PROSODIC ASPECTS IN ALARYNGEAL SPEECH

M- 9622

A Dissertation submitted as part fulfillment of
final year M.Sc. (Speech and Hearing)
to the University of Mysore,
Mysore.

May 1998

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DEDICATED

TO

GOD, TEACHER & FRIEND

CERTIFICATE

This is to certify that this dissertation entitled " PROSODIC ASPECTS IN ALARYNGEAL SPEECH" *is the bonofide work in partfulfilment for the degree of "Master of Science (Speech and Hearing) " of the student with register number* M-9622.

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DECLARATION

This dissertation entitled **"PROSODIC ASPECTS IN ALARYNGEAL SPEECH"** is the result of my own study under the guidance of **Dr. N.P. Nataraja,** Professor and Head, Department of Speech Sciences, All India Institute of Speech and hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore **M-9622**

May, 1998

ACKNOWLEDGMENT

First and Foremost, I extend my heartful gratitude to Dr. **Nataraja,** N.P Professor and Head, Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore, for his invaluable encouragement, suggestions, guidance and critical evaluation which enabled me to complete this work successfully.

My Sincere thanks to Dr. (**Miss) S. NIKAM,** Director, All India Institute of Speech and Hearing, Mysore, for granting me permission to carry out this study.

I thank **Mrs. Sridevi, Ms Lalitha, Mrs Sangeetha and Mrs Manjula** for their timely help.

I thank all the **Library Staffs** for helping me go through the vast literature in the library.

I thank **Dr. Rajashekhar. B.** Professor and Chief in Audiology and Speech Pathology, Kasturba Hospital, Manipal, for his support and encouragement.

Kanaka- I am grateful to you for the immense help offer during this work.

Thanks to all the juniors especially **Arushi, Hemalatha,Neha Rawat, Kaveri, Kavitha** and **Ashley** for your timely help.

Raj- Your friendship means a lot to me. I will always cherish it. Thank you for being always there for me.

Anitha, Srabanti-I will always remember the time spent with you guys.

Shammi - Thanks a lot for your co-operation and encouragement during your 3 days stay at AIISH.

Visa, Priya and Haripriya- Thank you so much for your support and concern.

Rohi- Thanks for those joyous time.

Sara, Manoj, Binu.R. J.P. and Rathna - It's fun talking to you guys

Preeti and Roopa - Thanks a lot for your timely help.

Appa, Amma, Sisters and Brother-in-laws - For your silent prayers and blessing for success in all my endeavours for providing me all the support I so much needed. I owe you everything what I am today.

Chikkappa and Chikkamma -I am grateful to you.

Prajwal- There is only one word for you **"TERRIFIC".** Hope to catch up those days I missed when all others had fun with you. I am really lucky to have a nephew like you. Love you.

Lastly, But maximally I thank **Ms Smitha.G (Sri Guru Enterprises)** for your neat and wonderful job in preparation of the manuscript.

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INTRODUCTION

Speech is a multidimensional signal that elicits a linguistic association (Flanagan, 1972). It is believed that human beings are specialized for speech communication most evidently for speech production.

The act of speaking is a very specialized way of using the vocal mechanism. Speaking demands a combination or interaction of the mechanism of respiration, phonation, resonation and articulation. The underlying basis of speech is voice. Voice being the vital entity for communication is affected in various vocal fold pathological conditions. One of the common conditions leading to abnormality of voice is cancer of larynx. Laryngeal cancer threatens to destroy one of the most essentially attributes-communication through speech. Cancer of the larynx calls for surgical or radiological intervention. These can be partial or total removal of the larynx and this may lead to significant alteration or complete loss of speech.

Hence speech rehabilitation of the laryngectomized patients is vital and interesting as it amounts to a new life for them. So voice restoration following total laryngectomy remains a challenging problem for both head and neck surgeon and speech pathologist. It is, however, the key to return laryngectomees to productive life. Different methods of restoration of voice following laryngectomy have been developed such as esophageal speech electronic/artificial larynx. But with the development of Tracheoesophageal puncture (TEP) techniques and Blom- Singer's (BS) voice prosthesis (Singer and Blom, 1980), a third alternative is available, which uses the pulmonary air source to vibrate the Pharyngoesophageal (PE) segment.

Evaluating the factors affecting the intelligibility of the alaryngeal speech is important for the rehabilitation of the laryngectomees. Changes in the speech production mechanism occasioned by laryngectomy are reflected in the acoustic characteristics of alaryngeal speech in many ways (Hillman and Weinberg, 1982; Robbins, Fisher, Blom and Singer, 1984; Sisty and Weinberg, 1972; Weinberg, 1986; Weinberg and Bennet, 1972a and Weinberg, Horii and Smith 1980).

Both TEP and esophageal speech are characterized by altered fundamental frequency, speaking rate, duration and intensity characteristics. These altered characteristics highlight some of the differences between normal and alaryngeal speech, serve to identify parameters of speech important to clinical evaluation and management.

Change in 'Prosody' otherwise termed 'suprasegmental' features of speech, alters the meaning of an utterance, even when there is no change in the segmental structure. The melody of speech is conveyed through the prosodic features. These features are considered as one of the most important but highly evasive properties of spoken language (Price, Ostendorf, Shattuck-Hufnagel and Fong, 1991). Prosody includes the intonation, Stress, Tempo and Rhythm. (Heuvel, Reitveld and Crannen, 1994). The prosodic structure of speech is the result of complex interaction with and within different levels of speech such as the semantic, pragmatic, syntactic, phonotactic, rhythmic and others (Rossi, 1993).

As a result of total laryngectomy and the use of non normal voicing systems (Whether intrinsic or extrinsic) considerable reductions exist in the speech of the larayngectomised person's because of reduced ability to manipulate frequency, intensity and duration. In normal laryngeal speakers, the ability to volitionally manipulate these acoustic parameters is believed to underlie the speakers ability to signal a variety of linguistic contrasts. Thus, the ability for alaryngeal speakers to signal linguistic (suprasegmentals) markers such as stress, intonation, juncture and duration may be observed. Yet the physiologic limitations exhibited by certain type of alaryngeal talkers may result in differences in their ability to code such prosodic elements.

Control of important dimensions of speech and voice is critical to the realization of linguistic contrast. Unfortunately, there is an absence of information concerning the ability of laryngectomized speakers to realize such contrasts. Moreover, study of normal speakers, realization of certain types of linguistic contrasts has been limited and conducted with considerable procedural variations.

Aim of the Study :

The present study is undertaken to:-

- Determine the degree to which Kannada speaking alaryngeal speakers are able to produce prosodic patterns or features.
- Compare the speech of tracheoesophageal and esophageal speakers based on prosodic features.
- To determine the difference between alaryngeal speakers and normals on the following parameters.
    a) Temporal Features
    b) Intonation and Stress pattern
    c) Fundamental frequency and Intensity variations.
- To relate the deviations in various parameters to reduced intelligibility in alaryngeal speakers

METHODOLOGY:

The speech samples of three groups (esophageal, TEP and normal speakers) each containing five subjects were studied. The fundamental frequency, intensity, temporal factors were analyzed using Computer programme. The data has been subjected to appropriate statistical analysis and results have been discussed.

HYPOTHESIS :

1. There is no significant differences in terms of parameters studied between esophageal and normal speakers i.e.
2. There is no significant differences in terms of parameters studied between TEP and normal speakers i.e.

   a) Fundamental frequency
   b) Intensity
   c) Temporal features.
      * Rate of speech
      * Pauses
   d) Intonation and Stress patterns.

IMPLICATIONS :

It would help in improving therapy techniques for laryngectomee. This information helps in better understanding the physiology of speech using neoglottis.

LIMITATIONS OF THE STUDY :

1) Only male speakers have been studied
2) Five subjects in each age group have been studied.
3) Only few aspects of prosody have been considered.

REVIEW OF LITERATURE

One of the most important attribute of man in the ability to communicate with other human being. This distinguish him from other species of animals. The ability to use the vocal apparatus to carry out interpersonal, intrapersonal and group communication is unique to human beings. The one form of communication which people use most effectively in interpersonal relationships is speech. Speech is most commonly that allows human beings to share their thoughts with others. In a real sense, speech is the key to human existence. It bridges the difference and distance and helps to give meaning and purpose of their lives. (Fisher 1975).

The act of speaking is a very specialized way of using the vocal mechanism, demanding a combination or interaction of respiration, phonation, resonance and articulation. (Boone 1985), Weinberg (1986) considers human speech production as a diverse and fascinating endeavour, the diversity of which is highlighted by the capacity for human communication by speech to be examined at several levels: Physiological, acoustical, psychophysical, linguistic and psycholinguistic levels underlying both production and perception of speech. Normal speech production is accomplished by generating source sounds in the larynx or at various sites in the vocal tract and differentially modifying then-sounds by acoustic filtering.

The underlying basis of speech is voice. Voice is defined as laryngeal modulation of the pulmonary airstream which is then further modified by the configuration of the vocal tract (Michel & Wendahl 1971).

The production of voice depends on the synchrony between the respiratory, the phonatory, and the resonatory system.Voice has both linguistic and non linguistic functions in any language. The degree of dependence of language on these functions varies from language to language. "Tone languages" For Eg : rely more on the voice or pitch, more specially than other languages variation in voice in terms of pitch and loudness provide rhythm and break the monotony. Voicing has been found to be a major "distinctive Feature" in almost all languages, providing more phonemes and making the language broader. Voice plays an important role at the semantic level. Use of different pitches with the same string of phonemes would alter the meaning. Speech prosody, intonation, stress, rhythm of language are functions of pitch and loudness as well as of phonetic duration.

Perkins (1971) has identified five non-linguistic functions of voice.They are: speaker identity, personality, emotion, somatic condition, aesthetic function. According to Walters and Maxell (1980) have reported several studies wherein based on voice, it was possible to identify status, racial features, height and weight. It is known that voice basically reflects the anatomical and physiological conditions of the respiratory,phonatory and resonatory systems.

