12-1984

Speech Results Following Modified Pharyngeal Flap Surgery

Karen S. Zalewski
Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/masters_theses

Part of the Speech Pathology and Audiology Commons

Recommended Citation
https://scholarworks.wmich.edu/masters_theses/1573
SPEECH RESULTS FOLLOWING MODIFIED PHARYNGEAL FLAP SURGERY

by

KAREN S. ZALEWSKI

A Thesis
Submitted to The
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Speech Pathology and Audiology

Western Michigan University
Kalamazoo, MI
December 1984
SPEECH RESULTS FOLLOWING MODIFIED PHARYNGEAL FLAP SURGERY

Karen S. Zalewski, M.A.
Western Michigan University, 1984

It is the purpose of this study to provide a descriptive analysis of 13 patients who have undergone a modified pharyngeal flap surgery completed by one plastic surgeon. Variables associated with the speech of these individuals were based on four measures, including a questionnaire, the Iowa Pressure Articulation Test, the screening portion of the Templin-Darley Test of Articulation, and listener ratings of audio-taped post-surgical speech samples.

Of the eight subject variables studied, two variables were found to be closely associated with speech results. These variables included number of surgeries performed on subjects and number of years in speech therapy. The rating scales were also found to be effective instruments for the measurement of hypernasal resonance and nasal emission. Information gathered in this study would be helpful to others who seek to evaluate the effects on speech of individuals who have undergone various surgical interventions for the improvement of speech articulation and intelligibility.
ACKNOWLEDGEMENTS

Many persons were instrumental in the completion of this study, and all deserve to be recognized for their valuable contributions. I would first like to thank my committee: Chairman Dr. Clyde Willis, for his support and guidance, Dr. Frank Newman, for his helpful suggestions and permission for patient evaluations, Dr. Nickola Nelson, who was instrumental and invaluable in the organization and design of this study, Mr. Jeffrey Higginbotham, for his assistance in statistical analysis and graphics, and especially Dr. John Hanley, for his unlimited guidance, motivation, and encouragement throughout the research period.

Sincerest appreciation is extended to Mr. William Dawson, for advising in the design of audio taping procedures, the Department of Speech Pathology and Audiology and the College of Health and Human Services for the use of their facilities and equipment, and especially The Graduate College, for financial support through The Graduate College Research Fund. Thanks are also extended to Dr. Newman’s staff, patients and parents for their cooperation during the collection of data. Finally, the author would like to thank her parents, family and Mr. Alan Ferenc for their unlimited support during this research period.

Karen S. Zalewski

ii
INFORMATION TO USERS

This reproduction was made from a copy of a document sent to us for microfilming. While the most advanced technology has been used to photograph and reproduce this document, the quality of the reproduction is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help clarify markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure complete continuity.

2. When an image on the film is obliterated with a round black mark, it is an indication of either blurred copy because of movement during exposure, duplicate copy, or copyrighted materials that should not have been filmed. For blurred pages, a good image of the page can be found in the adjacent frame. If copyrighted materials were deleted, a target note will appear listing the pages in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed, a definite method of "sectioning" the material has been followed. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For illustrations that cannot be satisfactorily reproduced by xerographic means, photographic prints can be purchased at additional cost and inserted into your xerographic copy. These prints are available upon request from the Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases the best available copy has been filmed.
ZALEWSKI, KAREN SUE

SPEECH RESULTS FOLLOWING MODIFIED PHARYNGEAL FLAP SURGERY

WESTERN MICHIGAN UNIVERSITY M.A. 1984

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark \( √ \).

1. Glossy photographs or pages
2. Colored illustrations, paper or print
3. Photographs with dark background
4. Illustrations are poor copy
5. Pages with black marks, not original copy
6. Print shows through as there is text on both sides of page
7. Indistinct, broken or small print on several pages
8. Print exceeds margin requirements
9. Tightly bound copy with print lost in spine
10. Computer printout pages with indistinct print
11. Page(s) lacking when material received, and not available from school or author.
12. Page(s) seem to be missing in numbering only as text follows.
13. Two pages numbered. Text follows.
14. Curling and wrinkled pages
15. Other

University Microfilms International

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vi</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Experimental Questions</td>
<td>3</td>
</tr>
<tr>
<td>II. REVIEW OF THE LITERATURE</td>
<td>4</td>
</tr>
<tr>
<td>Patterns of Velopharyngeal Closure</td>
<td>4</td>
</tr>
<tr>
<td>Velopharyngeal Closure Evaluation</td>
<td>9</td>
</tr>
<tr>
<td>Management of Velopharyngeal Insufficiency</td>
<td>13</td>
</tr>
<tr>
<td>Related Information</td>
<td>23</td>
</tr>
<tr>
<td>III. METHOD</td>
<td>26</td>
</tr>
<tr>
<td>Subject Selection</td>
<td>26</td>
</tr>
<tr>
<td>Procedures</td>
<td>28</td>
</tr>
<tr>
<td>Reliability</td>
<td>31</td>
</tr>
<tr>
<td>Listener Judgment</td>
<td>33</td>
</tr>
<tr>
<td>IV. RESULTS</td>
<td>38</td>
</tr>
<tr>
<td>Speech Articulation Test Results</td>
<td>38</td>
</tr>
<tr>
<td>Relationship of Subject Variables to Articulation Scores and Ratings</td>
<td>39</td>
</tr>
<tr>
<td>Relationship of Selected Subjects to Unavailable Subjects</td>
<td>71</td>
</tr>
<tr>
<td>V. DISCUSSION AND CONCLUSIONS</td>
<td>75</td>
</tr>
<tr>
<td>Score Distribution and Related Variables</td>
<td>75</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Implications ........................................ 87
Conclusions ........................................ 91

APPENDICES
A. Letter of Inquiry ............................... 96
B. Questionnaire and Explanatory Letter ....... 98
C. Consent Letter .................................. 103
D. TDST and IPAT Items ......................... 105
E. Rating Instructions, Rating Scales, Response Form ........................................... 108
F. Selected Subject Characteristics, Means and Standard Deviations ..................... 116
G. Comparisons between Selected Subjects (Group A) and Subjects Not Available (Group B) for Analysis of Selected Variables ........................................ 118

BIBLIOGRAPHY.......................................... 120
LIST OF TABLES

1. Misarticulations Associated with Cleft Palate Speakers .......................... 30

2. Chi Square and Phi Coefficient Values for High and Low Speech Articulation Scores Compared to Selected Variables ........................... 44

3. Means and Standard Deviations of Judges' Mean Ratings of Speech Quality Grouped by High and Low Speech Articulation Test Scores ........................................ 57

4. Chi Square and Phi Coefficient Values for Subjects' High and Low Speech Articulation Test Scores Compared to Judges' Mean Ratings ......................... 67

5. Error Distribution for Test Items Specific to the TDST, IPAT or Both Tests for Members of the Low Articulation Test Group .............................. 70
LIST OF FIGURES

1. Ranked TDST and IPAT Scores ...................... 40
2. Frequency Distribution of TDST and IPAT Scores ... 41
3. A Comparison of High and Low Articulation Scores with Number of Surgeries .................. 45
4. A Comparison of High and Low Articulation Scores with Number of Years in Speech Therapy .... 46
5. A Comparison of High and Low Articulation Scores with Difficulty and No Difficulty from Birth ........................................ 47
6. A Comparison of High and Low Articulation Scores of Subjects Who Do and Do Not Display Cleft Palate.................. 48
7. A Comparison of High and Low Articulation Scores with Mean Number of Years Since Surgery ........................................ 49
8. A Comparison of High and Low Articulation Scores with History/No History of Hearing Loss ........................................ 50
9. A Comparison of High and Low Articulation Scores with Effective and Ineffective Speech Therapy ........................................ 51
10. A Comparison of High and Low Articulation Scores with Effective and Ineffective Surgery ........................................ 52
11. A Comparison of High and Low Articulation Scores with Males and Females .................. 54
12. Judges' Mean Ratings for Each Subject on Scale A. General Degree of Hyponasal Resonance .... 61
13. A Comparison of High and Low Articulation Scores with Judges' Ratings of Scale A. General Degree of Hyponasal Resonance .... 61
14. Judges' Mean Ratings for Each Subject on Scale B. Degree of Nasal Resonance ................. 62

vi
15. A Comparison of High and Low Articulation Scores with Judges' Ratings of Scale B. 
  Hypernasal Resonance .............................................. 63

16. Judges' Mean Ratings for Each Subject on Scale C. Nasal Emission .............................. 64

17. A Comparison of High and Low Articulation Scores with Judges' Ratings of Scale C. 
  Nasal Emission .......................................................... 65

18. Judges' Mean Ratings for Each Subject on Scale D. Intelligibility ...................................... 66

19. A Comparison of High and Low Articulation Scores with Judges' Ratings of Scale D. 
  Intelligibility ............................................................. 66

vii

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
CHAPTER I

INTRODUCTION

Certain speech characteristics, such as excessive nasal emission and the acoustic quality of hypernasality, have been associated with cleft palate speakers. In most cleft palate speakers and some non-cleft populations, velopharyngeal insufficiency, an inappropriate interaction of velar and pharyngeal nerves, muscles, and structures, leads to hypernasal speech quality.

Attempts to measure velopharyngeal insufficiency and management methods to reduce it have been carried out in a number of ways. Measurement methods have been both indirect and direct. Indirect measurements have included measures of airflow, air pressure, acoustic signals and analysis of speech characteristics. Direct methods of measurement include oral and nasal endoscopy, cinefluorography, electromyography, and other methods of X-ray analysis.

Direct and indirect measurement methods are also used to evaluate the results of clinical management procedures. The decision as to which method to select is often based, in part, on measurements of the size of the velopharyngeal opening and extent of movement of the existing structures. Other considerations, such as medical history, age, and
degree of structural and muscle impairments, are also important.

In this study, indirect measures were used in an attempt to evaluate the speech of 29 patients who had undergone a specific procedure. Subjects were individuals who had experienced a modified velopharyngeal flap procedure performed by a plastic surgeon between October, 1979 and September, 1983.

Speech analysis was chosen as the method of assessing the proficiency following the surgery over other methods of analysis for a number of reasons, but was primarily determined by the practical availability of test materials, examiner qualifications, and professional interests. However, the choice of technique was also based on the theoretical strong grounds that it is the speech of the individual that determines, in large part, how successful the treatment method is considered by society.

For this study, the speech analysis involved (a) articulatory assessments by an examiner and (b) listener judgments of several factors related to hypernasality in connected speech samples by a panel of trained judges. The articulatory assessments were accompanied by measures of intra- and inter-judge reliability. Other pertinent historical information about subjects was gathered through questionnaire information.
Experimental Questions

This study was designed to answer the following experimental questions:

(a) Are certain subject characteristics consistent with qualitative or quantitative characteristic speech results (i.e., Do males have higher speech articulation scores than females)?

(b) Are environmental factors associated with improved speech in these subjects (such as concurrent speech therapy)?
CHAPTER II

REVIEW OF THE LITERATURE

Patterns of Velopharyngeal Closure

Velopharyngeal closure has been defined in a number of ways. It can be described as the functional separation between the oral and nasal cavities. Closure is affected by the movement of the soft palate coupled with the mesial movement of the lateral pharyngeal walls and the slightly anterior movement of the posterior pharyngeal walls (Skolnick, 1975). According to Lubker (1975), velopharyngeal closure is the result of a certain group of muscles working together. The function of any one of the muscles is dependent on what the other muscles in the group are doing. Lubker suggests that this set functions across time as well as instantaneously. Additionally, Lubker suggests that critical relationships in the function of velopharyngeal mechanism include the spatial positions of the articulators for acceptable phoneme production and the context of the assumed positions. Such relationships are often described as the "coarticulation phenomenon" (Lubker, 1975).

Skolnick (1975) noted that the primary mechanism of velopharyngeal closure appeared to be sphincteric. The
velum forms the anterior margin of the sphincter, while "pharyngeal movements consist of motions of the pharyngeal walls, forming a crescent beginning from one side of the lateral aspects of the velum on one side and passing through the posterior aspects of the nasal pharynx to the lateral aspects of the velum on the opposite side" (p. 288). Skolnick (1975) noted some variance in the contribution of the velar and pharyngeal components between and within subjects. He described three types of closure patterns: (1) coronal (side-to-side), (2) circular, with and without Passavant's ridge, and (3) sagittal (front-to-back).

In the coronal pattern of velopharyngeal closure, velar action is usually equal to or greater than pharyngeal action (Skolnick, 1975). The circular pattern reveals an increase in the pharyngeal wall movement that may compensate for a shortened velum or for reduced velar movement. The sagittal types of closure demonstrate markedly increased mesial movement of the lateral aspects of the sphincter that results in midline approximation of the lateral portions of the sphincter. The velum then touches the bulge formed by the abutted lateral portions of the sphincter, instead of touching the posterior pharyngeal wall. This variety in normal patterns of closure suggest
that several important subject specific variables must be considered for subjects with velopharyngeal insufficiency.

Abnormal Velopharyngeal Closure

According to Bradley (1971), velopharyngeal insufficiency is "considered to be a physiological condition in which the soft palate fails to reach the posterior wall of the pharynx and functionally separate the nasal from the oral cavity" (p. 660). Bradley further noted that this velopharyngeal insufficiency results in hypernasal speech. Hypernasality is often considered to be an unacceptable speech quality that is often the symptom that prompts persons to seek management and evaluation of velopharyngeal insufficiency.

Investigations into the causes of velopharyngeal insufficiency have more clearly defined the factors associated with, but not necessarily causing the insufficiency. Factors frequently associated with velopharyngeal insufficiency include cleft palate with or without cleft lip, and congenital palatal insufficiency with or without visual stigmata (Peterson-Falzone and Pruzansky, 1976). Visual stigmata used to determine the presence of a submucous cleft are a triad of symptoms including the muscular disunion of the soft palate, a bifid uvula, and/or notching of the posterior border of the hard
palate. Hypernasal speech is usually evident (Calnan, 1954). It is important to note, however, that a variety of causes of velopharyngeal insufficiency may exist and the affected person may also display cleft lip and/or palate, the triad of symptoms previously mentioned, or have no other observable abnormalities present.

