are presented in Table

TABLE 1. Phonation classification, mean fundamental frequency in Hz, mean jitter in msec., and mean jitter ratio in msec. These data are based on recordings of sustained /ɑ/ phonations produced with and without voluntary pharyngeal wall movements. Subjects were recorded before and after the treatment period.

subjects	*percent of correct* judge classification*		*fundamental frequency*		*jitter*		*jitter ratio*	
	pre	*post*	*pre*	*post*	*pre*	*post*	*pre*	*post*
Pathologicals who were trained								
SZ pho. w/o mov.	20	50	149.8	144.8	.05	.02	7.5	3.5
pho. w/ mov.	80	60	145.0	144.8	.09	.02	12.9	3.2
BS pho. w/o mov.	0	70	221.9	166.4	.11	.02	14.3	2.9
pho. w/ mov.	100	40	236.3	173.9	.15	.07	35.8	12.8
Normals who were trained								
PB pho. w/o mov.	60	90	167.2	173.8	.03	.02	4.8	4.3
pho. w/ mov.	70	50	170.7	192.7	.03	.03	5.2	6.2
TL pho. w/o mov.	70	70	173.4	153.4	.04	.03	7.2	5.2
pho. w/ mov.	60	10	169.5	152.2	.03	.02	4.9	2.8
Controls not trained								
JA pho. w/o mov.	40	10	187.4	205.7	.05	.08	9.8	15.7
pho. w/ mov.	50	80	183.2	200.9	.06	.09	11.4	18.2
LS pho. w/o mov.	60	80	160.8	159.0	.05	.04	8.4	2.5
pho. w/ mov.	30	40	160.7	159.7	.02	.03	7.3	4.8

* Correct indicates that the judge assigned the response to the category that the subject was attempting to produce.

1. The jitter ratios for all phonations produced with and without voluntary pharyngeal wall movements pre- and post-treatment of all subjects were less than 18.0 with two exceptions. A jitter ratio of 18 or greater is considered abnormally large (*5*). Subject BS had an abnormally large jitter ratio (35.8) during the pre-treatment phonation with voluntary pharyngeal wall movements. During the post-treatment phonations control Subject JA had an abnormally high jitter ratio (18.2) associated with the phonation produced with voluntary pharyngeal wall movements. The post-treatment difference in mean jitter ratio between the two types of phonations for each subject ranged from −2.4 (minus sign indicates a lower jitter ratio with than without movement) to 9.9.

The mean jitter ratios for the subject pairs that received the training program were lower after the training than they were before the training program. This was true for both the normal phonations and phonations produced with voluntary pharyngeal wall movements. The mean jitter ratios for the control pair remained the same or increased from pre- to post-treatment testing. It is not possible from these data to determine whether the improved stability of laryngeal generation exhibited by the two experimental pairs was the result of either pharyngeal wall movement training or of having had more practice sustaining /ɑ/. The results do indicate that jitter ratios are little influenced by voluntary pharyngeal wall movements.

PERCEPTUAL JUDGMENTS OF NASAL RESONANCE. The means and standard deviations of nasal resonance pre- and post-treatment for each subject with velopharyngeal closure deficits were calculated. Before the training program, Subject SZ's nasal resonance was judged to be 6.45 (S.D. = .22) while after training it was judged to be 3.84 (S.D. = 1.18). Subject BS's speech resonance received a scale value of 4.68 (S.D. = .72) before training and 3.97 (S.D. = .54) after training. Although a decrease in nasal resonance during the production of a sentence by the subjects with velopharyngeal closure deficits was not expected, the results of scaling nasal resonance indicate both subjects produced less nasal resonance after treatment than they produced before the treatment. Because there was no control group of subjects with velopharyngeal closure deficits who did not receive the training program, the investigators are reluctant to infer a direct cause-effect relationship between training and reduction in nasal resonance. Even if some decrease in nasal resonance could be attributed to the training program, the cinefluorographic films, the nasal SL, and the manometric measure indicate the treatment was not effective in producing adequate velopharyngeal closure.