Voice is important for professional speakers and singers. Loss of voice has been found to lead to psychological, social and economic problems. These may get aggravated in case of teachers, lawyers, politicians and others where the individual is depending on his voice for his living. Therefore, the voice restoration in these cases becomes important.

A total laryngectomy necessitates the removal of entire larynx, sometimes including the hyoid bone, strap muscles and upper tracheal rings due to carcinoma. During surgical procedure trachea is sutured to the neck of the case to create a permanent respiratory stoma on the neck wall. Therefore it is clear that there is loss of ability to produce voice by conventional means. Therefore an alternate method of producing voice must be taught to these cases. There are several procedures to teach voice production in this cases. "Speech requisition and training involves more than getting the voice back". (Weinberg, 1981).

Laryngectomy for carcinoma of larynx has a 5 year survival rate of approximately 80% (Berry 1983) which is much higher than the survival rates after most operations for malignant disease. It is probably due to the fact that rumour extension beyond the larynx occurs late in most cases and laryngectomy usually removes the whole tumor.

Total laryngectomy results in a loss of ability to produce speech and voice by conventional means. Laryngectomized patients compensate for this loss by using alternate methods of voicing for speech production. Contemporary approaches to speech restoration following total laryngectomy are:

1) Learning to produce esophageal speech.

2) Developing speech i.e., mediated, in part, on a surgical prosthetic basis and

3)To produce speech powered by some type of artificial larynx.

Laryngectomees can generate sound at three locations

1) Within the oral cavity called buccal speech.

2) Within the pharyngeal cavity termed as pharyngeal speech and

3) At the lumen of the esophagus known as esophageal speech.

Esophageal Speech

Goldstein (1900) states that Gluck was the first to introduce esophageal speech as a speech restoration method for laryngectomees in 1882. Aronson (1980) states that the esophageal speech is based on the principle that air is taken into the esophagus and sound is produced on the release of the air by exciting the upper esophageal tract into vibration like 'belching'. Esophageal speech is produced by regurgitating air from the esophagus through a 'vibrating segment' (Pharyngo esophageal or PE-segment) in the reconstructed pharyngo esophagus. The volume of air which can be retained in the dilated esophagus rarely exceeds 80 CC (Edels, 1983) which is much less than the normal vital capacity of four liters in men aged 60 years (Cotes 1979) and this tends to produce short phrases of low pitched speech. Not all laryngectomees are able acquire esophageal speech. Reported percentages range from 43% (King, Fowlks, & Pierson 1968) to 98% (Hunt, 1964) with an average of 64-69% (Snidecor, 1975).

Tracheo Esophageal Speech

Surgical procedures have been devised to divert air from the trachea into the reconstructed pharyngo esophagus and thus increase the flow of air through the P-E segment. In this way it was hoped to produce louder and more sustained speech. Stafferi (1980) described a surgical technique for creating mucosal shunt between the trachea and the reconstructed pharynx so that digital occlusion of the tracheal opening (tracheostoma) during expiration caused air to pass into the pharynx. However, there were serious problems caused by aspiration of saliva and other fluids into the lungs. The next development was a valved prosthesis which could be passed through a surgically created fistula between the trachea and pharynx (Singer, & Blom, 1980, Panje 1981).

These prosthesis allow air to flow into the pharynx and prevent leakage into the trachea. Singer and Blom (1980) gave a fundamental impetus for the development of one such of new prosthesis known as Blom and Singer prosthesis (B.S. prosthesis). It is an endoscopic technique for voice restoration.

Tracheoesophageal puncture (TEP) a surgical prosthetic approach. This technique utilizes a one way valved silicone prosthesis designed by Singer, an otolaryngologist, and Blom, a speech pathologist. An appropriate prosthesis is selected and inserted into the puncture and voice therapy is initiated with immediate voice obtained by occluding the stoma.

Singer and Blom (1980) introduced a method of tracheoesophageal puncture and silicone 'duckbill' voice prosthesis for voice restoration following total laryngectomy. The duckbill voice prosthesis described by Blom and Singer (1980) is a hollow, 16-F diameter silicone tube manufactured in various lengths. An 8 mm slit in the proximal lip of the device acts as a one way duckbill valve. It opens as a duck's bill under positive pressure, permitting exhaled pulmonary airflow from the trachea into the esophagus when it exit via the stoma is blocked with a finger. It remain closed during swallowing and therefore functions as a competent one way valve. Weinberg and Moon (1984), Moon, Sullivan and Weinberg (1983) reported that the total airway resistance offered by duckbill prosthesis ranged from 106.5 to 117.5 cm. of water per liter per second (LPS) for the Blom Singer devices. The opposition offered to air flow by the larynx is in the range of 35-43 cm of water LPS (Smitheran and Hixon, 1981).

In 1982, Blom, Singer and Hamaker introduced a proto type low pressure voice prosthesis specially designed to reduce the airway resistance inherent in the duckbill prosthesis.

They reported this prosthesis which consists of a hinge type circular valve reversed within the hollow tip of the prosthesis to protect the opening movement of the valve from restriction by tissue contact. In the commercially available low pressure voice prosthesis, the lip has been reduced from 8mm to 2mm to minimize potential obstruction when used in patients with narrow esophageal lumen. Weinberg and Moon (1982), Smith (1980) have demonstrated that low pressure type prosthesis have a lower total resistance to air flow than the original duckbill voice prosthesis.

Hilgers and Schouwenberg (1990) introduced a new low resistance self returning prosthesis (Provox -TM) for voice rehabilitation after total laryngectomy. The results obtained from 19 patients indicated that the airflow resistance ranged from 1.0 to 3.9 KPa (mean = 1.9KPa). Speech quality was good in 91% of the patients. The self retaining properties of the prosthesis appeared to be satisfactory and the average device life was reported to be more than five months. Callanan et al (1995) studied Provox-TM valve usage by twenty eight laryngectmoees. The average valve life before failure was 148 days. Speech intelligibility score of 85 percent was achieved for complete sentences and 82 per cent for single words. The rate of speech measured was 147 words/min. The average duration of phonation for /a/ was 13.3 sec.

Parker et al (1992) studied the Groningen valve voice prosthesis in Sheffield. They studied twenty one patients who had made use of this device, seventeen of them undergone insertion at the time of surgery. Speech was noted to be generally excellent. The Groningen valve provided a highly acceptable means of obtaining vocalisation after laryngectomy.

O'Leary et al (1994) reported that the Grongingen valve assists in the production of speech which is of comparable quality to that produced by the Blom Singer prosthesis. Heaton and Parker (1994) compared fourty four Groningen high resistance (GHR), thirty seven Groningen low resistance (GLR) and nineteen provox speaking values. GHR valves had significantly higher forward opening pressures than both the newer valves and the GHR was significantly higher than the provox. The mean forward resistance of GHR was significantly higher than that of both. The provox valve resistance was significantly lower than that of GLR. In patients using tracheoesophageal valves following laryngectomy, durability of prosthesis, as well as quality of speech is of paramount importance. It has been found that the patients generally prefer lower pressure devices (Zijlstra et al 1991). Spraggs et al (1994) introduced the 'Allan Johnson' voice prosthesis. A modification of the Bivona voice prosthesis for immediate post fitting aphonia after secondary TEP. This prosthesis incorporates a stainless steel slide. It is observed that in patients who had not undergone myotomy the 'Allan Johnson' voice prosthesis may had a useful function in voice restoration when the problems of a) a narrow esophageal lumen and

b) Hypertonicity of the pharyngoesophageal (PE) segment co exists.

Primary TEP is defined as the voice restoration at the time of laryngectomy and secondary TEP as,voice restoration at a time subsequent to total laryngectomy. Singer et al (1983) reported a success rate of 63% and Hamaker et al (1985), reported 69% in their series of primary TEP cases. Perry et al (1987) reported that 94% of their patients who underwent secondary voice restoration were successful by three weeks after surgery but this success rate dropped to 73% by third month.

Artificial larnyx

An artificial larynx is a device meant to simulate an approximation to normal laryngeal tone. They developed mainly for individuals who had their larynx surgically removed. The quality of sound, the ease of use and other physical attributes vary greatly from device to device.(Goldstein 1982).

Goldstein (1982) categorized these devices into electronic and pneumatic, based on the source of energy. The pneumatic prosthesis are of two types i.e., external and internal. The electronic prosthesis are classified as internal, transcervical and implantable. Salmon (1993) reviewed the currently available artificial larynges. They are as follows:

Pneumatic artificial larynxes

Tokyo artificial larynx :

Speech with the Tokyo device has been described by Weinberg and Riekena (1973). It is an inexpensive Japanese made instrument consisting of either a steel or a soft rubber cover that fits over the stoma, a steel pipe leading to and away from a cylindrical chamber that houses a stretched rubber membrane held in position by a rubber hand, and a plastic or rubber mouth tube. The frequency can be changed by adjusting the width and tension of the vibrating membrane or by varying breath pressure during use. Varying breath pressure also results in a significant variation in intensity.

Nelson, Parkin and Poter (1975) described two modifications of the Tokyo type. Rigidity and curvature of the mouth tube are achieved by constructing the tube out of present stainless steel and by capping the portion that actually gets into the mouth with a short pieces of plastic tubing.

Electronic mouth type Artificial larynxes :

Creech (1976) described a simple and inexpensive modification of a standard western electric No. 5 neck type electronic larynx into a mouth type instrument. The tapered tip of a two ounce plastic irrigating syringe is cemented with epoxy over the screw on cap of a western electric No. 5, thereby enclosing the sound transducer. Dental acrylic is then applied around the circumference of the cap to secure the syringe tip further and to enhance the appearance of the instrument. This modified electronic larynx, either with or without a short piece of plastic tubing attached to the end of the syringe tip, is used similarly to any other mouth type artificial larynx.