Speech Characteristics

Certain speech characteristics are associated with velopharyngeal insufficiency, and the severity of speech disorder is related, in part, to the degree of velopharyngeal insufficiency. Speech characteristics include: (1) weak production of plosive sounds /p/, /b/, /k/, /g/, /t/, /d/; (2) alae constriction during production of consonants; (3) nasal emission of air during sound production; and (4) presence of non-speech sounds (Bradley, 1971). The consonants /s/, /ʃ/, /tʃ/, and /z/, and the high vowels /u/ and /i/ may be hypernasal if the previous four characteristics are observed. The attempted production of fricatives and affricates may result in glottal stops or pharyngeal fricatives.

Other speech characteristics in association with minimal velopharyngeal insufficiency include mild hypernasal voice quality, slight emission of air and
Pharyngeal distortions of the /s/ and /z/ sounds (Bradley, 1971). Trost (1981) noted deviant speech characteristics which included hypernasality, nasal air emission, "weak" pressure consonants, and compensatory articulation. Hypernasality was described by Trost as the resonance disturbance which accompanies vowels and vocalic consonants and which gives rise to the perception of a deviant voice quality. Nasal air emission, on the other hand, was described as the production of pressure consonants that was accompanied by nasal airflow.

The manner of production of weak pressure consonants is usually altered in speakers with velopharyngeal insufficiency. According to Trost, (1981), a correct articulatory movement gesture can be ineffective or limited because of reduced intraoral pressure. Compensatory articulations for weak consonant production included movements typically associated with the glottal stop, the pharyngeal fricative and the velar fricative. According to Trost, the glottal stop, a plosive consonant, is produced by vocal fold valving, while the pharyngeal fricative is the result of a narrowing of the pharyngeal area through lingua-pharyngeal articulatory constriction. The velar fricative is produced in the place of a /k/ or /g/ phoneme and is produced lingua-velarly. The pharyngeal stop is best described as a /k/ or /g/ produced with the tongue.
positioned inferior and posterior to its normal target place. Trost defines the mid-dorsum palatal stop as a stop consonant made in the approximate place of the glide /j/, but the posterior nasal fricative was variable in its placement. Sometimes it appears to be generated at the velopharyngeal port approximating the wall of the pharynx, but because there is no velopharyngeal seal, the air is released nasally. A number of acoustic, radiographic, or direct measurement techniques have been used to identify these varied speech behaviors.

**Velopharyngeal Closure Evaluation**

**Indirect Evaluation**

Evaluation of velopharyngeal closure may be undertaken in a number of ways. Methods have included both indirect and direct assessments. Indirect methods of velopharyngeal closure assessment encompass the measures of: (1) airflow, (2) air pressure, (3) acoustic speech signals; and (4) perceptual speech analysis.

Airflow measures have been used to indicate the patency of the velopharyngeal valve. A variety of instruments has been used, including those that measure both oral and nasal air flow. One such instrument, the pneumotachograph, measures airflow, but does not measure
air pressure in the oral cavity. Sensing of variations in air pressure during speech tasks, however, may be possible through the use of a pressure transducer which is attached to the instrument. Certain airflow measures, such as blowing devices and mirrors which record nasal fogging, have been observed by Warren, Wood and Bradley (1969) to be related more to respiratory effort than to palatal closure.

Oral manometers have been used to record breath-pressure ratios as an index of velopharyngeal adequacy (Morris, 1966). Morris described the usefulness of the oral manometer as a somewhat gross measure of the efficiency of the palatopharyngeal mechanism during blowing. The manometer measures only the amount of intraoral air pressure produced by persons during a blowing task, rather than measuring the pressures of the relatively rapid velopharyngeal movements required of a speaking task, and this may be a measurement which is less meaningful to the speech pathologist who is attempting to assess velopharyngeal competency. The time allowed for velopharyngeal closure for the manometer task is greater than that which is allowed during normal speaking tasks. This may result in misinterpretation of these measures which use these techniques if the discrepancy is not taken into consideration. In general, simple manometric
instruments have not provided the definitive diagnostic information required by most clinicians.

A number of acoustical measuring devices are available for assessment of velopharyngeal adequacy (Warren, 1975). These include sonograph recorders and nasality meters. In addition to such devices, researchers have also used spectral analyses from electronic speech synthesizers to associate certain acoustic characteristics with spectra that reflect nasalyzed speech (Skolnick, 1975).

Other indirect methods of velopharyngeal closure include speech analyses based on phoneme/linguistic criteria. A number of speech articulation tests are available, but the Iowa Pressure Articulation Test (IPAT) developed by Morris, Spriestersbach and Darley (1961), is particularly useful. This test is actually a subtest of the Templin-Darley Test of Articulation (Templin and Darley, 1960), and is useful primarily because of the normative data available which establishes validity and enhances interpretation of scores (Van Demark and Morris, 1977). This 43-item test assesses the adequacy of oral pressure for speech sound production. According to Morris, et al. (1961), the test inferentially assesses velopharyngeal closure adequacy. Findings of one study of this test completed by Van Demark and Morris (1977), indicated that a lack of improvement (over time) in test
scores is a good indicator that secondary palatal surgery will be needed to improve velopharyngeal adequacy.

Direct Evaluation

In addition to indirect methods of assessment, direct measures may also be used in the evaluation of velopharyngeal adequacy. Direct measures of velopharyngeal insufficiency are measures that are "obtained through the use of a procedure that yields information about the opening itself rather than inferring opening size through some indirect means" (Schwartz, 1975, p. 305) as in the methods previously described. Three direct methods were described by Schwartz (1975). These include: (a) the basal X-ray, which has the disadvantage of not being time-varying; (b) the use of fiberoptic nasendoscopy, which does not present a linear picture but one that distorts progressively as a function of the distance from the center of velopharyngeal closure; and (c) ultrasound, which is presently in a state of rapid technical development. Schwartz (1975) notes that all of these techniques fall short of being totally objective measures of velopharyngeal insufficiency.

Another direct method for the assessment of velopharyngeal insufficiency is the oral endoscope. The instrument is an illuminated tubular optical device
that allows examination of the velopharyngeal mechanism during phonation. Audio-visual recording associated with the view can be obtained. The surface anatomy of the mucosal membranes of the velopharyngeal mechanism can be observed. This observation is not possible with conventional X-rays. Several improvements have been made since the development of the original Taub oral panendoscope. Most notable is the introduction of fiberoptics which allow for the intense heat of the light source to be placed at a point more distal from the membranes under observation (Willis and Stutz, 1972). However, unless the examiner is well trained, the likelihood of accurate measurements may be reduced.

Management of Velopharyngeal Insufficiency

Nonsurgical Management

Primary non-surgical techniques for the management of velopharyngeal insufficiency include prosthetics and speech therapy. The primary function of prostheses is to assist the approximation of the soft palate and pharynx by providing the structural support necessary for appropriate speech production. According to Lang (1971), factors to be considered in the selection of treatment, especially in reference to prostheses, include the "peridontal condition
of the gingival tissues, clinical form and arrangement of teeth, occlusion, dental hygiene, and patient motivation for future care of dental structures and prosthesis" (p. 476-477).

A variety of prostheses are available to comply with the anatomical and physiological differences in patients. Appliances include: (1) cleft palate obturators; (2) modified speech-aid appliances; (3) modified palatal lift prostheses; (4) strap and bulb prostheses; and (5) palatal stimulators. Cleft palate obturators separate the oral and nasal cavities through the use of artificial materials. The strap and bulb prosthesis functions by separating the oral and nasal cavities. The speech-aid appliance improves soft palate function by supporting the intact soft palate.

Although the type of appliance might vary from individual to individual, some similarities of form and function in patients allow for grouping of patients relative to appliance type that might be most appropriate for them. If the individual has an active soft palate, either the cleft palate obturator or a speech-aid appliance may be used. If the velopharyngeal gap is large, the strap and bulb obturator may be more functional. In the case of a small velopharyngeal gap, a speech aid appliance may be more successful because the strap portion of the strap and
bulb prosthesis may interfere with tongue movement (Lang, 1971).

Patients with immobile palates and hypernasal speech often receive maximum benefit from the palatal lift appliance. The palatal lift appliance may increase speech intelligibility by elevating the soft palate in an upward and backward direction, a movement typical of normal speech (Lang, 1971). In the patient with an inconsistent palate, the palatal lift speech aid may also be helpful. The strap and bulb prosthesis or the modified palatal speech aid may be used for the patient who does not have the necessary tissue for velopharyngeal closure. Dental condition is also an important factor which must be considered in the selection of prothesis. Dental characteristics must promote the retention of the prosthesis in the patient's oral cavity (Lang, 1971).

Some inactive palates may be stimulated through the use of other palatal training devices. The palatal stimulation appliance provides resistance to the musculature involved in velopharyngeal closure. The purpose of these devices is to strengthen palatal musculature by working against the muscles through introduction of a mechanical resister placed above the soft palate. The soft palate may subsequently increase its
range of motion, thus reducing hypernasal speech in the speaker.

**Speech Therapy**

Bzoch (1971) suggests that to be maximally effective, speech therapy and language stimulation training with consistent parent counseling should be instituted in early infancy for each cleft palate child. Bzoch reported that this basic rationale has been followed over the past twenty years in cleft palate centers. Direct therapy services provided by a speech pathologist may be implemented when the child is 2 to 3 years of age. Clinical management should be initiated before the feeling of abnormality and perceptions of rejection are formed. Thus, direct therapy might be instituted at an earlier age.

Various types of therapy have been developed for those persons with cleft palate and velopharyngeal insufficiency. For older youngsters, management strategies have often included intensive residential therapy. This type of therapy is advantageous because it does not interfere with other traditional school programs when taught during the summer vacation months. When the costs, planning and coordination of such placements are prohibitive, supportive sponsorship by state programs may be necessary (Schendel and Bzoch, 1971).
The velopharyngeal muscle training approach for the correction of velopharyngeal insufficiency has been noted to be an effective therapy (Cole, 1971). This method employs direct, indirect and semi-direct techniques to effect closure of the velopharyngeal gap. Indirect techniques might include standard articulatory training, while semi-direct techniques include those that do not attempt manipulation of the velopharyngeal structures, such as yawning, blowing, and sucking techniques (Cole, 1971). However, some caution should be exercised in utilizing these semi-direct techniques, since they are not coded as speech movements. The velocity and temporal synchrony of velopharyngeal movements during ongoing speech is much different than those of the blowing and sucking activities which characterize these exercises.

The methods that have been briefly described are only a small sample of the many varied approaches that have been utilized. It should be noted that in many cases, speech intervention is accompanied by other procedures, such as surgery or prosthesis to effect maximum speech in these individuals.

Surgical Management

Surgical intervention is another consideration in the alleviation of velopharyngeal insufficiency.
According to Yules and Chase (1971), selection of surgical techniques may depend on the degree of velopharyngeal gap. However, there is no established method for selecting an individual patient for a given operation. Additionally, secondary procedures of palatal repair may be necessary when primary surgery does not produce normal speech, or when residual velopharyngeal incompetence is noted. Treatment methods include pharyngoplasty, pushback procedures, retropharyngeal implants and velopharyngeal flap procedures. These procedures may also be performed as primary surgeries in cases of marked velopharyngeal insufficiency without obvious cleft lip or palate.

Pharyngoplasty is designed to shorten and sometimes narrow the velopharyngeal space (Ross and Johnston, 1972). A specific type of pharyngoplasty known as the Hynes procedure, accomplishes both the desired shortening and transverse narrowing of the velopharyngeal space. This procedure includes the use of two lateral, superiorly based flaps of pharyngeal mucous membrane that are sutured to form a mound of membrane at the velopharyngeal closure area at the posterior pharyngeal wall. This method has been described as dynamic and mechanical in its production of nasal air blockage (Ross and Johnston, 1972).

Pushback procedures have been used since they were
first developed by Dorrance in 1925. These procedures were designed to produce a longer palate, a smaller velopharyngeal space and improved speech results (Ross and Johnston, 1972). A variety of pushback procedures have been developed. Some include modification of the hard palate, while others modify only the soft palate or the pharynx. These procedures have been criticized because the structures tend to migrate back to their original position (Ross and Johnston, 1972).

A third type of surgical procedure implements a retropharyngeal implant. Implants bring the posterior pharyngeal wall forward rather than elongating the palate. Materials used for implantation include paraffin, cadaver cartilage, cartilage grafts, silicone, teflon, and proplast (Blocksma, 1971). Regardless of material implanted, speech results have tended to be maximal when the velopharyngeal gap was no more than 5 mm preoperatively.

A fourth type of secondary palatal surgery is the velopharyngeal flap procedure. A variety of these procedures has been advocated. Blocksma (1971) advocated a combined flap and pushback procedure, where the pharyngeal flap was attached to the raw nasal surface after the palatal pushback procedure has been performed. Flaps have raised tissue inferiorly. According to Blocksma (1971), the superiorly based flap is more physiologically sound than
the inferiorly based flap. That is, the upward and backward movement of the velum would probably be more enhanced by a superiorly based flap that may also aid in the elevation of the soft palate for more effective closure (Blocksma, 1971).

According to Skolnick (1975), the pharyngeal flap "must occupy the gap between the lateral aspect of the pharyngeal wall at the region of their maximum mesial movement" (p. 291). Skolnick suggests three critical factors that must be considered to maximize achievement of velopharyngeal closure: (1) flap width along the horizontal plane, (2) flap position vertically in relation to the level of maximum mesial movement of the lateral aspect of the sphincter, and (3) flap position on a horizontal plane in relation to the degree of movement of each lateral portion of the sphincter. Skolnick (1975) observed that velopharyngeal closure is dependent upon a dynamic interplay between the flap and pharyngeal walls.

According to Newman (1984), the inferiorly based flap may be a simpler procedure, but the superiorly based flap is physiologically sound for speech, avoids the friability of adenoidal tissue which can weaken the repair, and can be easily seen through the use of the oral endoscope. The superiorly based flap, however, as with other flap repairs, has a tendency to "tube" itself,
leading to scarring and shrinking. According to Newman (1984), mucosal lining to the flap may prevent this from occurring. As an alternative method for achieving a wide, fully lined, superiorly based pharyngeal flap, an alternative technique has been proposed and is the focus of this study.