Discussion

Experimenter observations during training indicated that the subjects did learn to produce voluntary movements of the pharyngeal walls. However, these movements did not influence velopharyngeal closure as tested in several ways. The latter result is not consistent with the findings of Yules and Chase (*17*). However, their procedures differed from those used in this study. Where Yules and Chase used electrical stimulation to elicit pharyngeal wall movements during the initial stages of their training program, a cotton swab was used to elicit movement in the present study. Yules and Chase wrote "Although any object for touching the pharyngeal wall might prove effective, it is believed that electrical muscle stimulation is needed. . . ." A particular advantage for using electrical stimulation is that it may elicit the maximum movement from its first application. This maximum movement can be used as the criterion for the extent of movement which the subject must produce voluntarily. Additional investigation is needed to identify subject and other variables likely to be associated with successful development of movement. While cinefluorographic films of the two subjects with closure deficits did show contact between the palate and the posterior pharyngeal wall in some utterances, it is possible that their closure deficits exceeded some maximum associated with successful use of pharyngeal wall training. The conclusion that the subjects did learn movements is based on reliable intraoral judgments. However, the movements observed were below the level of interest, and no movement may have occurred that would contribute to closure. Clinicians applying these training procedures cannot rely on visual observation as evidence of success.

This study differed from the work of Yules and Chase in that here an attempt was made to measure change in velopharyngeal closure associated with each lesson. Limitation of measurement to pre- and post-treatment observations would have missed the evidence of progress and regression shown by subject SZ in the training trial data. Measurements were employed that had previously proved useful in deciding whether or not closure was adequate (*12, 13*). However, if modest improvements in closure occurred, the measurements failed to show them. Nasal SL was so variable from one recording to another that any treatment effect present was not evident. Variables in addition to closure influenced all of the closure measures. This study indicates that measurement of small changes in palatopharyngeal closure is much more difficult than evaluation of whether or not closure is adequate.

The water manometer has an advantage over nasal SL measurement in that normal performance involves little or no water displacement whereas no threshold associated with excessive nasal SL has been identified. Even though the water manometer clearly differentiated between the normal subjects and the pathological subjects, variability within the pathological subjects was so great that any treatment effect was not identified. To show a treatment effect, a subject would have to displace considerable water prior to a treatment, and during the treatment period his water displacement would have to approach zero. An individual with high manometer readings is probably a poor candidate for movement training. Nevertheless, if speaker effort during speech production and other unidentified subject variables could be held constant, the water manometer might prove to be useful for measuring modest closure improvement during treatment.

The cinefluorographic procedure used was adequate for assessment of movement of the posterior pharyngeal wall. Film clarity is important; otherwise the viewers may confuse the ramus of the mandible and the posterior wall. However, to be of clinical significance, developed movement must be of relatively great extent, and such movement can be identified in films of even modestly clear quality.

Training would be greatly enhanced if the experimenter and subject could directly observe the pharyngeal wall during closed mouth sounds. Perhaps the fiberscope discussed by Harris (*3*) will serve this purpose.

Originally color motion pictures were to be used to measure lateral pharyngeal wall movement. During the filming the subjects did not maintain this oral posture and the structures of interest could not be seen on the film. Therefore, upon completion of the training program three judges rated the extent and location of lateral pharyngeal wall movement and extent of anterior movement of the posterior pharyngeal wall during (1) normal phonation of /ɑ/, (2) phonation of /ɑ/ with voluntary pharyngeal wall movements, and (3) production of voluntary wall movements without phonation. The observers indicated that some of the subjects did not produce the voluntary pharyngeal wall movements during the post-treatment evaluation which they had produced during training sessions. Either the subjects were unable to maintain the newly acquired skill in the time between the termination of the training program and the testing session, or the observer's criteria for pharyngeal wall movement during the training program differed from the criteria used during the post-treatment testing. The investigators believe the latter occurred. However, maintenance of skilled use of learned pharyngeal wall movements following termination of training remains to be demonstrated.

The acoustical analysis of the /ɑ/ phonations demonstrated no negative changes in the voice signal. Nevertheless, the elevation of the larynx and interruption of voicing observed in one subject suggests that pharyngeal movement exercises may sometimes have an unwanted effect on the larynx. McWilliams, Bluestone, and Musgrave (*8*) reported data regarding the relationship between velopharyngeal closure and laryngeal pathology. They stated that children with borderline closure deficits may learn laryngeal compensations if given speech therapy. Any procedure used for developing pharyngeal wall movements should be carefully monitored to make sure that unwanted laryngeal movements do not occur.

Summary

Two subjects with velopharyngeal deficits and two normal subjects received a training program designed to teach voluntary pharyngeal wall movements during phonation. Training responses were recorded and measures related to velopharyngeal closure were made several times before and after treatment. Ability to make pharyngeal wall movements was improved, but any effect on closure was not clinically significant.

Acknowledgements: The authors wish to thank Mrs. Donna Brahl, Mrs. Mary Elbert, and Mrs. Virginia Wright for their participation in the study, Dr. William B. Arndt for providing statistical advice, and Dr. Karl A. Youngstrom for the cinefluorographic filming.

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