Williams and Ostroy (1976) developed a unique mouth type electronic larynx using a western Electric No. 5 as the basic unit. Their modification consisted of replacing the standard transducer with a conventional hearing aid receiver. An aluminum overplate is used to stabilize the plastic mouth tube that fitted over the nub of the hearing aid receiver. This modified instrument provided a tone almost totally devoid of extraneous noise radiating from the head of the unit. Another important feature of this modification is the battery drain was decreased significantly (0.2 Vs. 1.5 watts drain). If the original transducer was saved, the instrument could be changed back into a neck type electronic larynx when desired.

Accto Williams (1976), the modification consists of removing the complete vibrating diaphragm unit of replacing it with a standard body hearing aid receiver. The receiver acts as a transducer or a speaker. The hearing aid receiver is glued securely in place within the space originally occupied by the vibrating diaphragm.

The two wires from the Western Electric No. 5 circuit and the two short wires from the hearing aid receiver cord and soldered together, using the basic unit that supplies the energy to activate the hearing aid receiver. Zwitnan and Disinger (1975) reported a modification that consists of inserting a bypass plug into the circuiting of a western electric No. 5 electronic larynx to convert it into a mouth type instrument.

The artificial larynx should hold a significant role in the rehabilitation of individuals who undergo total laryngectomy. While considerable bias against the use of the electronic artificial larynx (whether a transcervical or intra oral device) has been observed, this bias is wholly unwarranted. The ultimate goal of post surgical rehabilitation for those who lose their larynx is perhaps complex in nature, but simple in its focus. i.e., post surgical rehabilitation should focus on having the patient achieve the capacity for functional communication. The method with which functional verbal communication is achieved is irrelevant. The artificial larynx certainly appears to offer such an opportunity to the patient particularly in the early post operative period of rehabilitation. It is essential to acknowledge, however, that use of the artificial larynx in no way limits either the patient's consideration or use of other methods of alaryngeal communication. The artificial larynx does provide a viable option for post surgical verbal communication and therefore, should be given fair consideration as a method of postsurgical alaryngeal speech for all who undergone total laryngectomy.

Prosody

There exists a difference of opinion among researchers as to what the term 'supra segmentals' actually refers to Crystal and Quirk (1964) tempo, prominence and pitch factors as suprasegmental features. However, Lehiste (1970) identifies suprasegmental parameters as intonation, stress and quantity (duration). Suprasegmentals are properties of speaker that have a domain larger than a single element and include the following: stress, intonation, rhythm and quantity.

Prosodic aspects of speech include the suprasegmental features of fundamental frequency duration and intensity that contribute to the melody of speech production. Speech prosody may function to signal many communicative distinctions including lexical, grammatical and emotional attributes (Crystal, 1979; Kent and Read, 1992). Prosodic characteristics of speech also may influence perceived intelligibility of the spoken language (Wingfield, Lombardi and Sokal 1984).

Prosody is characterized by the use of variations in vocal tone or pitch, stress and timing in speech prosody can fulfill many different functions. The most well known distinction is between its linguistic and emotional functions. The linguistic function, modulation of prosody can be used to introduce subtle alternations in the meaning of words, to deviate clause, boundaries or sentence type or to vary the emphasis in language. In the emotional or effective function prosodic features convey information as to the speaker's emotional state concerning the subject matter or context of an utterance (Crystal, 1979; Merewether and Alpert, 1990).

Prosodic aspects in alaryngeal speech

Over the past several years, there have been a series of experiments to determine the extent to which alaryngeal speakers can produce stress and intonation patterns in American English. Researchers also sought to identify the extent to which differences in the ability of alaryngeal speakers to signal such prosodic patterns can be related to the form of alaryngeal speech used. (Gandour and Weinberg et al, 1982, 1983, 1984.)

Gandour and Weinberg (1982, 1983, 1985) suggested that the perception of suprasegmentals in alaryngeal speech may provide a useful dependent variable. Weinberg (1980) noted that T.E. speakers were able to control fundamental frequency deviation and intensity characteristics in speech to mark these suprasegmentals (i.e., contrastive stress and sentence intonation).

Fundamental frequency and intonation :

Intonation is thought by many to refer only to the perceptual phenomenon of pitch variation across an utterance and the majority of intonation studies accordingly have been concentrated only on fundamental frequency contours. Denes and Milton-Williams (1962), and Lieberman (1967) found that the fundamental frequency at certain points in the intonation contour (Denes, 1954) appears to be the most important acoustic correlate of intonation.

1) Among the suprasegmentals, intonation seems to be an inclusive term that refers to variations in pitch as a function of time.

2) The concept intonation is viewed not as a single system of contours but as a complex of features from different prosodic systems. These vary in their relevance, but the most central are tone, pitch range and loudness with rhythm and tempo closely related.

3) Fairbanks (1940) used the term intonation to include both inflection and pitch shift. He used inflection to identify the pitch change within a single phonation and pitch shift to identify change in pitch from the end of one phonation to the beginning of the next phonation.

Lehiste (1970) uses the term intonation as the linguistically significant functioning of fundamental frequency at the sentence level. Contrastive function of fundamental frequency is called it one at the word level. She distinguishes between lexical tone, grammatical tone and morphemic tone.

Intonation is the salt of utterance (Delattre 1960). It is the fluctuation of voice, pitch as applied to the whole of sentence. It is the melody of the sentence i.e., superimposed on the sentence as a whole.

Denes (1959) states that the phonemic sequence is not only linguistic form in which information to be transmitted by speakers is organized. Factors like intonation, stress and rhythm also make their contributions. Recognition of these factors provides the listener with additional information about the speakers intention. Intonation does not change the meaning of lexical items but constitutes part of the meaning of the whole utterance. He also writes that intonation is the linguistic form, by which the speakers emotional attributes are conveyed such as doubt, agreement, questioning, affirmation, continuing interest etc.

Bolinger (1972) states that most important grammatical function of intonation is that of tying the major parts together indicating the locus of divisions, parts that are subordinate and the context i.e. narration, requesting or commanding.

The physiological correlate of intonation is the vibration of the vocal folds in phonation. The rate of vibration may be increased as a result of an increase in the rate of airflow through the glottis (Caused by increased activity of the respiratory muscles producing increased subglottal pressure) and as a result of an increase in tension of the laryngeal musculature itself, especially the vocalis muscle. Decrease in the rate of vibration of the vocal folds may be brought about by decreasing the rate of airflow and or by relaxing the laryngeal musculature. There is some guidance that some external laryngeal muscles may be involved actively in lowering the rate of vibration of the vocal folds

The acoustic correlate of vocal fold vibration is the fundamental frequency of the sound generated at the glottis. Intonation refers to the linguistically significant functioning of fundamental frequency at the sentence level. (Lehiste 1970). According to Pike (1945) Elodo (1961) the vibrations in the fundamental frequency is the basis for various intonation contours.

Analytic experiments found that a simple relationship existed between intonation and fundamental frequency. A straight forward fall in frequency for a falling tone or a simple rise in frequency for a rising intonation. (Lieberman 1968) comments that although relevant phonetic or instrumental analysis are not available at present for most languages, it is possible to generalize about intonation to the extent of studying that short declarative sentences, usually end with a falling fundamental frequency contour. Detailed instrumental analysis by Jones (1909), Chiba (1935), Fonogy (1958), Hadding-Koch (1961) and Abramson (1962) showed that this is the case in English, Spanish, French, Finnish, Hungarian, Italian, Thai, Japanese, Swedish and German. Thus some of the characteristics of intonation are universal.

The universal lowering of pitch towards the end of an unexcited discourse results automatically from running out of lung power. Subglottal pressure raises and lowers pitch, other things being equal. The universal raising of pitch for questions and other keyed up utterances is probably due to higher nervous tension in the body as a whole, which has a total effect of tensing of the vocal cords.

To bring about different emotions like surprise, joy, anger, fear etc. A speaker uses different fundamental frequency movements i.e., uses different intonation contours. These can be described in terms of rise, fall, flat and the combinations.

In English, differences in pitch changes serve minimally to distinguish declarative from interrogative versions of a sentence. (Atkinson, 1976; Ohala, 1970) considered the three word sentence. 'Bev loves Bob' spoken with a falling intonation, it is interpreted as a statement, spoken with a rising intonation, it is interpreted as a question. Measurements of the physical properties of such three word sentences have revealed that interrogative versions are associated with a minimal rise m fundamental frequency at the terminal portion of the utterance, while declarative versions are associated with a fall in the fundamental frequency contour during the terminal portion. Although considerable variability Intra speaker and interspeaker) in the speech of the fundamental frequency contours has been noted, differences in the fundamental frequency contours are regarded as primary cues listeners use to differentiate statements from questions.

The results of investigations dealing with the perception of synthetic statements, question intonation patterns have shown that listeners are on the relative speaks of fundamental frequency. The shapes of fundamental frequency contours, the absolute value of the end point frequency and differences in the rate of change of fundamental frequency. (Hadding, Koch and Studdert Kennedy 1964; Majewski and Blasdel, 1969; Studdert - Kennedy and Hadding, 1973). In general, it appears that listeners identify an intonation pattern by attending to certain aspects of the fundamental frequency contours.

From a production stand point, it has been well established that the control of voice fundamental frequency in speaker is accomplished through a dynamic interplay between pulmonary driving forces and laryngeal adjustments (Shipp and McGlone, 1971; Van Den Berg 1958). Although some controversy persists concerning the relative contribution of laryngeal Vs. pulmonary influences (Atkinson, 1978; Lieberman, 1967; Ohala, 1970) it is commonly agreed that the larynx does play a critical role in fundamental frequency control.