**Technique**

In the surgical procedure* used by Newman (1984), the patient is placed under general anesthesia and, with a Ray endotracheal tube in place, a Dingman mouth gag is positioned in the mouth. The posterior pharyngeal wall is adequately exposed and inspected and the mobility of the soft palate is tested.

Stay sutures, of 4-0 vicryl, are then placed approximately 1 1/2 to 2 cm. on each side of the uvula. With upward traction these sutures are hooked into the springs of the mouth gag. With further traction on the uvula, an incision is made with a long-handled knife blade, exactly posterior to the stay sutures. A second incision is made on the contralateral side, again, in line with the stay sutures. With the incisions extended

* A number of terms used in this surgery may require further clarification, which can be found in Butterworths Medical Dictionary (Critchney, 1978).
as far posteriorly as one can comfortably see, a blunt right angle clamp or Potts scissors is inserted through the muscular component of the uvular flap, in an attempt to connect the two incisions. Following complete and adequate elevation of the flap the scissors are withdrawn, opened and reinserted with only the posterior blade underneath and through the flap. With this particular configuration, the Potts scissors are closed, allowing the flap to be divided at its distal end. Stay sutures are then placed on each of the two newly formed corners, again utilizing 4-0 vicryl. With upward traction, the Potts scissors are used to further elevate the flap off of the palate, dissecting as far distally as possible. The flap is then stabilized by hooking the sutures into the superior springs of the mouth gag. This allows good visualization and pinpoint control of bleeding with the suction bovie.

A standard superiorly based pharyngeal flap is then constructed, placing stay sutures on the corners of the flap. These same sutures are used to assist in full elevation of the flap and are then stitched to the point of origin of the lining flap, approximating their raw surfaces. The corner sutures of the lining flap are then stitched into the base of the pharyngeal flap, completing their alignment. A third suture is then placed
in the middle of the lining flap and stitched into the base of pharyngeal flap. This is done in a vertical direction to obviate any blood supply compromise. Two lateral sutures can then be placed on either side of the flaps to further complete the coaptation of their new raw surfaces. Upon completion, a fully lined pharyngeal flap has been constructed. Following inspection, the mouth gag is then removed.

The nature of this post hoc analysis would not allow speech results for this selected population as they relate to the effectiveness of this procedure to be studied. However, subject variables which may be found to be associated with speech articulation test results and judges' ratings may lead to important prognostic indications.

Related Information

A number of related variables underlie defects of speech in cleft palate populations (Bzoch, 1971). The number of surgeries a person has undergone, for example, may be related to successful or unsuccessful speech articulation results. That is, as the number of surgeries increases, the expectancy of normal speech results decreases. However, secondary surgeries are usually performed to correct speech problems, and they should be expected to be successful if they are going to be attempted.
The duration of participation in speech therapy may also be related to good or poor speech articulation results. Over the years, therapy may or may not have an effect on speech improvement. The more years a child is in therapy may indicate that his problem is severe, or that his speech is not improving over time, or may be related to unknown factors.

Acquired conductive hearing loss from otitus media has been associated with cleft palate speakers (Bzoch, 1971), thus making a majority of this population susceptible to delays in speech and language development. Hearing loss should be seriously considered in the analysis of cleft populations and non-cleft populations, because it is implicated in speech articulation and language capability (Bzoch, 1971). Improvement, or lack of improvement post-surgically may also be related to the number of years since surgery. Faulty or mislearned habitual patterns in cleft palate individuals, as discussed by Trost (1981), may also be related to the lack of improvement in speech articulation.

Persons with severe cleft of the palate and lip may have worse speech articulation than those with velopharyngeal insufficiency (VPI) due to the likelihood of more scar tissue in the velopharyngeal area, or because of neurological deviances, or other unknown
reasons (Bzoch, 1971). It would be worthwhile to examine the differences in these two different groups to discover if these hypotheses hold true for this study's selected subjects.

Because of genetic and developmental factors, males may have a tendency to perform differently than females. Although this tendency may or may not be evident in this particular study, it is a factor which should be considered in data analysis.

Disordered speech for cleft palate clients may also be related to disease, genetic limitations, biological predispositions, or other factors not related to the cleft palate condition. In any case, these variables need to be considered in the analysis of speech articulation results.
CHAPTER III

METHOD

This study was designed to implement a post hoc analysis of the variables associated with the post-surgical speech of individuals who have undergone a modified pharyngeal flap procedure. Primary emphasis was placed on two dependent variables: (1) articulatory proficiency and (2) analysis of quality of speech. Comparative analyses of historical data, survey of current data, and speech articulation analysis, which emphasized oral pressure sounds, were completed.

While a comparison of measures with pre-surgical data would be ideal, it was not possible for this study. Thus, measures were taken to observe trends relative to normative data and to develop hypotheses about the effectiveness of the modified flap procedure in relation to specific characteristics of the examined population.

Subject Selection

Subjects who were invited to participate in this study (Inquiry Letter, Appendix A) had undergone the modified pharyngeal flap surgery described in a previous section of this paper. Subjects were between the ages of seven and fourteen at the time of the evaluation, and all had
participated in the flap procedure between October, 1979 and September, 1983 (All data discussed in this section is contained in Appendix F.) Seven female subjects and six male subjects participated in this study. Although 29 persons had undergone the modified pharyngeal flap procedure, only 45% (13/29) subjects completed the entire evaluation procedure. The representativeness of the participating subjects is reported in the next chapter. The mean age at time of evaluation (July and August, 1984) was 9.52. Age at time of surgery ranged from four years; eleven months to twelve years. Mean age at time of surgery was 6.83. Subjects displayed a variety of symptoms related to their velopharyngeal incompetency. These included defects which ranged from complete bilateral cleft palate with or without cleft lip (62%) to congenital palatal insufficiencies (38%). Mean number of years since surgery was 2.69. Number of years in speech therapy was 3.0 for the selected population.

**Related Subject Characteristics**

Seventy-seven percent of the selected subject informants reported history of hearing difficulty for their children (Appendix F). Ninety-two percent of the informants also reported that speech improvement was evident post-surgically. Sixty-two percent of the
informants reported that their child had difficulties from birth with swallowing, blowing or speaking. Almost all (92%) reported a speech improvement which resulted from speech therapy.

**Procedures**

**Historical Data**

Whenever available, patient speech information in files was correlated with post-surgical articulation information. It should be noted that parental informants, and not speech pathologists, evaluated the effectiveness of surgery and speech therapy for their children. File data included the time lines of surgery/surgeries, age at time of surgery/surgeries, pre-surgical speech information when available, and other pertinent medical information.

**Survey of Current Data**

A questionnaire (Appendix B) was designed to validate and supplement information obtained from patient files. Identifying information, history of the problem, surgical information, and pertinent speech, language and hearing information were gathered with the questionnaire. Historical considerations included source of referral, nature and onset of the problems and a
listing of time, place and nature of surgeries. Therapy setting, frequency of services and types of therapy were also included. Parental informants were asked to provide descriptions of the effects of therapy on speech quality/change. Information related to hearing ability was also gathered. Prior to the initiation of these procedures, informants were asked to sign a letter of informed consent (Appendix C).

Speech Analysis

A standardized sub-test of the Templin-Darley Test of Articulation, the Iowa Pressure Articulation Test (IPAT), (Templin and Darley, 1960) was administered. The 43-item IPAT was selected because it was designed to test the perceived adequacy of oral pressure for speech sound production. In other words, this test provides an indirect assessment of the adequacy of velopharyngeal closure. Test items include the fricative, plosive and affricate sounds because they have been shown to require greater intraoral breath pressure than other sounds. Subjects were asked to spontaneously name pictures shown to them as the examiner presented the lead-in probes provided with the test materials. Imitative methods were used to elicit responses when necessary. The 50-item screening sub-test of the Templin-Darley Test of
Articulation was also administered to each subject in order to assess overall speech proficiency.

Since it was difficult to separate developmental misarticulations from those associated with cleft palate speech, tested sounds in words were marked incorrect if they were perceived to be incorrect without consideration of developmental level. Those misarticulations associated with cleft palate include the phonological behaviors described by Trost (1981) and reviewed in Chapter 2 (Table 1).

Table 1
Misarticulations Associated with Cleft Palate Speakers

<table>
<thead>
<tr>
<th>Misarticulation</th>
<th>Voiced</th>
<th>Unvoiced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glottal Stop</td>
<td>?</td>
<td>none</td>
</tr>
<tr>
<td>Pharyngeal Fricative</td>
<td>€£</td>
<td>€£</td>
</tr>
<tr>
<td>Velar Fricative</td>
<td>¥</td>
<td>×</td>
</tr>
<tr>
<td>Mid-dorsum Palatal Stop</td>
<td>€</td>
<td>3</td>
</tr>
<tr>
<td>Posterior Nasal Fricative</td>
<td>none</td>
<td>△</td>
</tr>
<tr>
<td>Pharyngeal Stop</td>
<td>þ</td>
<td>þ̃</td>
</tr>
</tbody>
</table>
Reliability

Intrascorer and interjudge reliability was established through the sequential rescoring of three randomly selected audio-taped TDST and IPATs. Each was scored by the primary investigator and also by each of the three selected judges (who were graduate students enrolled in a cleft palate course).

Intrascorer Reliability

The Pearson product-moment correlation, also known as the Pearson r, is a measure of association between two sets of measures (Silverman, 1977). When this statistical measure was applied to the two sets of TDST and IPAT scores given by the investigator, r coefficients were calculated for the TDST (r = 0.993) and the IPAT (r = 0.978). These values indicated an extremely strong degree of association between the sets of rescored data. That is, rescored test values were similar to the initial scoring completed by the investigator for each test. The correlation indicated that the investigator was considered a reliable scorer of articulation tests for this selected population of individuals.
Interjudge Reliability

In order to establish interjudge reliability between the investigator's scoring of the TDST and IPAT and judges' ratings, 3 subjects' tests were randomly selected and scored by the three judges. The judges' scores were then statistically compared to the investigator's scores. Because only 3 scores were generated by each of the three judges, these scores were combined and compared to the intrajudge reliability scores (a third score was generated by taking the median between the 2 intrajudge scores). The three scores were then randomly paired with the judges' scores for each subject and correlated.

The Pearson product-moment correlation and the Spearman rank-order coefficient were used to assess the relationship between the test scores. Because of the low N (9), the Spearman rank-order coefficient was also used to provide an index of the degree of correspondence between the two rank orderings of the judges' scores. The Spearman r does not take into consideration the magnitudes of differences between measures, and can be used for analysis of this relationship. Pearson r coefficient for the TDST (r= 0.874) and the IPAT (r= 0.921) indicated strong relationships between the investigator's scores and those presented by selected judges. When the Spearman r was
applied (TDST \( r = 0.63; \) IPAT \( r = 0.547 \)), a weaker relationship resulted. However, the relationship is still positive and indicates that judges tended to score the tests similarly to that of the investigator.

**Listener Judgment**

**Selection and Training of Judges**

A group of graduate students of speech-language pathology enrolled in a cleft palate seminar course were trained by the examiner and the course instructor to identify speech characteristics typical of cleft palate speakers. Potential judges first listened to a training tape which contained speech samples of three children. Speech characteristics present in each sample were identified by the examiner and course instructor. All speakers in the training tape were different from the experimental subjects whom the judges rated. (Rating instructions, rating scales and rating forms can be found in Appendix E).

After the potential judges had listened to the training tape, they listened to another tape in which they were asked to score three speech samples. These samples were similar, but not identical to the samples upon which they had been trained. Prospective judges were given
a scoring sheet and scored the same characteristics that were described to them in the training tape. Scoring sheets were then analyzed and rank ordered. Those whose choices were most similar to those of another experienced judge (the faculty member teaching the seminar) were placed first on the list, and the other students who were not as close were placed under these students, until rank-ordering was completed. Those who were most consistent were invited first to participate. If these persons were not available and/or did not wish to participate in this study, persons lower on the preference list would be asked to participate until three judges were selected. However, the most consistent persons (missing 0, 3 or 4 items of 24 in the training procedure) were available and did participate in this study.

Two of the three selected judges listened to speech samples simultaneously approximately one month after training was completed. However, due to scheduling differences, the third judge was unable to listen to the samples at that time and listened to the samples approximately three weeks later.

The Rating Process

The judges were given instructions by the investigator to score each subject's speech according to specific
characteristics of speech associated with velopharyngeal insufficiency. However, instructions given to them stated that they (the judges) may or may not be listening to speech characteristics of persons with velopharyngeal insufficiency. These included a general judgment of hypernasal characteristics, and separate judgments of degrees of nasal resonance, nasal emission and intelligibility on equal appearing interval scales (See Appendix E). Judges were encouraged to make comments related to other concerns or observations, such as the subjects' language, prosody, stress or pitch. The experimental rating form was slightly different from the original rating scales the judges used in training. Slight adjustments of categories were completed to equalize the number of points for each item. Both scales are included in Appendix E. Prior to beginning the experimental rating task, judges were informed of the changes, and were invited to ask any questions or receive clarification.

Judges were then given a written list of sentences that each subject had read. Judges were instructed to rate the sentences according to the rating scales. These audio-taped sentences were of three types:

(1) Those which contained an abundance of nasal consonants;

(2) Those which contained no nasal consonants; and
Those which contained nasal consonants in zero, one or two words.
The sentences included:

1. Nasal
   a. Jane wants that man's new cane.
   b. Running in the snow can be fun.
   c. King Nick reigned over his grandmother's land.
   d. Can Nan count to nine or ten?

2. Non-Nasal
   a. All boys like to play football.
   b. Do you have a brother or sister?
   c. Ted had a dog with white feet.
   d. Sue played ball out at the park.

3. Mixed
   a. We shouldn't play in the street.
   b. Let's go fly a kite.
   c. She is going to the city.
   d. I like strawberry ice cream.