There are only a few previous linguistically relevant reports on the control of fundamental frequency in alaryngeal speakers. Although esophangeal speakers are able to phonate over a wide range of vocal fundamental frequencies. (Damste 1958; Snidecor and Curry, 1959; Wienberg and Bennet 1972) the extent to which they are able to exercise intentional and systematic control over voice fundamental frequency in speakers remains an open question. Although Angermeier and Weinberg (1981) found that esophageal speakers were less proficient than normal speakers in controlling the steady state attributes of their voicing source in a vocal pitch matching task, it has yet to be determined to what extent esophageal speakers are able to exercise the dynamic control over voice fundamental frequency which is critical to the realization of linguistic contrasts in speech. There are no published data about this issue for other types of alaryngeal speakers. Thus, the degree to which alaryngeal speakers are able to achieve important prosodic features is not known.

Gandour and Weinberg (1983). The achievement of intonational contrasts by four normal and sixteen laryngectomized speakers are assessed. The laryngectomized subjects represented seven clinical sub groups of alaryngeal speech :- esophageal, TEP, Western Electric # 5 electro larynx and servox electro larynx. High quality tape recordings of each subjects productions of two pairs of sentences (Bev loves Bob) spoken in statement and questions were presented to seventy listeners for evaluation using a two interval forced choice procedures. Intonation contrasts were achieved in a highly effective manner by the normal, esophageal and TEP speakers. In contrast, users of electronic larynges were generally unable to achieve these intonational distinctions except for one user of the western electric # 5 electro larynx.

Micheal and Trudean (1988) studied two proficient tracheoesophageal speakers, experienced in use of the tracheostoma valve (TS V) produced a total of sixty four examples of 'Bev loves Bob'. These productions varied with location of contrastive stress, type of sentence intonation and use of TS V. Thirty four listeners judged the utterances in terms of stress placement and intonation contour simultaneously. An analysis of variance of the perceptual results indicated that TSV use reduced speaker ability to signal the two suprasegmental features, however, locus of the suprasegmental features, particularly stress placement, appeared to exert a stronger effect.

Gandour & Weinberg (in press) found that esophageal and tracheo esophageal speakers realized intonational contrasts (eg. Bev loves Bob Vs. 'Bev loves Bob?") in a highly effective manner, while users of electronic artificial larynges were generally unable to do so. Their findings suggest that both conventional esophageal and TEP speakers are able to exercise intonational and systematic control over voice fundamental frequency. The principal acoustic correlate of intonation in normal speaker. They interpreted these results to suggest that the surgically reconstructed pharyngoesophageal segments, powered either by air insufflated in the esophagus or by pulmonary diverted air, proves a sufficiently adequate, non conventional phonatory apparatus to enable these groups of laryngectomised speakers to realize intonational contrasts.

Sanyogeetha (1993) compared the intonation contours for specific sentences uttered by esophageal and normal laryngeal Marati speakers. He found out that esophageal speakers can produce the intonation patterns like normals, But they showed great amount of variability in the use of intonation patterns for the sentence under study. The change in frequency was intermittent (or discontinuous) for most of the esophageal speakers identify the intonation patterns. Thus esophageal speakers too try to achieve intonation contrasts as normal speakers but they fall short in terms of controlling the change of frequency adequately.

Fundamental frequency is the lowest frequency that occurs in the spectrum of a complex tone. In human voice also, the lowest frequency in the voice spectrum is known as the fundamental frequency. "Both quality and loudness of voice are mainly dependent upon the frequency of vibration of vocal cord. Hence it seem apparent that frequency is an important parameter of voice (Anderson, 1961; Emrickson, 1959) opines that the same general structure of the cords seem to determine the range of frequencies that one can produce. The perception of pitch and measurement of fundamental frequency are based on the systematic opening and closing of the vocal folds during the production of voiced speech signals. Hence when fundamental frequency is measured acoustically, the process is actually to count these openings and closings by objective method.

Variations in Fo play an important role in speech has been studied as intonation.The study of fundamental frequency has important clinical implications. The other implications include the relation between optimum frequency, vowel duration, importance of intonation, stress and duration, importance of intonation and stress on sex identification, emotional status, intelligibility and acceptability of speech.

It is a fact that the intonation contours occurs in various forms in different words, one finds enough support in the literature which points to the more or less consistent features of Fo (Lehiste and Peterson, 1961; Silverman, 1986). This, however does not remain the same at phrase or sentence level (O'shanghnessy and Allen, 1983).

Two models namely the 'rise fall dichotomy' and the 'no rise view' were proposed to describe the influence of the stop voicing on the Fo. Proponents of 'rise fall' dichotomy view (Lehiste and Peterson, 1961; Mohr, 1971; Lea, 1973; Hombert, 1985) claimed that the Fo fell after voiceless stops but rise after voiced stops. They also stated that the direction of post release Fo was contextually invariant. The 'no rise' view (Silverman, 1986) on the other hand claimed that the onset frequency of post release Fo was raised after all stops, if they were phonologically voiced.

Accordingly this view, the Fo contour was a combination of segmental perturbations added onto a smooth underlying intonation contour i.e., the direction of post release Fo depended not only on segmental phonetic features but also on the prosodic structure (Silverman, 1986).

mean of which was 94.38 Hz. Hoops and Noll (1969) extracted the Fo (speech) from the first paragraph of the Rainbow passage by the measurement of Oscillogram. The mean Fo (sp) in 22 esophageal speakers was 65.59 Hz. Weinberg and Bennet (1971, 1972) measured the Fo (sp) in 18 male esophageal speakers and reported a mean Fo (sp) of 57.4Hz.

Investigator	**Mean Fo (sp) Hz**	
	Esophageal	TEP
Damste (1958)	67.5	
Curry and Snidecor (1961)	63.0	
Hoops and Noll (1969)	94.38	
Shipp (1967)	65.59	
Weinberg and Bennet (1971, 1974)	57.4	
Torgerson and Martin (1980)	65.7	
Blood (1984)	64.6	88..3
Robbins(1984)	77.1	101.7
Pindzola and Cain (1989)	84.1	107.7
Rajashekhar et al(1990)	90.80	114.0
Rajashekhar(1991)	68.00	136.7
Sanyogeetha(1993)	185.90.	

Table 1 : The mean Fo (sp) in esophageal and tracheoesophageal speakers by various investigators.

Cooper and Damon (1983) determined the influence of speaking rate and emphatic stress on patterns of Fo. They reported that Fo peaks were higher in fast speakers and in fast rates of speech. Emphatic stress, was associated with an increase in Fo on the emphasized word and a lowering of Fo on the neighbouring word.

Hadd and Silverman (1984) tested for IFo effects in paragraphs of connected speech as well as in carrier phrase. They investigated IFo in specific contexts in which they controlled the sentence position, nuclear stress and high or low Fo in the speakers range. The results indicated that the intrinsic Fo differences in the post nuclear, low Fo condition were smaller than those in other conditions. Based on this, they have concluded that low Fo, rather than low stress or phrase final position, accounted for decrements in intrinsic Fo effect. In addition, they found that the final nuclear stress condition had larger intrinsic Fo differences than the final post nuclear stress condition, even when the speakers Fo was about the same.

O'Shaughnessy and Allen (1983) commented on the effects of various linguistic modalities on Fo in speech. They observed that most syllables in an utterance had little or no Fo emphasis and formed part of the gradual Fo fall.

Evaluation of the fundamental frequency in phonation may not represent the fundamental frequency used by an individual in speech. Studies have shown that the Fo in phonation and speech are different (Nataraja and Jagadeesha, 1984). Hence determination of fundamental frequency in speech. Using an adequate speech sample becomes important. Using a reading task other than spontaneous speech has an advantage for comparison between speakers, if the same material is used (Baken, 1987).

Many investigators have studied the SFF/Fo (sp) as the function of age and in various pathological conditions (Micheal, Hollien, Moore 1965; Shipp, Huntington, 1965; Bohme and Hecker, 1970; Fitch and Holbrook, 1970; Hollein and Shipp, 1972; Murray, 1978; Murray and Doherty, 1980; Hudson and Holbrook, 1981; Hirano, 1981; Kushal Raj, 1983; Gopal, 1986; Nataraja, 1986). The Fo(sp) is reported to decrease with age upto adolescence and increase in advanced age group (Bohme and Hecker, 1970; Hollien & Shipp, 1972; Nataraja and Jagadeesha, 1984) measured the fundamental frequency in phonation, reading, speaking and singing in normal males and females.They observed that the fundamental frequency increased from phonation to singing with speaking and reading.

Studies of Fo (sp) variability in pathological cases have been carried out. Hecker and Kruel (1971) found a restricted Fo (sp) range in patients with laryngeal cancer. Murray's (1978) study supported Hecker and Kruel's (1971) findings.

The measurements of Fo (sp) in esophageal speakers needs to be viewed from the perspective that it could contribute to the intelligibility and acceptability of esophageal speech and evolve setting up of therapeutic goals.

Determination of the Fo (sp) in esophageal speakers is more difficult because of the fact that only rarely the sound signals are purely periodic. More commonly the vibrations of the PE segment are a periodic, so that it is difficult speak of a tone. The occurrence of a periodicity was attributed to three causes by Damste (1958).

1. To variations in subneoglottic pressure : The volume of air in the esophagus is small (approximately 80 CC), any fold in the mucous membrane below the level of the PE segment may easily influence the supply of air.

2. The length and elasticity of the PE segment are not so constant and adjustable as in the normal glottis.
3. The accumulation of mucous above the mouth of the esophagus, a handicap for most laryngectomees. The third reason is considered to be the most important. Thus the air is forced in a highly irregular way through the PE segment through varying layers of secretions. It is therefore noise that is produced rather than secretions. It is therefore noise that is produced rather than tone (Perry, 1989) .

According to Perry (1989) there was some confusion as to whether esophageal speech can truly be said to have fundamental frequency as it involves a periodic sound. Often the recording is a regular note at the PE segment with aperiodic overtones. Additionally, the results of analysis using 'good' esophageal speakers may be very different from analyzing those who have difficulty in producing sound (Curry and Snidecor 1961). However, many investigators have used the term Fo in speech.

Few studies measuring the Fo in speech in esophageal and tracheoesophageal speakers have been carried out

Damste (1958) used 20 randomly selected subjects who read a four word sentence. The mean fundamental frequency was 67.5 Hz in these subjects. (Snidecor and Curry ,1959; Curry and Snidecor, 1961 and Curry 1962) used the Rainbow passage for Fo (sp) measurement. They reported a mean Fo sp) of 63 Hz. Shipp (1967) extracted the fundamental frequency from the second sentence of the rainbow passage from the recordings of the six best esophageal speakers.

mean of which was 94.38 Hz. Hoops and Noll (1969) extracted the Fo (speech) from the first paragraph of the Rainbow passage by the measurement of Oscillogram. The mean Fo (sp) in 22 esophageal speakers was 65.59 Hz. Weinberg and Bennet (1971, 1972) measured the Fo (sp) in 18 male esophageal speakers and reported a mean Fo (sp) of 57.4Hz.

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Table 1 : The mean Fo (sp) in esophageal and tracheoesophageal speakers by various investigators.

Torgerson and Martin (1975) determined fundamental frequency of esophageal speech produced by laryngectomized and non laryngectomized male subjects. They obtained the mean Fo (sp) from the second sentence of the Rainbow passage by using the Honeywell visicoder oscillograph. They observed a significant difference between the two groups in the standard deviation of fundamental frequency. The laryngectomized speakers exhibited a comparatively lower mean and standard deviation values than the non-laryngectomized speakers. They opined that the mean fundamental frequency produced following laryngeal ampertation is apparently more homogeneous among the speakers and i.e., perhaps related to reorientarion of the pharyngeal and esophageal musculature. Torgerson and Martin (1980) reported a mean fundamental frequency and standard deviation of 65.7 Hz and 2.06 tones in fifteen esophageal speakers. Blood (1984) reported that the mean Fo (sp) for ten esophageal speakers for the second sentence of the rainbow passage was 64.6 Hz with a standard deviation of 14.5 Hz.

Similarly Robbins et al (1984) who extracted the mean Fo (sp) from the second sentence of the Rainbow passage read by fifteen esophageal speakers found a mean Fo (sp) of 77.1 Hz and a standard deviation of 18.2 Hz.

Pindzola and Cain (1989) compared selected characteristics in the speech, of five tracheo esophageal, five esophageal and fifteen normal adult speakers. The average fundamental frequency in speech for esophageal speakers in their study was 84.1 Hz.

Robbins et al (1984) found that the mean fundamental frequency (Fo) of the TE speakers was similar to that of the normal laryngeal speakers while the esophageal speakers had a lower mean Fo. This is related to the typically lower pitched voices of esophageal speakers. They also found that two TE speakers with consistently high Fo values were perceived to have voices that were 'high pitched' and stained, suggestive of excessive vocal tract resistance to air flow.

Rajshekhar et al (1990) reported a mean Fo (sp) of 68Hz by esophageal made in one case of laryngectomee, Proficient in both esophageal and tracheo esophageal mode of alaryngeal speech.

Rajashekhar (1991) in another study on twenty esophageal speakers reported the mean Fo (sp) to be 90.8 Hz.

Santhosh Kumar (1993) measured the Fo in speech for normals and TE with D.B., L.P and I.P. prosthesis. The TE speakers (with D.B, L.P, and I.P) showed higher Fo in speech than in phonation of vowels. The normal group however showed lower mean Fo in speech as compared to the vowels. Also found that T.E. speakers had lower Fo in speech than normals. Among T.E.P. group, I.P aided T.E. speakers showed higher mean Fo in speech than L.P and D.B. aided T.E. speakers. Normal group demonstrated less variability (S.D.) than T.E.P group. Among T.E.P. group less variability was seen in L.P. aided group than D.B. and I.P. The range in Fo of speech for T.E.P group were larger than normal group (136-171). Among the T.E.P. group, D.B. (42-235) had the greatest range in Fo than L.P and I.P. group. He found mean Fo for D.B. is 117.18Hz and for L.P. 114.39Hz for I.P 136.48Hz. Sanyogeetha (1993) measured the mean fundamental frequency in speech of the esophageal group (185.9 Hz) was greater than that of the normal group (154.4). However the esophageal group showed a greater variability (S.D.41.55 Hz) as compared to the normal laryngeal group (S.D. 12.7 Hz).

Frequency Range in Speech :-

While describing the feature of Fo, Vaissiere (1983) noted that the range of Fo variation generally narrowed as a function of time. In general, the Fo maxima and minima decreased from the beginning to the end in simple declarative sentences. The maximum values of Fo tended to decrease more rapidly than the minimum values.

The patterned variations of speech over linguistic units of different length (syllables, words, phrases, clauses, paragraphs) yield the critical prosodic features namely intonation (Freeman 1982). In other words during speech the fundamental frequency varies with time. The difference between the maximum and minimum fundamental frequency is called the frequency range in speech (Hirano 1981).

Hudson and Halbrook (1981) studied the fundamental frequency range in reading in normal young male black and reported a mean range of 81.95 to 158.5Hz.

Nataraja (1986) reported the mean frequency range in speech of 248 Hz in normals. Gopal (1986) from a study of normal males from 16-65 years, reported the frequency range in speech as ranging from a mean of 13 Hz (16-25 years) to a mean of 181.49 Hz (36 - 45 years).

Kent (1976) states that the general conclusions about the diagnostic value of fundamental frequency variability are difficult to make because such measurements are helpful in certain pathological conditions, but not in others. Shipp and Huntington (1965) indicated that in cases of laryngitis, the voice had significantly restricted ranges than did post laryngitis voice. Murray (1978) found reduced semitone ranges of Fo (sp) in patients with vocal cord paralysis.

Robbins et al (1984) reported a frequency range of 118.1 Hz (S.D. = 43.88) and 85.9 Hz (S.D. 18.88) in esophageal and normal groups respectively during reading.

Pindzola and Cain (1989) measured the frequency range in connected speech in normal and esophageal subjects. The Normal speakers showed average frequency range of only 129 Hz are as the esophageal speakers had an average range of 177 Hz, which according to them was higher than expected. In their study, frequency variability probably was produced equally well by normal and esophageal speakers. Since listeners perceived intonational contrasts effectively in both the groups. Sangyogeetha (1993) found that the frequency range in speech was slightly higher in the esophageal group than the normals. Santhosh Kumar (1993) found larger frequency range in speech was seen with I.P. aided T.E. speakers as compared to D.B. and L.P. aided speakers.

Stress :

Stress may be defined as an articulatory gesture, related to the degree of force of an utterance. According to Lehiste (1970), stress was prominence produced by means of respiratory effort. Phonetically stress conveys the meaning of emphasis or exclamation (Pike, 1945). The emphatic stress is used to reinforce either a normal innate stress or reinforce regular stress to convey the meaning of more emphasis in special sentence placement. Several acoustic cues exist for stress. One of the important acoustic correlates of stressed syllables in words in intensity or amplitude and fundamental frequency (Lieberman, 1978; Hadding-Koch, 1961; Ladefoged and McKinney, 1963). However Fry (1955, 1958) felt that duration was a better cue compared to intensity. Also, the duration of change in fundamental frequency rather magnitude of change F0, is an important cue for stress.

Commenting on the ambivalent nature of sentence stress, Ladd (1978) reported that in analysis of American English, sentence stress was considered to be another "level of stress" and stress and variation in pitch were considered to be independent elements of the suprasegmental system. In British traditon, sentence stress was called the "nucleus".

Primary syllabic stress may be defined as a high level of speaker intended syllabic prominence the stressed syllable being perceived by listeners as 'emphasized over' surrounding speech segments" (Netsell 1973). Primary stress may function to produce word emphasis or contrast, to signify syntactic relationships between words or word parts or to indicate the grammatical structure of words. Primary stress appears to be realized by a complex interaction of fundamental frequency, sound pressure, duration and resonant (formant) frequency position the perceptual correlates of which are pitch, loudness length and quality (Fry, 1959; Cheung, Holden and Munific, 1975; Fry, 1959; Lehiste and Peterson, 1959) have attempted to assess the cue potency and perceptual weighting of stress associated acoustical characteristics. Listeners appear not to consider independently the correlates of primary stress, although in certain instances one particular characteristic may be more important perceptually.

Physiological constraints may limit the ability of individuals to vary consistantly certain characteristics associated with primary syllabic stress.

In general, perception of contrastive stress is apparently influenced by more than one acoustic or temporal parameters. In English, an increase in the duration of an emphatically or contrastive stress word (Coker, Umeda and Brownman 1973) and changes in the fundamental frequency contour (Klatt 1976) have been to influence stress perception. Klatt (1976) has suggested that 'segmental duration or speaking rate is one of the primary uses to the existence and location of emphasized or contrastively stressed material. From a physiological perspective, investigations of stress in English have shown that stressed syllables are produced with increases in activity of the expiratory muscles during or slightly preceding, each stressed syllable in English (Ladefoged 1967) increases in activity of the laryngeal muscles (Ohala, 1970) and increases in extent and one of articulator movement (Kent and Netsell 1972).

William (1986) stated that there was a fair degree of consensus was that the primary cue to stress was a change in fundamental frequency with in a syllable and the next most important cue was a step change in Fo between a stressed syllable usually having higher Fo. Also important was the fact that the stressed syllable usually had longer duration and greater amplitude, though the relative importance of these two cues was uncertain (Williams, 1986). For Lieberman (1960), the measure of peak amplitude was more reliable than duration, while for Fry (1958) the opposite was the case. Fry (1958) also note that in the case of changes in Fo within a syllable more than the actual shape and extent of the Fo change, its occurence was more important.

Esophageal speakers' production of lexical stress to distinguish noun verb pairs has also been shown to be perceived like that of normal speakers Gandour, Weinberg and Garzione (1983).