In summary, data for analysis were compiled from file information, articulation tests, parental informant responses to questionnaires, and speech articulatory and intelligibility judgments. File information included demographic data which pertained to: age, sex, number of surgeries, and flap with or without overt cleft lip/palate.
Articulation test scores included the Templin-Darley Screening Test of Articulation and the Iowa Pressure Articulation Test. Parental informant information pertained to: (a) effectiveness of speech therapy; (b) effectiveness of flap surgery; (c) difficulties in speaking, swallowing, sucking, blowing, breathing, or facial contortions since birth; and (d) history of hearing problems. Speech judgment information included (a) general judgment of effect of hypernasal characteristics; (b) degree of nasal resonance; (c) nasal emission; and (d) intelligibility.
CHAPTER IV

RESULTS

The purpose of this study was to evaluate the speech adequacy of subjects who have undergone the modified pharyngeal flap procedure. Selected subject variables were analyzed in an attempt to evaluate the relationship of these variables to speech articulation test results and speech quality ratings of judges. Since no consistent pre-operative speech data were available (except for informant reports), a post-hoc descriptive analyses of speech following surgery was completed. All 29 subjects who had undergone the modified pharyngeal flap procedure were invited to participate. Forty-five percent (13) completed the entire evaluation procedure. A comparison between available and unavailable subjects was completed to assess the representativeness of the evaluated group.

Speech Articulation Test Results

Score Distribution

Templin-Darley Screening Test (TDST) and Iowa Pressure Articulation Test (IPAT) scores were rank-ordered from least to most number correct for all subjects, and the frequency distribution was tabulated. As shown in Figure 38.
1, subjects had either perfect (50 of 50 correct items) scores or achieved scores between 22 and 33 on the TDST. No subject scored between 34 and 47 items correct, suggesting a bimodal distribution. Scores were distributed similarly for the IPAT. Subjects either had perfect (43 of 43 items correct) scores on the IPAT (with the exception of one subject who missed 2 items), or achieved scores between 23 and 28 items correct (Figure 2). The perfect or near-perfect scorers were labeled "high scores," and those with lower scores were called "low scores." For purposes of analysis, the operational definition of "high scores" was a range of zero, one, or two errors. The "low score" group was defined as those subjects with more than two errors for both tests. The "high" and "low" groups were compared with other variables studied.

Relationship of Subject Variables to Articulation Scores and Ratings

In order to determine which, if any, of the variables in this study were systematically related to the "high score" or "low score" group, Chi-Square statistical comparisons of differences reflecting the association between subject variables (e.g., number of surgeries, history of hearing loss, etc.), between males and females, and between judges' ratings were completed.
Figure 1. Ranked TDST and IPAT Scores

- ▲ = Templin-Darley Screening Test
- ■ = Iowa Pressure Articulation Test

Ss Ranked by TDST Scores
50/50=Perfect Score for the TDST
43/43=Perfect Score for the IPAT

Figure 2. Frequency Distribution of TDST and IPAT Scores
**Statistical Measures**

The statistical measure Chi Square ($X^2$) establishes the degree of relationship of two variables (Siegel, 1956). A two by two contingency table for each variable pair was developed according to a procedure discussed by Bruning and Kintz (1977). Because of the small number of subjects in this study, a correction for continuity (Siegel, 1956) was applied. This computation attempts to remove the source of error that may occur when the expected frequency of occurrence of an event or condition is small (Siegel, 1956). A Phi coefficient ($\phi$) was also calculated to establish the degree of relationship between selected variables. This measure is identical to a standard correlation coefficient for a two by two table, ranging from $+1.00$ (perfect positive relationship) to $-1.00$ (perfect negative relationship).

**Subject Variables**

Eight subject variables were compared to speech articulation scores and judges' ratings. These comparisons were completed in an attempt to determine which (if any) of the variables were associated with high and/or low speech results. Variables included number of surgeries, years in speech therapy, comparisons of primary structural...
conditions, difficulty from birth, duration between surgery and speech testing, history of hearing loss, and informants' reports of speech therapy and surgery effectiveness (Table 2). The following analyses of these variables begins with those variable relationships which are strongly related to high and low scores in statistical analysis, and is concluded with those variable comparisons which indicate little or no relationship to the high and low speech articulation test results.

**Number of Surgeries**

The number of surgeries performed on each subject was compared to the high score and low score groups. It was hypothesized that the number of surgeries each subject had undergone may be related to severity of the speech disorder. Most of the subjects in this study have undergone at least two surgeries: a tonsillectomy and adenoidectomy, and the pharyngeal flap procedure. In an attempt to discover associations between number of surgeries and speech performance, those subjects who had undergone two or less surgeries were separated from those who had undergone three or more surgeries. Results indicate that a moderate relationship existed between these variables ($X^2 = 4.27; \phi = 0.57$). Subjects with more surgeries were likely to also
Table 2

Chi Square* and Phi Coefficient Values for High and Low Speech Articulation Test Scores Compared to Selected Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Chi Square*</th>
<th>Phi Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Surgeries</td>
<td>4.27</td>
<td>0.57</td>
</tr>
<tr>
<td>Years in Speech Therapy</td>
<td>2.01</td>
<td>0.39</td>
</tr>
<tr>
<td>Difficulty Since Birth</td>
<td>0.85</td>
<td>0.26</td>
</tr>
<tr>
<td>Primary Structural</td>
<td>0.85</td>
<td>0.23</td>
</tr>
<tr>
<td>Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years Since Surgery</td>
<td>0.09</td>
<td>0.08</td>
</tr>
<tr>
<td>History of Hearing Loss</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Effectiveness of Speech</td>
<td>0.009</td>
<td>0.03</td>
</tr>
<tr>
<td>Therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness of Surgery</td>
<td>0.006</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*Chi Square was calculated using Yate’s correction for continuity for small samples.
have low articulation test scores than were those subjects
with two or less surgeries, who were more likely to have
high articulation test scores (Figure 3).

![Graph](image)

Figure 3. A Comparison of High and Low Articulation
Scores with Number of Surgeries

Years in Speech Therapy

It was hypothesized that the number of years of
participation in speech therapy may be related to high or
low speech test score results. In order to determine this
relationship, the number of years in therapy was divided
into two groups: subjects with more than two years in
therapy and subjects with two or less years in therapy.
This was an arbitrary division which divided the group in
half. The results indicated that a moderate relationship existed between these variables \( (X^2 = 2.01; \phi = 0.39) \). That is, subjects with more than 2 years in therapy were more likely to have lower speech scores than those subjects with less than 2 years in therapy (Figure 4). Subjects with less than 2 years in speech therapy were more likely to have high speech articulation test scores.

![Figure 4. A Comparison of High and Low Articulation Scores with Number of Years in Speech Therapy](image)

**Difficulty from Birth**

Subjects whose informants reported speech related difficulties from birth and those whose informants reported no difficulties from birth were separated and these two groups were compared to high and low speech articulation
scores. The results indicated that no relationship existed for these variables ($X^2 = 0.85; \phi = 0.26$). That is, subjects who were reported to have difficulty from birth were no more likely to have high or low articulation test scores than were subjects without difficulties from birth (Figure 5).

![Graph showing comparison of high and low articulation scores for subjects with and without difficulty from birth.]

**Figure 5.** A Comparison of High and Low Articulation Scores of Subjects Who Do and Do Not Display Difficulty From Birth

**Primary Structural Condition**

Primary structural condition (i.e. velopharyngeal insufficiency only versus cleft palate and/or cleft lip) was also compared to high and low articulation test scores.
Results indicate that these variables are not related ($X^2 = 0.85$; $p = 0.23$). Subjects with velopharyngeal insufficiency were no more likely to have high or low speech articulation test scores than were subjects with cleft palate and/or cleft lip (Figure 6).

![Figure 6](image)

**Figure 6.** A Comparison of High and Low Articulation Scores of Subjects Who Do and Do Not Display Cleft Palate

**Years Since Surgery**

The number of years since surgery was also considered to be a variable that might be associated with high and low speech articulation test scores. The number of years since surgery was divided into two groups: those subjects with less than the mean (2.69) number of years since surgery, and those with more than the mean number of years since...
surgery. The results indicated that no relationship existed between these variables ($X^2 = 0.09; \psi = 0.08$). Subjects who have undergone the flap surgery more than 2.69 years ago were no more likely to have high or low speech articulation test scores than those with a smaller time lapse between surgery and testing (Figure 7).

![Figure 7: A Comparison of High and Low Articulation Scores with Mean Number of Years Since Surgery](image)

**Figure 7.** A Comparison of High and Low Articulation Scores with Mean Number of Years Since Surgery

**History of Hearing Loss**

Another variable, history of hearing loss, may be associated with high or low speech articulation test scores. For subjects in this study, no relationship existed between these variables ($X^2 = 0.02; \psi = 0.04$). That is, a history of hearing loss was not related to high or
low speech articulation scores (Figure 8).

![Diagram showing comparison of high and low articulation scores with history/no history of hearing loss.]

**Effectiveness of Speech Therapy**

Like the informant responses to effective versus ineffective pharyngeal flap surgeries, parent informants were asked to report whether or not their child's speech improvements were related to speech therapy. The results indicated that there is no relationship between the measured variables ($X^2 = 0.009; \phi = 0.03$). According to parental reports, speech improvements through speech therapy were not related to high or low speech articulation test results (Figure 9).
Figure 9. A Comparison of High and Low Articulation Scores with Effective and Ineffective Speech Therapy

Effectiveness of Surgery

Although no formal speech articulation testing was completed prior to flap surgery, parental informants were asked to report if any of the surgeries, particularly the flap surgery, resulted in a notable improvement in speech. While the parents' competence for making formal speech analysis evaluations must be carefully interpreted, they are certainly concerned observers and their evaluations of speech improvement following surgery are extremely important. However, most (12/13) parents reported surgery
to be effective, whether or not their children were in the high or low speech articulation group (Figure 10). No relationship existed between parental reports of surgery effectiveness and high or low speech articulation scores ($X^2 = 0.006; \phi = 0.02$).

![Figure 10. A Comparison of High and Low Articulation with Effective and Ineffective Surgery](image)

**Sex**

Six male and seven female subjects participated in this study (See Appendix F). Mean ages at time of evaluation were noted to be 9.66 for males and 9.33 for females. Age at time of surgery was 7.08 for males; 6.61...
for females. Males ranged in age at time of surgery from 5 years, 0 months to 10 years, 0 months, while the female range was 4 years, 5 months to 8 years, 1 month.

The mean score for the Templin-Darley Screening Test of Articulation (TDST) was 35.5 for males and 43.14 for females. It should be noted, however, that two of the male subjects achieved perfect scores, while the remainder of the male group scored between 22 and 28 correct. Thus, mean scores were significantly altered by extremely high scores of two subjects. Five of seven females achieved perfect scores, while two scored 23 and 29 on the TDST. These lower scores also influenced mean scores of the female group.

Mean number of surgeries was 2.0 for males and 2.43 for females. Number of surgeries ranged from 1 to 4 for males and 1 to 5 for females. Sixty-six percent of the males and 14% of the females experienced cleft palate with or without cleft lip (males= 66%; females= 14%). Thus, the interaction between number of surgeries and the organic condition presented for surgery is assumed.

Mean scores for the Iowa Pressure Articulation Tests (IPAT) were 32 for males and 37.29 for females. It should be noted that four females, or 57%, scored 43 of 43 items correct, while the other females, or 43%, scored from 23 to 29 correct. Also, more of the males'
informants (83%) reported positive effects of speech therapy than did the females' informants (57%).

High and low female articulation test scores were compared to high and low male articulation scores. The results indicated that a weak relationship existed for these variables ($X^2 = 0.66; \phi = 0.23$). Thus, neither group were likely to have higher or lower speech articulation test scores than was the other group (Figure 11).

![Figure 11. A Comparison of High and Low Articulation Scores with Males and Females](image)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Ratings

Trained judges rated four aspects of articulation:

Scale A. General Judgment of Hypernasal Characteristics
Scale B. Degree of Nasal resonance
Scale C. Nasal Emission
Scale D. Intelligibility

A scale (Appendix E) of 1 to 7 was used for each scale. The first two scales contain the numbers with negative values to denote a continuum ranging from -2 to +4 to separate denasal characteristics from those associated with hypernasality. For data analysis and discussion purposes, negative ratings were transformed to a scale of 1 to 7 which should not affect the equal appearing interval nature of the relationships. The last 2 scales remained in their original form (1-7) for analysis. However, it should be noted that ratings of 3 were "normal" for Scales A (General Effect of Hypernasal Characteristics) and B (Degree of Hypernasal Resonance); while ratings of 1 were "normal" for Scales C (Nasal Emission) and D (Intelligibility).

The ratings of each judge for each subject were analyzed. Because of the somewhat subjective nature of the rating system, and the fact that the scales had 7 points each, it was decided to set an "agreement" criterion. Judges in perfect agreement, or judgments which did not
deviate from one another by more than one unit were considered as judgments of "agreement." Based on this criterion, the judges were in agreement ninety-two percent of the total number of ratings completed for variables and subjects. The items on which agreement did not occur (as defined above), were deleted from analysis because the nature of the differences could not be determined. With this criterion estimate, 92% (all but 4) of the ratings were included for comparison.

Responses to the four rating scales were divided into two groups--those which represented subjects' "high" speech articulation scores, and those which represented "low" speech articulation scores. (These groups were identical to those divided for previous comparisons.) When the means and standard deviations compared, results showed a distribution of ratings that might be expected. Table 3 indicates that those subjects with low speech articulation scores were judged as a group to have more hypernasal speech characteristics than the group of high scorers.

For rating scale A (Appendix E), "General Judgment of Effect of Hypernasal Characteristics," results varied between the two groups (high: \( \bar{X} = 3.6, SD = 0.47 \); low: \( \bar{X} = 6.13, SD = 1.21 \)). The mean for the high scores fall between the judged ratings "non-nasality" and "occasional nasality," while the mean for the low scores falls between...
Table 3

Means and Standard Deviations of Judges’ Mean Ratings of Four Categories of Speech Quality Grouped by High Articulation and Low Articulation Test Scores

<table>
<thead>
<tr>
<th>Rating Scale</th>
<th>High Scorers</th>
<th></th>
<th>Low Scorers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>A</td>
<td>3.60</td>
<td>0.47</td>
<td>6.13</td>
<td>1.21</td>
</tr>
<tr>
<td>B</td>
<td>3.76</td>
<td>0.87</td>
<td>6.11</td>
<td>1.00</td>
</tr>
<tr>
<td>C</td>
<td>1.76</td>
<td>0.71</td>
<td>5.58</td>
<td>1.75</td>
</tr>
<tr>
<td>D</td>
<td>2.24</td>
<td>0.76</td>
<td>4.28</td>
<td>1.13</td>
</tr>
</tbody>
</table>

A = General Judgment of Effect of Hypermusal Characteristics  
B = Degree of Nasal Resonance  
C = Nasal Emission  
D = Intelligibility  
SD = Standard Deviation

"consistently nasal" and "extremely nasal." That is, judges perceived the high scorers to have lesser degrees of hypermusal qualities to their speech than the low scorers did.