Table 2- Summary of findings the acoustic cues in the production of stress in English and other languages.

Investigator	**Language**	**Fo**	**Io**	**Duration**	**Fo+ Io+**	**F0+I0+ DurDur.+Others.**
Fry(1958)	English	----	----	Duration increase in Stress	----	----
Lehiste	English	----	----	----	----	Speech power,fund freq; phonetic quality and duration and some extent laryngeal quality contribute to Stress
Leiberman (1960)	English	----	Peak amplitude more in stress	----	----	----
Morton & Jassem (1965)	English	A raised fundamental freq seen in Stress	----	----	----	----
Fonogy (1966)	English	Stress is a fucntion of greater speaking of fort	----	----	----	----
Rathna; Nataraja	Kannada	----	Intensity is important in stress	Duration also important in stress		

Fo= Fundamental Frequency Io = Intensity Dur = Duration.

Meltenry, Geich and Minifie (1982) studied the perception of prosodic contrasts of examining the ability of esophageal speakers to use primary syllable stress to emphasize one word in a sentence. Esophageal speakers were perceived with a relatively high level of accuracy but at a level less than that obtained with normal speakers.

Walker and Morris (1988) studied to assess the ability of esophageal speakers to effect systematic changes in listeners perceptions of syllable stress. Ten male functional esophageal speakers and ten normal speakers were instructed to produce twenty five repetitions of the syllable / mama / using five different conditions of syllable stress, ranging from strong second syllable stress. Nine normal listeners judged both relative and absolute syllable stress of the disylables using a nine point scale for each syllable. The results indicated that highly reliable judgements can be made when judging relative and absolute syllable stress in disyllables produced by both normal and esophageal speakers.

Several signal attributes may be altered in esophageal speech i.e. levels and ranges of fundamental frequency, sound pressure and duration. These differ somewhat from normal values, even in excellent esophageal speakers.

An average fundamental frequency of esophageal speakers is reportedly about one octave lower that of normal speakers. (Angermeier and Weinberg, 1981; Curry and Shidecor, 1961; Kyalta, 1964; Snidecor and Isshiki, 1965). However, fundamental frequency range (in semitones) during oral reading and isolated esophageal vowel production appears to be resonably similar to that of normals. (Snidecor and Curry, 1959; Snidecor and Isshiki, 1965; Weinberg and Bennett, 1972). The lower average fundamental frequency of esophageal speech may be related to neoglottic folds that are longer or thicker than normal vocal folds (Damste and Lerman, 1969; Vanden Berg and Moolenaar Bijl 1959). In addition, the pharyngoesophageal (PE) segment musculature may not be adequate to 'tension time' or increase the effective stiffness of the vibratory mass, thus decreasing average fundamental frequency. Furthermore, the altered elasticity and mass of irrudiated tissues (presumably related to tissue destruction, scar formation and altered fluid balance) may result in less consistent intentional control of fundamental frequency (Angermeier and Weinberg 1981).

Gandour and Weinberg (1982) studied the contrastive stress in alaryngeal speaker. The ability to signal contrastive stress in American English was assessed by obtaining high quality tape recordings of sentence production from four normal and sixteen laryngectomized speakers using four different types of alaryngeal speakers. The recordings of the structures, paired on the basis of differences in the location of contrastive stress, were presented to fourty listeners for perceptual evaluation of stress location using a two interval forced choice procedure. They found that the four normal speakers achieved high (95% or above) levels of stress constrast. Contrastive stress patterns were also realized in a highly effective manner (93% or above) by three esophageal speakers, three TEP (Blom-Singer) speakers and three users of the Western Electric five artificial larynx. Contrastive stress pattern were realized in a lower (86.88%) but reasonably effective manner by two users of the serox artificial larynx.

In general, average sound pressure level of esophageal speakers is 6-10 dB less than values typically found for normal speakers (Hoops and Noll, 1969; Snidecor and Isshiki, 1965; Weinberg, Horii and Smith, 1980.) sound pressure range also appears to be restricted. Snidecor and Isshiki (1965) measured a sound pressure range of 20 dB during a crescendo diminuendo vowel task produced by a single superior esophageal speaker. Normal speakers increase the sound pressure level by augumenting exhaltory airflow; increase the proportion of glottal closed time and reducing upper vocal tract impedance (Isshiki 1964, 1965) Biochemical or neuromuscular constraints may limit the ability of esophageal speakers either to increase the proportion of neoglottic closed time or reducing upper vocal tract (Isshiki, 1964, 1965). Scarpino and Weinberg (1981) assessed the realization of junctural contrasts by normal and esophageal speakers. Ten normal subjects and ten laryngectomised subjects using esophageal speakers provided high quality tape recordings of three productions of five ambiguous two word phrases. These recordings were presented to fourty listeners for evaluation using a two interval forced choice procedure. Both normal and esophageal speakers realized junctural contrasts in ambiguous phrases in a highly effective manner. Significant differences in listeners overall perception of juncture locus were found for talker group and individual speaker main effects.

Scarpino and Weinberg (1981) found that esophageal speakers were able to effectively realize junctural contrasts. Their findings seem to indicate the esophageal speaker exercise control over vowel duration, silent intervals. Intensity characteristics etc. All of which have been suggested as cues for the perception of word boundary.

Temporal measures

Rate of Speech :

The rate of speech is usually expressed in terms of words per minute (WPM). Darley (1940) reported the 50^{th} percentile for normal speech as 166 WPM. Rathna, Bharadwaj and Subba Rao (1979) reported a rate of speech of 93.68 WPM for normals during passage reading in Kannada language. Venkatesh, Purushothama and Poornima (1983) reported a rate of speech of 282 syllable/minute for normals in Kannada.

Snidecor and Curry (1959, 1960) have demonstrated that the rate of speech of esophageal speakers is markedly reduced. The rate of speech of superior esophageal speakers in their study ranged from 85 to 129 WPM, with a group average of 113 WPM. The assumption has always been that the decrement in rate of esophageal speech is due to the increase in the amount of time spent in silent pauses. This increase in silence pause results from the esophageal speakers limited ability to sustain voice. Hoops and Noll, (1969) reported a mean rate of speech of 114.3 WPM in twenty two esophageal speakers. The rate of speech in the twenty esophageal speakers of Filter and Hyman's (1975) study was considerably low (100% WPM).

Singh (1983) reported the rate of speech in four TEP subjects to range from 97-136 WPM. This value exceeded the esophageal groups and since pulmonary air is used for TEP speech while esophageal speakers are dependent on air trapping. Robbins et al (1984) reported that the rate of speech in normals. T.E. and esophageal groups was 172.8 (SD = 23.3) 127.5 (SD = 21.1) and 99.1 (SD 24.8) respectively.

Pauloski et al., (1989) reported a higher rate of speech in T.E. speakers using duck bill and low pressure prosthesis with and without tracheostoma valve.

The maximum rate of speech of 160.22 WPM was observed when the patients were using the low pressure prosthesis with tracheo stoma valve.

Pindzola and Cain (1989) found a significant difference in the rate of speech during reading in normal, esophageal and T.E. speakers. Normal speakers (WPM = 158.8) averaged six WPM faster than T.E. speakers (WPM 152.2) which was not significantly different. The esophageal speakers had a rate of speech of 93.8 WPM and were significantly different from both the laryngeal and TE speakers. The rate of speech in TE speakers reported by Zanoff et al (1990) was considerably less when compared to other studies. The rate of speech in their TE speakers with and without tracheostoma valve was 87.11 and 87.78, respectively. Trudeau and Qi (1990) reported a WPM of 138.03 in female T.E. speakers. Rajshekhar et al (1990) comparing the esophageal and T.E. modes in a single laryngetomee reported WPM of 57 in the esophageal as against seventy eight in the T.E. modes. Rate of speech ranging from 25-150 WPM in eighteen T.E. speakers fitted with Blom Singer's prosthesis have been reported by Hazariked et al(1990).

In general the review of literature shows that the esophageal and T.E. speakers, produced speech at a slower rate than the normal speakers, with the esophageal speakers showing the most extreme rate reduction.

Syllable/second being an indirect measure of the rate of speech has been reported by some investigators. A rate of speech of approximately 2.25 syllable/sec, for good esophageal speakers. Sedory et al (1989) reported 2.86 syllable/sec. Faster rates of speech ranging from 2.6-3.6 syllable/sec have been reported in T.E. speakers (Robbins et al., 1984; Sedory et al 1989).

Total duration has been used as another measure of rate of speech. The total duration required to read the second sentence of rainbow passage by esophageal speakers ranged from 5.47 to 6.27 seconds (Snidecor and Curry, 1959; Shipp, 1967; Weinberg and Bennett, 1972; Torgerson and Martin, 1980; Baggs and Pine, 1983) found a greater mean duration (3.02 sec) in esophageal speakers, followed by T.E. speakers (2.09 sec) and laryngeal speakers (1.95 sec), in fourteen model sentences used as speech stimuli.

According to Robbins et al (1984), a total duration of 34.0 sec in case normals, 47.3 sec in T.E. and 62.5 sec. in esophageal speakers were required to read the paragraph. They stated that WPM and total duration for the paragraph reading were inversely related for all the three groups. The normal speakers produced the greatest number of WPM in the shortest duration of total reading time where as the esophageal group produced the fewest number of WPM in the longest duration of total reading time.

Sanyogeetha (1993) found that the mean rate of speech in the esophageal group (2.78) was less than the values obtained for the normal group (3.59).

Pause Time :

Robbins et al (1984) demonstrated the total pause time, total number of pauses, mean pause time, percentage of total reading time in normal, esophageal and TEP groups. Except the mean pause time, which was greatest for the T.E. speakers, all other pause time measurements were larger for esophageal speakers and hence most deviant from the normal speakers. The greater total pause time and number of pauses shown by the esophageal speakers may be attributed to their limited air reservoir (Diedrich 1968). The increased mean pause time in T.E. speakers has been attributed to measurement limitations and the time required for digital occlusion (Robbins et al; 1984). In addition to the information concerning pausing and phrasing patterns, Robbins et al (1984) measured the mean syllable duration and reported it to be, greater in esophageal speaker group. Sedory et al (1989) reported findings similar to Robbins et al. (1984).

According to Hammarberg and Nord (1989), the percentage of pause time ranged between 17-40% in esophageal speakers, 20-38% in T.E. and 14-21% in normal speakers. The study on female T.E. speakers (Trudeau and Qi, 1990) revealed that the females were similar to male T.E. speakers in number of pauses, but inferior in % of pause time and mean pause time.

Sanyogeetha (1993) found that the mean pause duration in esophageal speakers to be greater than that of normals.

Sunitha (1994) found that the I.P. aided TEP speakers showed lesser number of pauses (86.5) compared to L.P. and D.B. group and L.P. aided showed lesser number of pauses (100) compared to D.B. group. Also showed I.P. aided group showed lesser percentage of pauses (39.09) compared to L.P. and D.B. aided group and L.P. aided showed lesser percentage of pauses (43.68) compared to D.B. group.

Weinberg (1980) rightly pointed out that there is an absence of information concerning the ability of larygectomized speakers to realize the linguistically important contrasts like intonation. Studies on these aspects are awaited to throw light on the acoustic and temporal parameters used in such intonation contours and therein comparability to normal intonation produced by esophageal speakers.

As total laryngetomy leads to considerable anatomical and physiological alteration, in the realization of intonation is expected. Such information will help in the development of clinical procedures and materials to enhance prosody realisation in alaryngeal speakers. Therefore, it is considered that it will be interesting and useful to study intonation in alaryngeal speakers.

METHODOLOGY

The present study aimed at comparing the prosodic or suprasegmental aspects of the speech of the tracheo-esophageal, esophageal and normal speakers to determine the similarities and differences between the groups and to explore the possibilities of suggesting therapeutic implications. The following parameters were studied:-

1) Fundamental Frequency Features

    a) Mean Fundamental Frequency in Speech

    b) Fundamental Frequency Range in Speech

2) Intensity features

    a) Mean Intensity in Speech

    b) Intensity Range in Speech

3) Temporal features

    a) Rate of Speech - Number of syllables per second.

    b) Pauses

        I) Intraword Pauses

        ii) Interword Pauses

        iii) Intersentence Pauses

        iv) Total Pauses

4) Intonation Contours - Variations in Fo in the sentence

5) Stress- Significant changes in Fo and /or intensity and /or duration at syllable level.

Subjects :-

There groups of five male speakers in each group, participated in the study. Three groups of five male speakers namely T.E.P., esophageal and normals, with Kannada as mother tongue, matched in terms of age and sex participated in the study. All of the subjects were screened for hearing, motor and sensory abilities and found to be normal except for laryngectomy subjects in the first two groups.

The first group consisted of five subjects who had a tracheoesopahgeal puncture (T.E.P) as a secondary procedure having undergone laryngectomy earlier and were using Blom singer's voice prosthesis. All of them had tracheoesophageal and Blom singer prosthesis fitting and speech services. The mean age of this group was 57.4 years with the range of 50 - 69 years. Details of the subjects are provided in Appendix I

The second group of alaryngeal speakers comprised of 5 subjects who used esophageal mode of communication. The mean age of this group was 53 years with the range of 37-61 years. Details of the subjects are provided in appendix II.

The third group consisted of five normal laryngeal speakers matched for age, and language with the alaryngeal speakers. This group had no speech, voice and hearing impairments as evaluated by qualified speech and hearing specialist . The mean age of the group was 50 years ranging from 38 -67 years.

Speech Materials Used :-

The test material consisted of a popular, simple and common of kannada language story (appendix III). The story contained eleven sentences. The subjects were instructed to read the story at their comfortable loudness and rate. Each subject was allowed time to familiarize himself with the story before the recording

Data Collection :-

Each of the speaker was instructed to read the story, at their comfortable loudness and rate. The recordings were made in a sound treated room. Recordings were made on a hi-bias metal cassette using a professional stereo cassette deck with a high quality microphone.

All the subject were required to perform the above mentioned task. These recordings were used for analysis.

Analysis :-

The analysis involved the following equipment:-

(1) H-Legend D-80mic

2) Tape deck to play the recorded speech samples.

(3) A-D/D-A converted (12bit)

(4) Speech interface unit

5) Software for analysis and digitizing (developed by voice and speech system, B'lore)

(6) Sharp AH 307 stereo headphone

(7) Pentium HCL computer with 200 Mhz processor.

(8) Printer Epson Fx 1000.

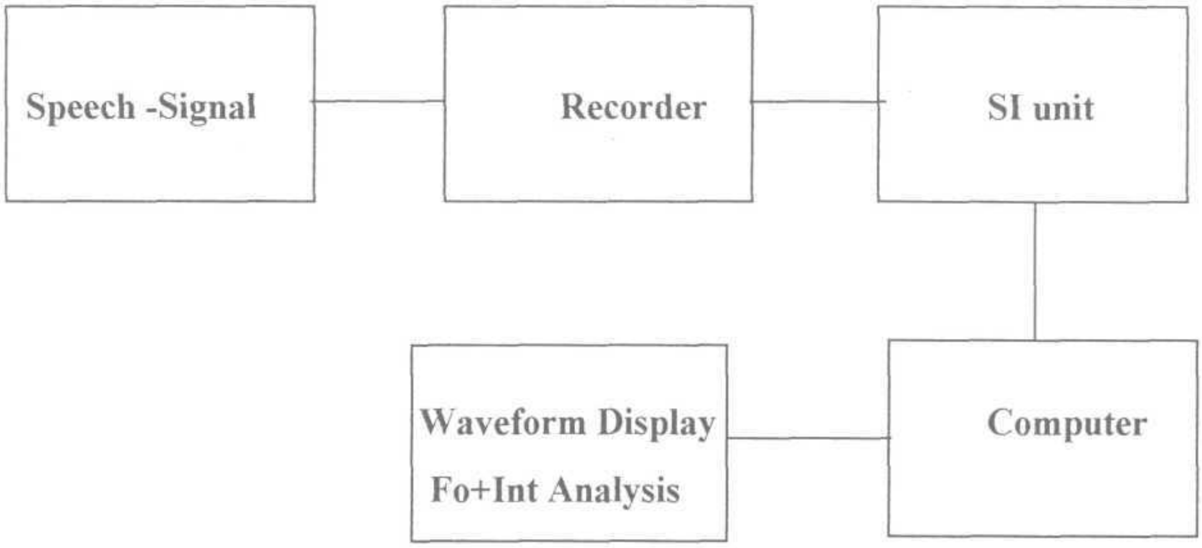
Procedure used for analysis:-

The aims of this analysis were:

1) To obtain the speech wave form, fundamental frequency curve and relative intensity curve on a temporal scale of each sentence.

2) To obtain the table of numerical values of the fundamental frequency, intensity and duration of the sentences at an interval of 10 milli seconds.

The instruments were arranged as shown in the block diagram :-



The instruments used for the objective analysis of the sentences are shown in Fig. 1. The analysis was carried out in two stages

a) Objective analysis

b) Subjective analysis.

The recorded speech sample i.e. each sentence at a time was fed through the interface unit at a sampling rate of 16KHz using the programme 'Record' of VSS software. Before digitizing, each sample was passed through the anti alaising filter at 3.5 Khz with the role off 48 dB per octave. Digitized data was stored on the hard disk of the computer (HCL.PC with Pentium 200 Mhz processor). The level indicator of the speech interface unit was used to monitor the intensity level of the signal to avoid any distortion while digitizing the signal.

Each sentence was analysed using the software packages SSL developed by voice and speech systems Bangalore.

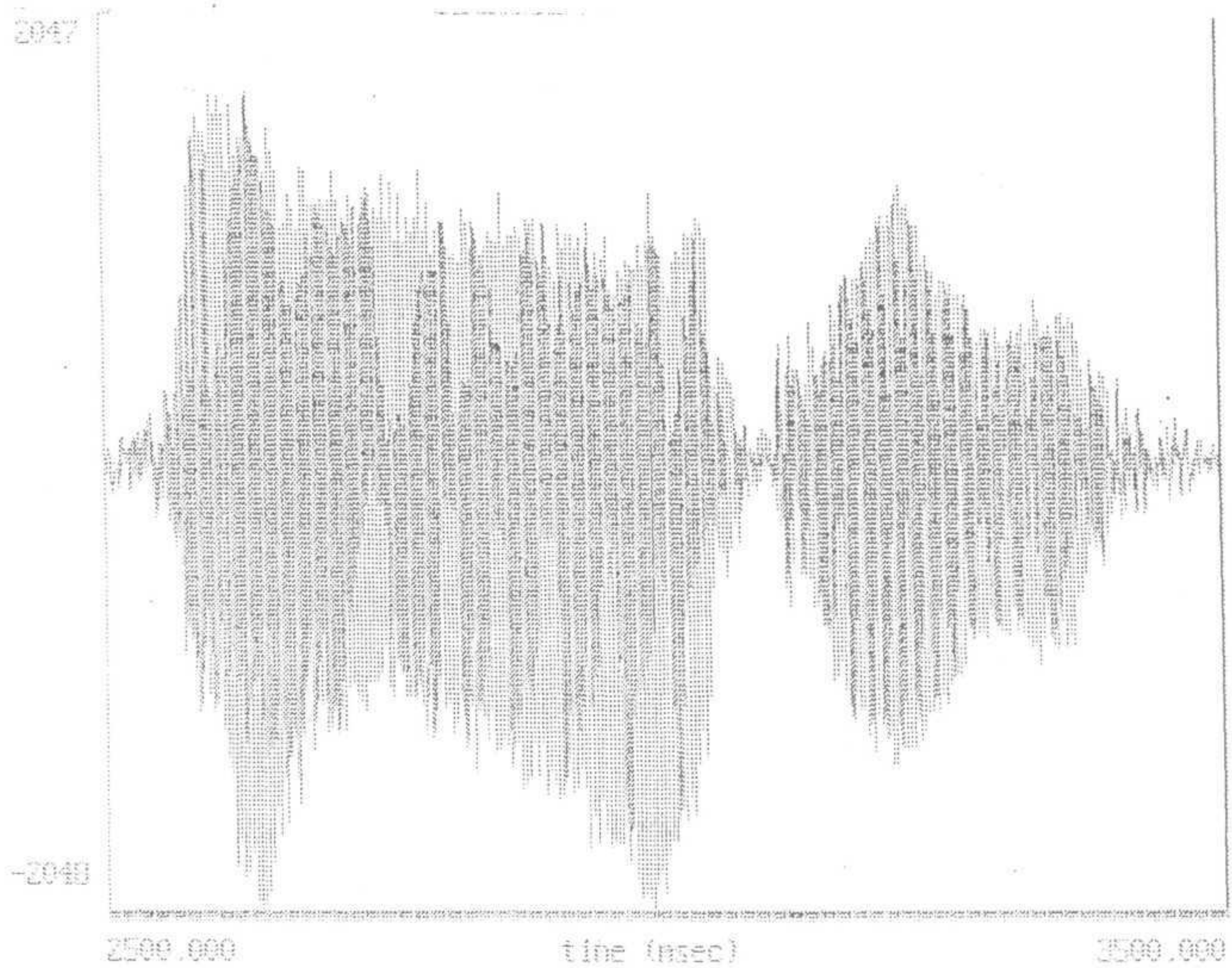
Fig 1:- Photograph showing Instrumentation for analysis of Alaryngeal Speech.