In the B rating scale (Appendix E) "Degree of Nasal Resonance," the results were again divided between those with high (X = 3.76; SD = 0.87) articulation scores and those with low scores (X = 6.11; SD = 1.0). The group mean for subjects with high scores was placed between "non-nasal" and "occasional nasality." Mean scores for
subjects with low scores indicated that judges perceived "pervasive assimilated nasality; consonants still relatively pure," and "severe and pervasive assimilated or non-assimilated nasality involving both consonants and vowels." "Pervasive" nasality is hypernasal resonance which heard throughout speech, but may or may not be severe. "Assimilated" nasality is defined by Boone (1983) as the nasalization of vowels immediately before or after nasal consonants. The high scorers were thus judged to have less nasal characteristics in their speech than were the group of low scorers.

For the C rating scale (Appendix E) "Nasal Emission," the high scorers ($\bar{X} = 1.76; SD = 0.71$) were perceived by judges to have "none present" and "specific to a single phoneme only," while the low scorers ($\bar{X} = 5.58; SD = 1.75$) were judged to be between "consistent; involves nasalized consonants and phonemes adjacent to them," and "consistent, involves some fricatives and some stop consonants regardless of contextual position." These differences between the two groups indicate that the high scorers were perceived by the judges to have lesser degrees of nasal emission than were the low scorers, who were judged to have consistent nasal emission in their speech.

In the D rating scale (Appendix E), "Intelligibility," the high scorers ($\bar{X} = 2.24; SD = 0.76$) were
perceived as a group to be between "all sounds clearly intelligible and developmentally appropriate (though not perfectly articulated)" and "some sounds distorted affecting intelligibility occasionally, but developmentally appropriate." The lower scorers (X = 4.28; SD = 1.13) were rated by the judges as a group between the ratings "most sounds and words fairly intelligible, but some whole words unintelligible" and "many words unintelligible." Again, these differences indicate that the high scoring group was perceived by judges to have more clearly intelligible speech than the low scorers, who were judged to have less intelligible speech.

The ratings tend to fall into two groups: those with high articulation test score results and judged to have normal or close to normal speech characteristics, and those with low articulation test score results and judged to have high degrees of hypernasality, more nasal emission and worse intelligibility ratings by judges. These results indicate that, on the whole, the group of subjects with high articulation scores were more capable of producing intelligible, less hypernasal speech than was the group with low articulation scores.
Comparison of Judges’ Mean Ratings and Speech Articulation Test Results

It was hypothesized that subjects with better quality ratings would likely be members of the high articulation test group, while subjects with worse quality ratings would likely be members of the low articulation test group. Distribution of ratings for each scale tended to indicate two group of ratings (good, poor) for each of the 4 categories mentioned. In order to test this hypothesis, ratings were divided into two groups for each scale. These divisions were based on the distribution of scores for each scale, and were agreed upon unanimously by two independent judges. The relationship of these two groups of ratings, as each relates to high and low articulation test scores, were tested statistically through Chi-Square ($\chi^2$) and Phi Coefficient ($\phi$) analyses. Chi Square was again used with Yate's correction factor for small samples.

Scale A (Appendix E) "General Judgment of Hypernasal Characteristics," was divided into two groups of judge ratings. The "good" group consisted of ratings which placed at or between 3.0 (non-nasal) and 4.33 (slightly above "occasionally nasal"). On the "poor" scale, ratings placed between 6 (consistently nasal) and 7 (extremely nasal) on the rating scale. The rating distribution and division is shown in Figure 12.
The results for Scale A indicated that a fairly strong relationship does exist between these variables ($\chi^2 = 4.48; \phi = 0.63$). Subjects with high articulation scores were more likely to have closer to normal ratings than were subjects with low articulation scores. This relationship is shown in Figure 13.
Judges' mean ratings for Scale B (Appendix E) "Degree of Nasal Resonance" were divided into two groups of subjects for results analysis. The rating distribution and division for this scale is shown in Figure 14.

Figure 14. Judges' Mean Ratings for Each Subject on Scale B. Degree of Nasal Resonance

Divisions for Scale B were again based on the distribution of scores for each scale, and were also agreed upon unanimously by the two same judges. The "good" group consisted of 9 ratings which placed between 2 (slightly denasal) and 5 (pervasive non-assimilative nasality) on the rating scale while the "poor" group consisted of 4 judges' ratings which placed between 6 (pervasive assimilated nasality; consonants still relatively pure) and 7 (severe...
and pervasive assimilated or non-assimilated nasality involving both consonants and vowels).

The results for Scale B indicate that a moderate relationship existed between the variables ($X^2 = 3.97; \phi = 0.55$). Subjects with higher articulation scores were again more likely to have normal or close to normal ratings, while those subjects with low articulation scores were more likely to have hypernasal resonance as rated by judges. This relationship is shown in Figure 15.

![Figure 15](image)

Figure 15. A Comparison of High and Low Articulation Scores with Judges' Ratings of Scale B. Hypernasal Resonance

Judges' mean ratings for Scale C (Appendix E) "Nasal Emission" were divided into two groups of judges' ratings according to the same criterion set for scales A and B. The "good" group consisted of ratings which placed at or
between 1 (none present) and 3 (inconsistent; specific to several phonemes but with no effect on adjacent phonemes). "Poor ratings placed between 6 (consistent, involves some fricative and some stop consonants regardless of contextual position) and ratings of 7 (consistent; involves all stop consonants and all fricative regardless of contextual position). This rating distribution and division for this scale are shown in Figure 16.

Figure 16. Judges' Mean Ratings for Each Subject on Scale C. Nasal Emission

These two divided groups of Scale C were compared to high and low speech articulation test scores and the results indicated that a moderate relationship existed between these variables ($X^2 = 3.90; \phi = 0.59$) Thus, subjects with high articulation test scores were more likely to also
have normal or close to normal ratings by judges, while the subjects with low articulation test scores were more likely to have aspects of nasal emission present in their speech as rated by judges (Figure 17).

![Figure 17. A Comparison of High and Low Articulation Scores with Judges' Ratings of Scale C. Nasal Emission](image)

Judges' mean ratings for Scale D (Appendix E) "Intelligibility" were divided into two similar groups. The "good" group consisted of ratings at or between 1 (all sounds intelligible and flawlessly produced) and ratings of 4 (most sounds and words fairly intelligible, but some whole words unintelligible). The two "poor" ratings of 5.67 were closest to 6 (entire speech pattern almost completely unintelligible). The scale distribution and group division are shown in Figure 18.
These divided groups of Scale D were compared to high and low speech articulation test scores and the results indicated that a relatively weak relationship existed between the variables (\(X^2 = 0.79; \phi = 0.24\)). Subjects with high articulation test scores were not very likely to be rated by judges to be significantly more "intelligible" than were subjects with low articulation test scores (Figure 19). Chi Square and Phi Coefficients for each
scale are tabulated in Table 4. Of the 4 scales, "Intelligibility" was the only one in which a weak correlation was present between "good" ratings and high articulation test scores.

Table 4

*Chi Square and Phi Coefficient Values for Subjects' High and Low Speech Articulation Results Compared to Judges' Mean Ratings

<table>
<thead>
<tr>
<th>Rating Scale</th>
<th>Chi Square</th>
<th>Phi Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.48</td>
<td>0.63</td>
</tr>
<tr>
<td>B</td>
<td>3.97</td>
<td>0.55</td>
</tr>
<tr>
<td>C</td>
<td>3.90</td>
<td>0.59</td>
</tr>
<tr>
<td>D</td>
<td>0.79</td>
<td>0.24</td>
</tr>
</tbody>
</table>

A= General Effect of Degree of Hypernasal Characteristics
B= Degree of Nasal Resonance
C= Nasal Emission
D= Intelligibility

*Chi Square was calculated using Yate's correction factor for small samples

In addition to the statistical analyses described, informal descriptive analysis was undertaken to further evaluate the relationship between speech quality ratings.
and speech articulation scores. It was suspected that subjects whose ratings did not occur at the extreme ends of the rating continuum would tend to fall into either the high or low speech articulation score group. To separate these subjects from the other, more extreme ratings, a criterion was set. The four "best" speech quality ratings were selected from each scale to determine if subjects who were given "best" ratings by judges also received high articulation test scores by judges, and to determine if those subjects who received "worst" ratings were also those who received low articulation test scores. For the "worst" speech quality rating comparisons for scales C and D, fewer than four members of the groups (3 and 2 respectively) were selected for comparisons because these subjects were the only members of the "worst" ratings group for those scales.

After associations between these two groups were completed, it was apparent that all subjects with "best" ratings for scales A, B, C, and D were subjects who placed in the high articulation test score group. A similar relationship was identified for the "worst" speech quality rating group. That is, all subjects who received the "worst" ratings were also given low articulation test scores, thus indicating a high degree of relationship between high articulation test scores, and "best" speech quality ratings, and a high degree of relationship between
low speech articulation test scores and "worst" speech quality ratings.

It should be noted that all subjects who scored highly on both articulation tests were always rated by judges to have "good" speech qualities for the rating scales. This relationship is indicated on each of the figures (13, 15, 17, 19) by the absence of the "poor" group with high articulation test scores.

Error Analysis

The design of this study did not include an analysis of specific phoneme errors. However, cursory analysis of IPAT and TDST items should be completed. Items included in the IPAT are those which require greater introral pressure than items in the TDST, which assess overall articulatory proficiency. Some of the items in the IPAT are also contained in the TDST. In order to compare differences between item error on each test, an error analysis was undertaken to investigate whether or not incorrect items were resultant of subjects' overall articulatory deficiencies or to reduced intraoral pressure. Speech articulation test scores were separated into three types of errors:

a) Errors specific to the TDST;
b) Errors specific to the IPAT; and
c) Item errors that were part of both tests.

High occurrence of errors in the IPAT rather than the TDST are more likely related to velopharyngeal insufficiency. If most errors occur on items specific to the TDST, the errors are likely not to be associated with ineffective velopharyngeal port closure, and may be part of an overall articulatory deficiency.

Table 5 shows the distribution of errors between items which were specific to the TDST, to the IPAT, and those which were part of both tests. For example, for subject 1, the total errors on the TDST would include the
summation of Column 1 errors (17) and Column 3 errors (10) for a total of 27 errors for the TDST. Similarly, the total errors on the IPAT for subject 1 would include the summation of Column 2 errors and Column 3 errors (total of 20 errors for the IPAT). All subjects but one had more errors in the TDST. This observation may be related to the fact that there are more items in this test. All of the subjects included in this error analysis have had a cleft of the palate sometimes with and sometimes without cleft lip. The exception was a female (whose scores are not included in the table because she was a member of the high articulation test group) who missed two items only on the IPAT and none on the TDST. The rest of the group seemed to miss as many items on both tests than they did on items specific to either the IPAT or TDST.

Relationship of Selected Subjects to Unavailable Subjects

A total of thirteen subjects were selected from a 29 member pool who had experienced the modified pharyngeal flap procedure. Some subjects were excluded because they were unavailable to participate in the study. Although it may be possible that those who did not participate may have differed from those who were examined, no differences were immediately evident to the experimenter when subjective
comparisons were completed. The reasons for refusing participation included scheduling problems, vacations at the time of recall and travelling distance from the clinic. Sixteen parents did not respond to the inquiry letter or were not available.

Some information pertaining to unavailable subjects was available through medical files. Comparisons between selected subjects (Group A) and those not available for analysis (Group B) were completed to determine if the data for selected subjects represented the entire population of potential subjects. Mean age at time of surgery and evaluation, mean number of surgeries, mean number of years since surgery, number of subjects with or without cleft palate and/or cleft lip, and number of males and females in each group were calculated (Appendix G). Mean age at time of surgery for Group A was slightly lower than Group B ($A = 6.83; B = 6.94$), and mean age at time of evaluation was also lower ($A = 9.52; B = 9.95$). The number of years since surgery was similar in both groups (Group A = 2.69; Group B = 2.81). Group A showed a higher mean than Group B for a number of surgeries (Group A = 3.6; Group B = 2.37).

The number of subjects who had cleft palate with or without cleft lip was different for the two groups (Group A = 62%; Group B = 50%). The number of subjects who had undergone the flap procedure and who did not have an overt
cleft of the palate or lip was also different (Group A = 38%; Group B = 50%). Number of males and females in each group differed (Group A = 6 males, 7 females; Group B = 12 males, 4 females). Except for these last two comparisons described above, the two groups are fairly similar, and the selected population was judged to be representative of the entire group.

Summary

In summary, the results presented indicate that the subject group was divided into two groups by articulation scores. Seven subjects had perfect or near perfect scores on the TDST and IPAT, and six subjects scored between 22 and 33 items correct on the TDST and 23 and 28 items correct on the IPAT. When these two groups were compared to other subject variables, number of surgeries undergone by each subject and years in speech therapy were variables found to be closely associated with high and low speech articulation test scores. That is, when subjects had undergone two or less surgeries, they were more likely to have high speech articulation results. Similarly, when subjects had received two or less years of speech therapy, they were likely to have high speech articulation test results. The other six variables (difficulties from birth, primary structural conditions, years since surgery, history
of hearing loss and effectiveness of speech therapy and surgery) were not closely associated with high or low speech articulation scores.

Mean judges' ratings generally concurred with the speech articulation results. Those subjects with high articulation scores were rated within normal or close to normal range, while subjects with low articulation scores were rated by the judges to have more severe speech hypernasality and more nasal emission. A weak relationship, however, was found for intelligibility ratings, and this difference will be discussed in the following chapter.

When item errors on the TDST and IPAT were compared, errors tended to occur in similar number for both tests. One subject, however, missed only two items on the IPAT and none on the TDST. This difference will also be considered in more detail in the next chapter.
CHAPTER V

DISCUSSION AND CONCLUSIONS

The findings of this study lead to several areas of discussion. Although only 13 of a possible 29 subject pool participated in this study, analysis of subject characteristics obtained from medical files indicated that selected subjects were representative of the entire group. Similarities were found between subject mean age at time of surgery and evaluation, mean number of surgeries, and mean number of years since surgery. However, differences were noted in the number of subjects with or without cleft palate and/or cleft lip and in the male/female ratio. Fewer of the nonparticipants had velopharyngeal insufficiency without accompanying cleft lip or palate, and more males (12) did not participate than did females (4). This may have affected the results to some degree. However, the findings herein are thought to be representative of the entire population.

Score Distribution and Related Variables

The bimodal score distribution for the TDST and IPAT indicated that a number of individuals had perfect or near perfect scores, while others missed 15 or more items on both tests. These eight variables are again
discussed in order of descending degree of relationship to speech articulation scores. Statistical measures indicated that two moderate relationships existed for the number of surgeries performed upon each of the subjects and the number of years in speech therapy.

**Number of Surgeries**

Subjects who had undergone two or fewer than two surgeries were found to be associated with higher speech articulation scores. The number of surgeries each subject had undergone may be related to the severity of the presenting disorder. That is, the more severe the problem, the more surgeries have been completed in an attempt to correct it. Those subjects with cleft palate with or without cleft lip were likely to have more surgeries than those without overt clefts of the lip or palate.

**Years in Speech Therapy**

Number of years in speech therapy was found to be moderately related to high or low speech articulation test scores. This was probably related to differences in length of therapy sessions, motivational factors and habitual patterns. More years in therapy may indicate that the subject’s speech problem is severe, or it may be related to unknown factors.
Difficulty from Birth

It was also suspected that subjects who have had difficulty in speaking, swallowing, or breathing since birth would tend to have more speech articulation difficulties. However, a weak relationship resulted when these variables were statistically analyzed. Subjects in this study who have had difficulty from birth were just as likely as their counterparts to have high speech articulation results. The reasons for this may be related to effective speech therapy, effective surgeries or other unknown contributing factors.

Primary Structural Condition

When comparisons were completed for analysis of primary structural conditions, no relationship existed between the variables. It was suspected that subjects with velopharyngeal insufficiency only would have better speech results than subjects with cleft palate and/or cleft lip. This hypothesis did not hold true. This finding may be related to unknown variables, or individual differences in each subject.

Years Since Surgery

Number of years since surgery was compared to high
and low articulation scores, to see if those subjects who have had more time, and perhaps, more speech therapy for speech improvement may have had better speech articulation test score results. No significant relationship was found for these variables. Reasons for this may be related to individual subject differences, such as age at time of surgery, primary structural conditions or other unknowns which were not evaluated in this study.

**History of Hearing Loss**

An extremely weak relationship was found between hearing loss and high and low speech articulation scores. This was probably true because for this selected group, 10 of 13 informants reported that their children had some type of hearing loss, ranging from loss related to recurrent middle ear infections to moderate congenital hearing loss.

**Effectiveness of Surgery**

No relationship was found between parental informants' reports of surgery and high and low articulation test scores. Bias of parental judgments, which may evolve from phenomenon such as psychological suggestion or monetary concerns, may have effected their reports.
Effectiveness of Speech Therapy

No relationship was found between parent reports of effective speech therapy and high/low articulation scores. Although reasons may be related to informants' inability to judge the effectiveness of speech therapy, it is probably related to the fact that most (11/12) informants reported speech improvement through speech therapy.

Sex

Sex related differences for subjects were reported in the previous chapter. Females' higher articulation scores were probably related to the other variables which were in their favor. Females also had fewer surgeries and lower incidence of cleft palate with or without cleft lip than did males. Lower incidence of difficulty from birth was also noted for females.

These three variables probably interrelated, but could not be statistically analyzed because of the small number of subjects. That is, a subject without a cleft of the lip or palate would probably be less likely to have difficulty from birth than one with cleft lip and palate, since the structures should be closer to normal. Also, if fewer surgeries have been performed, the possibilities of less
scar tissue, and reduced deviances in the velopharyngeal area are likely. However, females' informants did not report improved speech post-surgically as much as did males' informants. The possibility exists that females' speech was closer to normal pre-surgically, and speech improvement was not as noticeable to parents of some subjects. Or, the surgery may not have been as effective for females as it was for males. Females did score higher than males for both speech articulation tests, but both sets of scores were within one standard deviation of each other. The design of this study did not allow for assessment of the relative improvement of speech across sexes. Thus, one can only speculate regarding the differences noted until such variables can be formally isolated and analyzed.

Factors Related to Speech Improvement

A number of factors probably relate to speech improvement in subjects. Pharyngeal flap surgeries may have been effective, or thought to be effective, by parents for a number of reasons. The flap surgery was (1) effective in the enhancement of velopharyngeal closure, thus reducing hypernasality in the child's speech; (2) effective in the production of velopharyngeal closure, creating the possibility of greater intraoral pressure, and thus
improving speech articulation of consonants; or (3) a combination of both factors may have yielded the results noted. Also, speech therapy may have been effective in (1) the reduction of hypernasality in the child's speech; (2) in the improvement of speech articulation; or (3) a combination of both factors.

A combination of some or all of these factors may have been essential in the speech improvement of those children who had high articulation test scores and/or were reported by parents to have improved speech post-surgically. However, this relationship could not be determined for the subjects participating in this study. It is assumed that the most likely explanation of findings indicate that a combination of speech therapy and the pharyngeal flap surgery was effective in improvement of speech articulation and reduction of hypernasality. The need for additional information regarding the specific control of surgery and speech therapy is indicated. Such information would be of interest to plastic surgeons who perform these operations, to speech pathologists who work with these populations, and to parents of these children who desire estimates of potential change to be expected following surgical intervention.
Factors Related to Lack of Speech Improvement

Lack of speech improvement following surgical intervention may be related to a number of factors that range from faulty habitual articulatory patterns and poor motivation on the part of the child to extreme organic conditions that preclude notable speech improvement even with the flap surgery. It is suspected that in some cases hypernasality could be reduced because of improved velopharyngeal closure created by the flap, but post-surgically, the child may continue to habitually force air around the ports of the flap. It should also be recognized that the child may also be continuing to substitute phonemes as a habitual response even though the capability for correct phoneme production is present following surgery.

Persons who had undergone more than 2 surgeries were found to have low articulation scores. This finding may be related to the instance of past surgical scar tissue in the velopharyngeal area or to physiological disability of a neurogenic or myomotor nature. Scar tissue may prevent the posterior and lateral pharyngeal walls from closing off the flap ports, or scarring may have caused the flap operation to be less effective in some cases. That is, the presence of shrunken, or necrotic scar tissue may have prevented the
surgeon from creating the most effective pharyngeal flap.

Speech therapy may have been ineffective in subjects for a number of reasons including poor student motivation for change, too few hours per week in therapy, or lack of transfer into spontaneous speech. The pharyngeal flap may have been ineffective in creating velopharyngeal closure due to narrow flap width, or pharyngeal muscle weakness, incompetence, or paralysis. Any of these limitations may have minimized the potential effect of speech therapy efforts. Open hard palates in two subjects may be related to continued listener perception of hypernasality and poor speech articulation of sounds that require high intraoral pressure. These two subjects received low articulation test scores, and were rated by judges to have higher degrees of hypernasality and nasal emission, and more speech intelligibility problems than some of the other subjects. Speech articulation test scores and judges' ratings for these two subjects may have been higher if they had had surgically closed palates. Another possibility for insuring maximally improved speech in future subjects would include the temporary artificial palatal closure (with dental wax or other occlusive material). Such was not the procedure for this study, but it might be attempted in future studies.
Associated health conditions in subjects also may related to low speech articulation test scores. One of the subjects displayed symptoms of asthma during the evaluation. This condition may have temporarily decreased his capability of usual speech production. His labored breathing may also have biased the judges' ratings of his speech in a negative direction, even though judges were informed by the investigator to separate the aspects of asthma from speech characteristics as much as possible.

One of the subjects who participated in this study missed two items on the IPAT and none on the TDST. The two items missed on the IPAT included /baks/ for /blak/ and /wAf/ for /wAlf/. Although the subject may indeed have produced the items as she normally does, it is thought that she may have mistakenly labeled the "block" a "box," and unfortunately, the examiner did not ask her to repeat the item. The omission of the /l/ in the word "wolf" may have been a developmental error not related to velopharyngeal insufficiency.

Ratings

Mean judges' ratings for each of the four scales were compared to high and low speech articulation test scores, and a moderate relationship existed for Scales A, "General Effect of Hypernasal Characteristics," Scale
B, "Degree of Hypernasal Resonance" and Scale C "Nasal Emission" (o was between 0.55 and 0.63 for each scale). This indicates that judges' ratings tended to agree with TDST and IPAT results. Reasons for agreement could be related to chance, but more likely, judges' ratings probably tended to correlate with the articulation test scores because listeners were professionally trained in speech sound discrimination procedures.

A correlation between high articulation test scores and normal (or close to normal) speech ratings, and between low articulation test scores and abnormal speech ratings might be assumed. However, the high correlation for those variables also indicated that rating scales A, B, and C, designed by the investigator, were appropriate measures of speech important characteristics. It is suspected that these scales could be indicative of potentially aberrant speech characteristics (degree of hypernasality and nasal emission) when used by other trained speech pathologists. This hypothesis needs to be further investigated.

Rating Scale D "Intelligibility" was found to be weakly related to high or low speech articulation test scores. Some (4/6) subjects who received low articulation test scores were rated by judges to have "good" speech intelligibility. That is, although numerous articulatory deviances may have been present, overall speech
intelligibility was relatively "good." However, two of six low scoring subjects received "poor" ratings, and thus the relationship between relative speech intelligibility and speech articulation can not be ascertained in this study. Future investigations might evaluate this relationship.

Language may effect speech intelligibility ratings in two ways. Language problems, if present, may have caused judges to rate subjects' speech as less intelligible (i.e., the omission of the possessive "s"). A language screening evaluation could separate language disordered subjects from those subjects with normal language processes. The natural redundancy and the listener's expectancy of what word may occur next in any particular utterance may have caused the judges to rate speech more closely to normal. This relationship also needs to be evaluated.

**Experimenter and Judge Bias**

Variables that may have affected the results of this study include experimenter bias and judge bias. The experimenter was well aware that all subjects in this study had undergone the velopharyngeal flap procedure, seemingly because of velopharyngeal insufficiency. This knowledge may have influenced the investigator's objectivity in speech evaluation. Intrascorer reliability, however, was established through the sequential re-scoring of TDST and
IPAT tests for three randomly selected subjects. The selected judges were also probably aware that they were judging speech characteristics typical of individuals with velopharyngeal insufficiency. However, instructions given to them stated that they (the judges) may or may not be listening to speech characteristic of those persons with velopharyngeal insufficiency (Appendix E). Scoring of the same three audio-taped subjects tests by the selected judges was used as a measure of interjudge reliability. This scoring was completed after the investigator re-scored the samples to reduce listener familiarity (on the part of the primary investigator) as much as possible.

Implications

The design and "post hoc" nature of this study presents a body of data of value for estimating potential speech benefits which may be realized for surgery of this type. Additionally, this study presents a number of important questions which should be addressed in future analyses. Several unsolvable problems were apparent due to the nature and design of the study. These problems may be addressed through controlled analyses as part of future studies. The lack of formal, objective a priori data, the small number of subjects, and the limited number of available judges precluded formal statistical analysis of
several interesting questions. Differences in age at time of surgery, as it relates to articulation test scores, is suitable for formal future investigations.

The lack of pre-surgical data limited the study of the effectiveness of the pharyngeal flap surgery. It is hoped that in future studies, and with future prospective flap patients, consistent pre-surgical and post-surgical articulation data and nasality judgments will be gathered.

The small number of subjects participating in this study prevented the statistical analysis of further interactions between variables. It was suspected that interaction between these variables was related to high and low speech articulation test scores. In particular, low number of surgeries, lack of difficulty in speech related behaviors since birth, and velopharyngeal insufficiency without cleft lip and/or cleft palate probably were related to high speech articulation scores. Conversely, high number of surgeries, difficulty from birth and velopharyngeal insufficiency with accompanying cleft lip and/or cleft palate were probably associated with low speech articulation test scores. The interactions between these variables might be tested statistically with larger populations of subjects with appropriate pre-surgical data in future studies.
A larger number of judges might have created the possibility of establishing more accurate correlations between articulation test scores and speech ratings. It was suspected that although the correlations between the two variables was moderate, the relationship may be even stronger. This hypothesis needs to be tested.

For the rating scales A and B (General Effect of Hypernasal Characteristics and Degree of Nasal Resonance, respectively), denasal characteristics were not separated from hypernasal characteristics on different scales. The normal rating for these two scales was thus placed at "0" on the continuum, while normal for scales C and D (Nasal Emission and Intelligibility) was at "1". While this may have been confusing to the judges, it may also have caused them to rate the speech characteristics differently than they would if each characteristic was on separate scales of increasing abnormality from ratings of "1" to ratings of "7." Separate scales for denasality, hypernasality, nasal emission and speech intelligibility would probably be simpler and easier to explain and understand than the scales used in this study. However, the fact that the scales each had 7 divisions probably increased the consistency of the judges' ratings. This hypothesis could be tested in future studies. Also, the fact that three of the rating scales were strongly related to articulation
test scores for this study indicates that this relationship may hold in other cases. This hypothesis needs to be investigated.

Open hard palates might be controlled through temporary palatal closure with dental wax. The elimination of air escape into the nasal cavity through the hard palate fistula may then reduce aspects of hypernasality. The procedure would allow the investigator to separate cleft hypernasality from hypernasality related to velopharyngeal insufficiency (resultant of a short palate or an ineffective pharyngeal flap). However, it should be noted that the use of an artificial closure device may not be effective in altering aspects of hypernasality, nasal emission or speech intelligibility, due to habitual speech patterns. Thus, subjects with open hard palates may be analyzed separately from those subjects with surgically closed hard palates.

Another variable that might be investigated in future studies relates to the age at time of surgery. It is suspected that speech performance might tend to be better in subjects who have had surgery at young ages, thus allowing less time for faulty, compensatory speech patterns to develop.

The obvious heterogeneity of this particular group of subjects was observed in the analysis of the eight subject
variables, articulation test scores, differences between sexes, and rating scales. It may be likely that the individual subject differences were related to the lack of strong statistical relationships between these variables. Single case study analysis might be conducted in future studies if similar heterogeneousities are noted.

Conclusions

Based on the results and discussion presented previously, a number of conclusions can be drawn. These relate to prognosis, quality of rating scales, and implications for future research.

Prognostic Information

Information gathered in this study may be useful in the design of subsequent investigations. It may also be valuable to others who seek to evaluate the speech effects of various surgical interventions. Specifically, results indicate that:

(a) Subjects who had experienced more than 2 surgeries were more likely to have low speech articulation test scores than those with two or less surgeries;
(b) Subjects who had experienced two or less than two years in speech therapy were more likely to have high articulation test scores than those subjects with more
than two years in speech therapy;

(c) Factors related to difficulty from birth, primary structural conditions, years since surgery, history of hearing loss, effectiveness of speech therapy as reported by parents, and differences between males and females did not seem to be related to postsurgical articulation test scores for this selected population.

While the above information reflects characteristic aspects of the population studied, it must be carefully reported to parents and surgeons. It should be noted that these findings, which reflect group data, may not apply for any particular child. Additionally, information should be presented as it relates to this particular population of subjects with characteristics which may be unique for the sample studied.

Lack of A Priori Data

The effectiveness of flap surgeries and speech therapy could not be ascertained in this study, due to lack of consistent and objective a priori speech articulation data. Instead, effectiveness of surgery and therapy was based on parental reports. While this procedure provided important information about pre-surgical conditions, a more appropriate procedure would have the included a standard, consistent method of evaluating pre-surgical and
post-surgical speech articulation data to assess the effectiveness of a) the surgical procedure, and b) relative improvement resulting from speech therapy experiences.

Rating Scales

Three of the rating scales used in this study were shown to be effective indices of important variables related to characteristics usually associated with cleft palate speakers (hypernasal resonance and nasal emission). The observation that judgments of speech quality were reliable estimates of hypernasal resonance and nasal emission suggests that both pre-surgical and post-surgical speech evaluations should include such formal speech quality estimates. Findings indicate that subjects may in fact possess the ability to approximate articulatory targets readily, but resonance distortion or nasal emission may depress a listener's perception of speech intelligibility, thus minimizing communicative effectiveness, and contributing to negative affective or psychosocial impression of these individuals as communicators. However, findings from rating scale D "Intelligibility" indicated that subjects may not possess good articulation of phonemes in words, but be fairly intelligible to listeners.

The scales also add specificity to the results of the
Iowa Pressure Articulation Test by promoting categorizations (denasal, hypernasal and nasal emission) which are more likely to elucidate the aerodynamic adjustments which result from the pharyngeal flap procedure. Certainly, these scales may also serve the speech pathologist as instruments for periodic assessment of the impact of their clinical procedures following surgery, thus promoting the eventual identification of effects which are due primarily to surgical intervention versus those which result from clinical motivation.

**Future Research**

The implications for future research discussed earlier in this chapter, suggest the following:

(a) a larger number of subjects and judges for improved statistical analyses;

(b) a separation of denasal from hypernasal characteristics for two of the rating scales (A and B);

(c) comparisons between age at time of surgery and speech articulation scores for promotion of more detailed information regarding developmental factors related to speech performances, and possibly to prognostic
information about more ideal ages for surgery, 
minimization of aberrant compensatory habit strength, etc.

(d) temporary closure of open hard palates (with dental wax or other occlusive material) to isolate the relative speech quality contributions of various structural deviations to possible structural areas where hypernasality may occur.
APPENDIX A

LETTER OF INQUIRY
May 3, 1984

Dear Parents:

We are currently doing research in the area of cleft lip and palate. According to information available from Kalamazoo Plastic Surgery and Dr. Frank Newman, your child fits the requirements of this study. Your participation would include: (a) answering a questionnaire; and (b) having your child’s speech assessed at Western Michigan University’s Speech Clinic. If you would be willing to help us out in our research, please let us know by mailing the enclosed postcard no later than May 18, 1984. A questionnaire will be sent to you following our receipt of your postcard. All help will be greatly appreciated.

Sincerely,

Frank J. Newman, M.D.

Clyde R. Willis, Ph.D.
Professor

Karen Zalewski
Graduate Student

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
APPENDIX B

QUESTIONNAIRE AND EXPLANATORY LETTER
IDENTIFYING INFORMATION

Name of Subject ___________________________ Birthdate ___________ Phone _______

Parents’ Name __________________________________________

Address __________________________________________

HISTORY OF THE PROBLEM

When was the subject first examined at the Kalamazoo Plastic Surgery Offices?

How many times was the subject examined after the initial visit? Give month and year. ____________________________

Who originally referred you to this clinic? (check one) self or parent _________; speech therapist ________;

doctor (specify type) ___________________; family member ________;

other (specify profession) _____________________ Describe as best as you can the nature of the problem that resulted in referral to this office:

__________________________

If there was special concern about the subject's speech, describe as best you can the nature of the speech problem. Include information on specific problems such as air leakage through the nose, too little air through the nose, difficulty with certain sounds, etc. _______________________

__________________________

Describe any related problems. Include information on specific items such as drinking, sucking, swallowing, or blowing difficulties, breathing abnormalities, facial contortions, etc. _______________________

__________________________

When did the problem seem to originate? That is, was the problem always apparent? Or, was there a specific onset of the problem? _______________________

__________________________
List all surgery the subject has had, including the nature of the surgery, the date and place surgery was performed, and the surgeon or surgery team who performed the surgery. List ALL surgery, regardless of its nature.

<table>
<thead>
<tr>
<th>DATE</th>
<th>NATURE OF SURGERY</th>
<th>HOSPITAL</th>
<th>SURGERY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Did any of the above procedures have either a positive or negative effect on the subject's speech? That is, did speech improve or get worse after any of the above operations? If so, please identify the surgical procedure and describe the change in speech.

SPEECH THERAPY

Identify the amount of speech therapy the subject has received by listing the year (or grade), setting (school, preschool, speech and hearing clinic, university clinic, private therapist, other), and the frequency (times per week).

<table>
<thead>
<tr>
<th>YEAR OR GRADE IN SCHOOL</th>
<th>SETTING</th>
<th>FREQUENCY GROUP OR INDIVIDUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Describe as best you can the effect speech therapy has had on the subject's speech.
HEARING

Does the subject have a history of ear problems? ______ yes ______ no

If yes, describe the kinds of ear problems the subject has experienced.

________________________________________________________________________

Identify below the treatment for ear problems the subject has had:

<table>
<thead>
<tr>
<th>DATE</th>
<th>TREATMENT</th>
<th>SPECIALIST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Describe the present status of the subject's ears and hearing. Add any other relevant information on the nature and course of the hearing problem.

________________________________________________________________________

ADDITIONAL INFORMATION

In the space provided below, add any other information that you feel may be relevant. You may want to include information on such items as: genetic counseling, use of prosthetic devices, school performance, social adjustment, self concept, etc.

________________________________________________________________________

________________________________________________________________________

FORM COMPLETED BY _______________________

RELATIONSHIP TO SUBJECT _______________________

RETURN NO LATER THAN _______________________

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
June 22, 1984

Dear Parents,

Enclosed is the questionnaire you agreed to complete to help us in our research. Information about specific subjects will remain confidential. No individual subject will be referred to by name in the results of the study. Information obtained from this questionnaire will be compiled and used to describe characteristics of the population seen at the Kalamazoo Plastic Surgery Offices.

Please be sure to fill in every answer. If you do not know the answer to any question, please indicate that the information is unknown or unavailable but DO NOT LEAVE ANY QUESTION UNANSWERED!! Be sure to include all dates requested as these are very important to the results of this study. Please include approximate dates (especially the year) if the actual date is unknown. Feel free to use the back side of the questionnaire or additional paper if more space is needed to adequately answer any question. Ms. Karen Zalewski will be contacting you soon if she has not already done so to arrange an appointment for the audio-taped speech portion of the study. This will be conducted at the W.M.U. Speech Clinic. Any questions that you may have can be answered at that time.

Thank you for your time. Your help is greatly appreciated.

Sincerely,

Frank J. Newman, M.D.

Clyde R. Willis, Ph.D.
Professor

Karen Zalewski
Graduate Student
APPENDIX C

CONSENT LETTER
Date

I agree to participate in this study completed by Karen Zalewski, a graduate student in Speech Pathology and Audiology at Western Michigan University. I understand that Dr. Frank Newman has given permission to Ms. Zalewski to collect file information and analyze this data.

I further understand that the audio-taped procedure is two-fold: my child will be (1) shown pictures of objects and be asked to name them; and (2) asked to repeat sentences spoken by Ms. Zalewski. I know that if I or my child wish, we may discontinue our participation at any time during the study. If either my child or I decide not to participate, I understand that this decision will in no way affect any treatment received by me or my child by Dr. Newman or Western Michigan University. I understand that the procedure described are not invasive or harmful in any way.

I have been informed that all information gathered will remain confidential and my name will not be associated in any way with the findings of this study. I understand that at the appropriate time, my participation will include a visit to Western Michigan University's Speech Clinic for the above mentioned procedure. This portion of the study will be scheduled at a later date.

Parent/Guardian

Ms. Zalewski and/or my parents/guardians have explained what is expected of me as part of this study, and I agree to come to the Speech Clinic at the appropriate time.

Child (8 years and over)

I grant permission for segments of my child's audiotape to be used for educational purposes in speech pathology training.

Parent/Guardian
APPENDIX D

TDST AND IPAT TEST ITEMS
<table>
<thead>
<tr>
<th></th>
<th>TEMPLIN-DARLEY SCREENING TEST OF ARTICULATION (TDST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>bird /$/__________</td>
</tr>
<tr>
<td>2.</td>
<td>music /j/__________</td>
</tr>
<tr>
<td>3.</td>
<td>red /r/__________</td>
</tr>
<tr>
<td>4.</td>
<td>arrow /r/__________</td>
</tr>
<tr>
<td>5.</td>
<td>leaf /l/__________</td>
</tr>
<tr>
<td>6.</td>
<td>valentine /v/_______</td>
</tr>
<tr>
<td>7.</td>
<td>thumb /θ/__________</td>
</tr>
<tr>
<td>8.</td>
<td>toothbrush /θ/______</td>
</tr>
<tr>
<td>9.</td>
<td>teeth /θ/__________</td>
</tr>
<tr>
<td>10.</td>
<td>there /θ/__________</td>
</tr>
<tr>
<td>11.</td>
<td>feathers /ʃ/_______</td>
</tr>
<tr>
<td>12.</td>
<td>smooth /ʃ/__________</td>
</tr>
<tr>
<td>13.</td>
<td>zipper /z/__________</td>
</tr>
<tr>
<td>14.</td>
<td>shoe /ʃ/__________</td>
</tr>
<tr>
<td>15.</td>
<td>dishes /ʃ/__________</td>
</tr>
<tr>
<td>16.</td>
<td>fish /ʃ/__________</td>
</tr>
<tr>
<td>17.</td>
<td>television /z/______</td>
</tr>
<tr>
<td>18.</td>
<td>yellow /j/__________</td>
</tr>
<tr>
<td>19.</td>
<td>onions /j/__________</td>
</tr>
<tr>
<td>20.</td>
<td>chair /tʃ/__________</td>
</tr>
<tr>
<td>21.</td>
<td>matches /tʃ/_______</td>
</tr>
<tr>
<td>22.</td>
<td>watch /tʃ/__________</td>
</tr>
<tr>
<td>23.</td>
<td>jump /dʒ/__________</td>
</tr>
<tr>
<td>24.</td>
<td>engine /dʒ/__________</td>
</tr>
<tr>
<td>25.</td>
<td>presents /pr/_______</td>
</tr>
</tbody>
</table>
# IOWA PRESSURE ARTICULATION TEST (IPAT)

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>shoe</td>
<td>/ʃ/</td>
<td>26</td>
<td>sun</td>
<td>/s/</td>
<td>31</td>
<td>dresses</td>
<td>/s/</td>
</tr>
<tr>
<td>2</td>
<td>dishes</td>
<td>/ʃ/</td>
<td>27</td>
<td>mouse</td>
<td>/s/</td>
<td>32</td>
<td>scissors</td>
<td>/z/</td>
</tr>
<tr>
<td>3</td>
<td>fish</td>
<td>/ʃ/</td>
<td>28</td>
<td>pocket</td>
<td>/k/</td>
<td>33</td>
<td>paper</td>
<td>/p/</td>
</tr>
<tr>
<td>4</td>
<td>jump</td>
<td>/dʒ/</td>
<td>29</td>
<td>wagon</td>
<td>/ɡ/</td>
<td>34</td>
<td>cracker</td>
<td>/kɾ/</td>
</tr>
<tr>
<td>5</td>
<td>bread</td>
<td>/br/</td>
<td>30</td>
<td>telephone</td>
<td>/f/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>tree</td>
<td>/tr/</td>
<td>31</td>
<td>dresses</td>
<td>/s/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>drum</td>
<td>/dr/</td>
<td>32</td>
<td>scissors</td>
<td>/z/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>crayons</td>
<td>/kr/</td>
<td>33</td>
<td>paper</td>
<td>/p/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>grass</td>
<td>/ɡɾ/</td>
<td>34</td>
<td>cracker</td>
<td>/kɾ/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>planting</td>
<td>/p/</td>
<td>35</td>
<td>tiger</td>
<td>/ɡ/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>clown</td>
<td>/kl/</td>
<td>36</td>
<td>washer</td>
<td>/ʃ/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>glasses</td>
<td>/ɡl/</td>
<td>37</td>
<td>fork</td>
<td>/ʃk/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>smoke</td>
<td>/sm/</td>
<td>38</td>
<td>blocks</td>
<td>/bl/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>snowman</td>
<td>/sm/</td>
<td>39</td>
<td>wolf</td>
<td>/l/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>spoon</td>
<td>/sp/</td>
<td>40</td>
<td>'possum</td>
<td>/sm/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>stairs</td>
<td>/st/</td>
<td>41</td>
<td>socks</td>
<td>/ks/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>skates</td>
<td>/sk/</td>
<td>42</td>
<td>stamps</td>
<td>/mps/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>twins</td>
<td>/tw/</td>
<td>43</td>
<td>stopped</td>
<td>/pt/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>string</td>
<td>/str/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>two</td>
<td>/t/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>cat</td>
<td>/k/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>truck</td>
<td>/k/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>girl</td>
<td>/ɡ/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>dog</td>
<td>/ɡ/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>knife</td>
<td>/f/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
APPENDIX E

RATING INSTRUCTIONS, RATING SCALES AND RESPONSE FORM
INSTRUCTIONS FOR SCORING TESTS OF ARTICULATION

The task I am asking you to perform is similar to the one you were trained to do in the Cleft Palate Seminar. The speech samples you will hear may or may not have features of nasality present. Your task is to decide if nasal resonance, nasal emission and other nasality features are present and rate them as closely as possible to the scales provided.

The first task you will perform will be the scoring of three tests of articulation. The sounds in words to be tested are listed on the scoring sheet. Remember to score only the sound(s) being tested as incorrect or correct. If other sounds in the word are not correct, but the tested sound is, then the word is marked correct. Tested sounds produced with hypernasal resonance, hypernasal emission or produced distortedly should be marked incorrect. Place a check in the space next to those items in which the sound is correctly produced. Place an "x" next to those tested items that are produced incorrectly.

INSTRUCTIONS FOR RATINGS FORM

You will be listening to speech samples of children who may or may not have nasality present in their speech. You will hear each sentence repeated twice, once by the examiner and once by the child. The first four sentences
include many nasal consonants, the second group of four contain none and the third group include a few of them. These divisions may help you decide if assimilated nasality is present on the sentences containing nasal consonants.

For the first rating scale, make a decision if the speaker is (-2) denasal; (-1) slightly denasal; (0) non-nasal; (1) has occasional nasality; (2) is mostly nasal; (3) consistently nasal; or (4) extremely nasal. Make your response on the appropriate place on your scoring sheet.

For Part B, make a decision about the degree of nasal resonance: (-2) extremely denasal; (-1) slightly denasal; (0) non-nasal; (1) occasional nasality; (2) pervasive nonassimilative nasality; (3) pervasive assimilated nasality; consonants still relatively pure; (4) severe and pervasive assimilated or non-assimilated nasality involving both consonants and vowels.

For Part C, make a decision with regard to nasal emission. (1) none present; (2) specific to a single phoneme only; (3) inconsistent, specific to several phonemes but with no effect on adjacent phonemes; (4) inconsistent; involves nasalized consonants and phonemes adjacent to them; (5) consistent; involves nasalized consonants and phonemes adjacent to them; (6) consistent; involves some fricatives and some stop consonants regardless of contextual position; (7) consistent; involves
all stop consonants and all fricatives regardless of contextual position.

For Part D, you will be hearing samples of spontaneous speech from each of the speakers. Make a decision with regard to the speaker's intelligibility. (1) all sounds intelligible and flawlessly produced; (2) all sounds clearly intelligible and developmentally appropriate (though not perfectly articulated); (3) some sounds slightly distorted affecting intelligibility occasionally, but developmentally appropriate; (4) most sounds and words fairly intelligible, but some whole words unintelligible; (5) many words unintelligible; (6) entire speech pattern almost completely unintelligible; or (7) completely unintelligible.

For Part E, make comments of other concerns if you wish.
### RATING SCALE

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>JUDGE</th>
</tr>
</thead>
</table>

#### A. GENERAL JUDGMENT OF EFFECT OF HYPERNASAL CHARACTERISTICS:

<table>
<thead>
<tr>
<th>Denasal</th>
<th>Slightly non-nasal</th>
<th>Occasional</th>
<th>Mostly</th>
<th>Consis-</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

-2 extremely denasal
-1 slightly non-nasal
0 occasional
1 mostly non-nasal
2 nasality
3 nasal
4 extremely nasal

#### B. DEGREE OF NASAL RESONANCE:

| Ex- | Slightly non-nasal | Occasional | Nonassimilated | Pervasive | Severe |
|-----|--------------------|------------|----------------|-----------|
| -2  | -1                 | 0          | 1              | 2         |

Exremely denasal
Slightly non-nasal
Occasional
Nonassimilated
Pervasive
Severe

#### C. NASAL EMISSION:

<table>
<thead>
<tr>
<th>None</th>
<th>Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Present to a single phoneme</td>
</tr>
<tr>
<td>2</td>
<td>Specific to several phonemes</td>
</tr>
<tr>
<td>3</td>
<td>Inconsistency</td>
</tr>
<tr>
<td>4</td>
<td>Inconsistency</td>
</tr>
<tr>
<td>5</td>
<td>Inconsistency</td>
</tr>
<tr>
<td>6</td>
<td>Consistency</td>
</tr>
<tr>
<td>7</td>
<td>Consistency</td>
</tr>
</tbody>
</table>

- None
- Specfic
- Inconsistency
- Consistency

---

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
D. INTELLIGIBILITY:

PLEASE ASTERISK (*) IF UNINTELLIGIBILITY IS MORE RELATED TO OTHER FACTORS NOT DIRECTLY RELATED TO VELOPHARYNGEAL COMPETENCY.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| all sounds intelligible and flawlessly produced | all sounds clearly intelligible and develop-mentally appropriate (though not perfectly articulated) | some intelligible, slightly distorted affecting intelligibility basically | most sounds fairly intelligible but some | many words almost intelligible | entire completely | speech perfectly pattern uninter- }
### TRAINING SCALE

**A. GENERAL JUDGMENT OF EFFECT OF HYPERNASAL CHARACTERISTICS:**

<table>
<thead>
<tr>
<th>2</th>
<th>1</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denasal</td>
<td>Non-nasal</td>
<td>Assimilated</td>
<td>Fairly nasal</td>
<td>Extremely nasal</td>
</tr>
</tbody>
</table>

**B. DEGREE OF NASAL RESONANCE:**

<table>
<thead>
<tr>
<th>2</th>
<th>1</th>
<th>0</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denasal</td>
<td>Non-nasal</td>
<td>Assimilated</td>
<td>Severe assimilated nasality; consonants still relatively pure</td>
<td>Pervasive nasality involving both consonants and vowels</td>
</tr>
</tbody>
</table>

**C. NASAL EMISSION:**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Present phoneme</td>
<td>Involves consonants next to nasal</td>
<td>Involves fricatives and some stop consonants</td>
<td>Involves all stop consonants and all fricatives</td>
</tr>
</tbody>
</table>

**D. INTELLIGIBILITY:**

PLEASE ASTERISK IF UNINTELLIGIBILITY IS MORE RELATED TO OTHER FACTORS NOT DIRECTLY RELATED TO VELOPHARYNGEAL COMPETENCY

all sounds some sounds most sounds many words almost clearly slightly fairly in- unintelli- com- intelligible distorted, telligible, gible pletely develop- intelligible whole words unintelli- telligible mentally bility occa- gible sionally, not per- priate, but develop- appropriate fectly though mentally 4 & 5: Both of these would likely involve errors beyond those directly related to velopharyngeal functioning

**E. COMMENTS ON OTHER CONCERNS:** (e.g., language, etc.)
<table>
<thead>
<tr>
<th>SUBJECT NO.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**E. COMMENTS ON OTHER CONCERNS (e.g., language, prosody, stress, pitch, etc., or other phenomena of interest)**

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX F

SELECTED SUBJECT CHARACTERISTICS, MEANS AND STANDARD DEVIATIONS
### Characteristics of Subject Population

<table>
<thead>
<tr>
<th>N</th>
<th>Sex</th>
<th>Eval Age</th>
<th>Surg Age</th>
<th>Yrs Surg</th>
<th>No Surg</th>
<th>Yrs Tx</th>
<th>Hist Hrg</th>
<th>CP*/-CL</th>
<th>FL</th>
<th>Imp Surg</th>
<th>Diff birth</th>
<th>Eff 1</th>
<th>Eff 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>7.25</td>
<td>6.40</td>
<td>0.85</td>
<td>3</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>7.66</td>
<td>4.92</td>
<td>2.74</td>
<td>6</td>
<td>0</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>50</td>
<td>41</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>9.25</td>
<td>5.16</td>
<td>4.09</td>
<td>4</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>9.92</td>
<td>8.08</td>
<td>1.84</td>
<td>1</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>8.92</td>
<td>4.04</td>
<td>4.52</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>14.92</td>
<td>12.00</td>
<td>2.92</td>
<td>2</td>
<td>5</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>7.92</td>
<td>5.33</td>
<td>2.59</td>
<td>2</td>
<td>1</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>9.75</td>
<td>5.00</td>
<td>4.73</td>
<td>8</td>
<td>7</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>8.33</td>
<td>5.40</td>
<td>2.93</td>
<td>7</td>
<td>3</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>7.56</td>
<td>5.66</td>
<td>1.00</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>10.08</td>
<td>9.00</td>
<td>1.08</td>
<td>2</td>
<td>4</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>50</td>
<td>43</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>8.92</td>
<td>7.40</td>
<td>1.52</td>
<td>4</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>13.33</td>
<td>10.00</td>
<td>3.33</td>
<td>3</td>
<td>5</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>22</td>
<td>28</td>
</tr>
</tbody>
</table>

**Mean**

- Eval Age: 9.52
- Surg Age: 6.83
- Yrs Surg: 2.69
- No Surg: 3.60
- Yrs Tx: 3.0

**SD**

- Eval Age: 2.26
- Surg Age: 2.33
- Yrs Surg: 1.25
- No Surg: 2.14
- Yrs Tx: 1.9

**N**

- Number of Subjects

**Eval Age**

- Age at time of evaluation

**Surg Age**

- Age at time of surgery

**No. Surg**

- Number of surgeries

**Yrs Tx**

- Number of years in speech therapy

**Hist Hrg**

- History/no history of hearing loss

**CP*/-CL**

- Cleft palate with or without cleft lip

**FL**

- Pharyngeal flap without cleft lip or palate

**Imp Surg**

- Parental reports of speech improvement post-surgically

**Diff birth**

- Parental reports of difficulty/no difficulty from birth

**Eff Tx**

- Parental reports of effectiveness of speech therapy
APPENDIX G

COMPARISONS BETWEEN SELECTED SUBJECTS (GROUP A) AND
SUBJECTS NOT AVAILABLE (GROUP B) FOR
ANALYSIS OF SELECTED VARIABLES
### Appendix H. Comparisons between Selected Subjects (Group A; N=13) and Unavailable Subjects (Group B; N=16) for Analysis of Selected Variables.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>F</td>
<td>7.25</td>
<td>9.5</td>
<td>6.4</td>
<td>4.75</td>
<td>3</td>
<td>2</td>
<td>0.85</td>
<td>4.75</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>F</td>
<td>7.66</td>
<td>13.41</td>
<td>4.92</td>
<td>8.33</td>
<td>6</td>
<td>2</td>
<td>2.74</td>
<td>5.08</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>F</td>
<td>9.25</td>
<td>16.08</td>
<td>5.16</td>
<td>12.16</td>
<td>4</td>
<td>1</td>
<td>4.09</td>
<td>3.92</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>F</td>
<td>9.92</td>
<td>8.75</td>
<td>8.08</td>
<td>5.41</td>
<td>1</td>
<td>2</td>
<td>1.84</td>
<td>3.34</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>M</td>
<td>8.92</td>
<td>7.0</td>
<td>4.04</td>
<td>5.0</td>
<td>3</td>
<td>7</td>
<td>4.52</td>
<td>2.0</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>H</td>
<td>14.92</td>
<td>10.75</td>
<td>12.0</td>
<td>7.58</td>
<td>2</td>
<td>1</td>
<td>2.92</td>
<td>3.17</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>M</td>
<td>7.92</td>
<td>10.66</td>
<td>5.33</td>
<td>7.75</td>
<td>2</td>
<td>2</td>
<td>2.59</td>
<td>2.91</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>8</td>
<td>H</td>
<td>H</td>
<td>9.75</td>
<td>11.25</td>
<td>5.0</td>
<td>7.5</td>
<td>8</td>
<td>3</td>
<td>4.75</td>
<td>3.75</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>9</td>
<td>H</td>
<td>M</td>
<td>8.33</td>
<td>10.41</td>
<td>5.4</td>
<td>7.58</td>
<td>7</td>
<td>1</td>
<td>2.93</td>
<td>2.83</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>M</td>
<td>7.56</td>
<td>5.16</td>
<td>5.66</td>
<td>3.5</td>
<td>2</td>
<td>3</td>
<td>1.0</td>
<td>1.66</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>11</td>
<td>H</td>
<td>M</td>
<td>10.08</td>
<td>16.66</td>
<td>9.0</td>
<td>13.41</td>
<td>2</td>
<td>1</td>
<td>1.08</td>
<td>3.24</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>12</td>
<td>H</td>
<td>M</td>
<td>8.92</td>
<td>7.0</td>
<td>7.4</td>
<td>5.75</td>
<td>4</td>
<td>2</td>
<td>1.52</td>
<td>1.25</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>M</td>
<td>13.33</td>
<td>7.91</td>
<td>10.0</td>
<td>4.91</td>
<td>3</td>
<td>3</td>
<td>3.33</td>
<td>3.0</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>14</td>
<td>M</td>
<td>F</td>
<td>7.75</td>
<td>4.33</td>
<td>4</td>
<td>3.33</td>
<td>4</td>
<td>3</td>
<td>3.42</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>M</td>
<td>5.5</td>
<td>4.58</td>
<td>3</td>
<td>0.92</td>
<td>3</td>
<td>1</td>
<td>2.83</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>M</td>
<td>M</td>
<td>11.33</td>
<td>8.5</td>
<td>1</td>
<td>2.61</td>
<td>3</td>
<td>1</td>
<td>2.61</td>
<td>Y</td>
<td>62%</td>
<td>50%</td>
</tr>
</tbody>
</table>

*P=54%  x=9.52  X=6.35  =6.94  =2.37  =2.69  =2.81  =62%  =50%

*P=46%  X=2.66  X=3.97  =2.14  =2.14  =1.25  =1.30  =38%  =50%

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
BIBLIOGRAPHY


120

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