Measurement of Pauses :

The digitized signal was displayed on the computer screen using DISPLAY programme of SSL. On execution of this programme a specified portion of the speech signal was dispalyed on the monitor of the computer. A vertical cursor which could be moved horizontally was used to mark a specified portion of the wave form to highlight and listen to the signal present in that marked part of the wave form. The highlighting would permit to note the time between any given points on the wave forms. Using this it was possible to segment or edit and measure the duration of any desired portion of the waveform.

All the sentences spoken by the subjects of the three groups were analysed and temporal parameters were obtained. The speech wave form was visually inspected for silent intervals. The duration of silence was then calculated by placing the cursor at the points of pause onset and termination. Pause onset was defined as the point where the wave form stopped appearing on the display screen, and the pause termination was defined as the point where the wave form next started again. The portion was highlighted everytime and listened using headphones to confirm the correct marking of the silence (Fig 2.) When pausses were identified their location and duration was noted. (Interword, Intraword and Intersentence). Locations were confirmed by an acoustic playback of the portion of the signal surrounding the pause.

The speaking rate was calculated by total number of syllables divided by the time taken to read the story.


2047
-2040
time (msec)

INTON Analysis :

INTON programme, of VSS-Software was then used to extract the fundamental frequency and intensity curve for each of the sentence uttered by the subjects. This programe enabled simultaneous visualization of the fundmental frequency pattern for a given portion of speech signal, i.e., the intonation contours and also the wave form. A vertical cursor which could be moved horizontally enabled marking of particular points/portion on the wave form. The fundamental frequency and intensity measures corresponding to this portion could be noted at the points where the cursor was placed on the wave from. Average fundamental frequency and intensity variations for each syllable were extracted and the following fundamental frequency and intensity values were also obtained.

1. Mean fundamental frequency in speech (Hz).
2. Range of fundamental frequency in speech (Hz).
3. Mean Intensity (in dB)
4. Range of Intensity (In dB)

Stress Identification and Intonation Curve :

The analysis of intonation for each of the sentences of the story was carried out using the INTON programme. The difference of 20 Hz or more between two points was considered adequate for the production of 'rise' or 'fall'. Any change less than 20 Hz was considered as 'flat'. Then the intonation contours were compared to find the pattern of intonation in esophageal and tracheoesophagel speech.

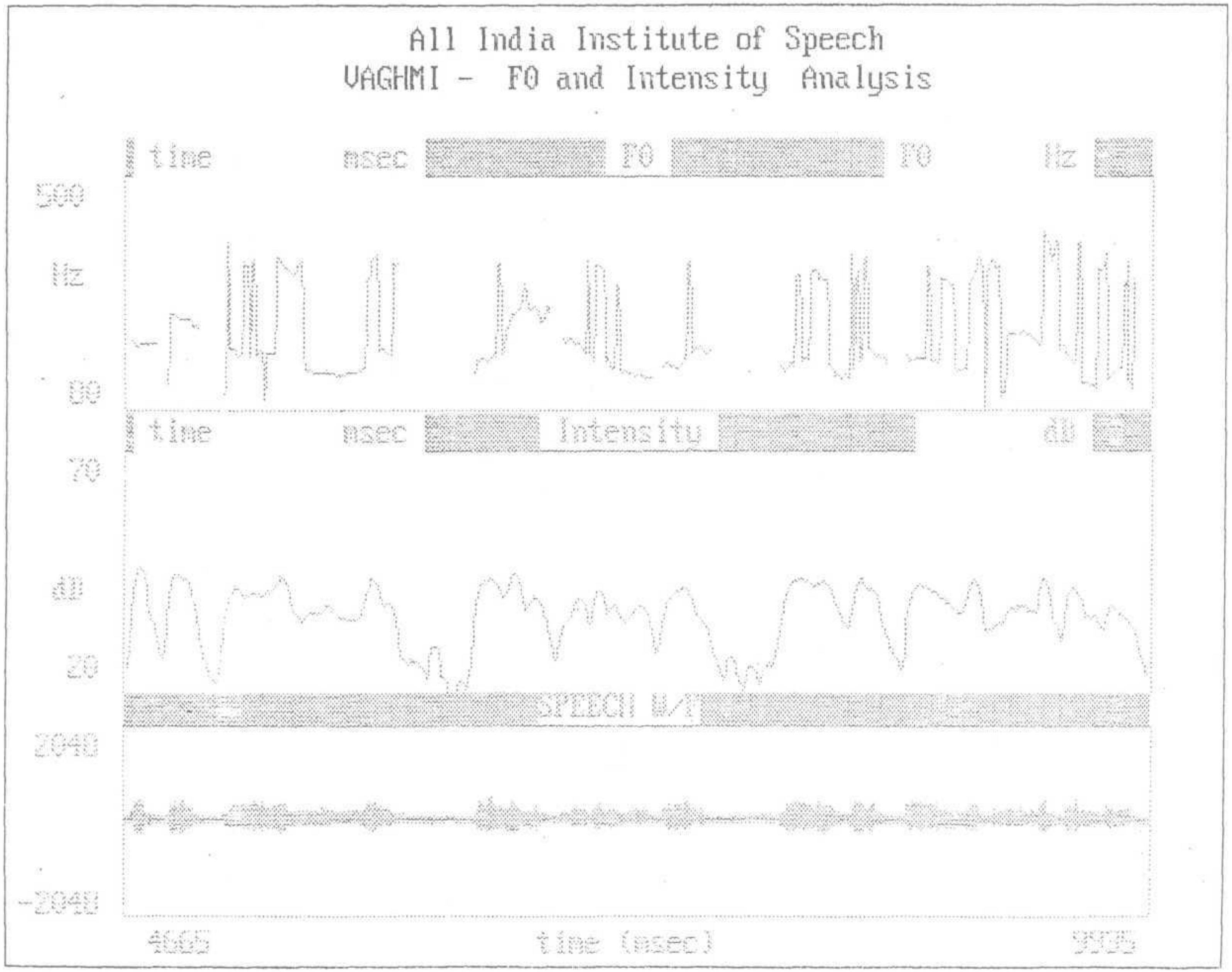
Stress analysis was carried out considering the syllable as the basic unit (House et al, 1989). The locus of stress as evidenced by higher fundamental frequency, intensity and longer duration were determined using the data given in the table with fundamental frequency, intensity and duration for each 10 msec of each sentences i.e., whenever there was an increase of fundamental frequency approximately 20 Hz more or an increase in intensity approximately 5dB more or when increase in duration of a syllables approximately 50msec more was noted.

This analysis also provided a table consisting of fundamental frequency and intensity values at every 10 ms durations for each sentence of every speaker as given below.

VAGHMI- INTON

DURATION	FO	INTENSITY	VUS
850	0	23.91687	S
860	0	23.68528	S
870	0	23.31759	S
880	0	23.0988	S
890	0	24.58254	S
900	0	25.20745	S
910	0	27.33057	S
920	0	28.4136	S
930	0	30.14162	S
940	0	30.60232	S
950	0	31.16537	S
960	302.0058	32.1465	V
970	303.2237	34.49033	V
980	307.4811	35.4193	V
990	299.4052	38.38448	V
1000	144.7127	39.75631	V
1010	149.2571	40.33926	V
1020	103.7892	40.22086	V
1030	315.812	39.9982	V
1040	309.6225	38.38542	V
1050	315.5053	36.50468	V
1060	331.3642	34.87064	V
1070	341.7851	34.41154	V
1080	342.174	34.4471	V
1090	170.7927	34.93312	V
1100	337.053	35.46815 -	V
1120	330.584	35.34137	V

A print out of the Fo an intensity curves and waveforms and duration were obtained using the printer (Epson Fx 1000) and the Fo and intensity values



All India Institute of Speech
VAGHMI - F0 and Intensity Analysis
time
msec
F0
F0
Hz
500
Hz
80
time
msec
Intensity
dB
70
dB
20
SPEECH W/F
2048
-2048
4665
time (msec)
9905

corresponding to the stressed syllable was noted on from the table and curve. They were then compared to see the whether the groups had stressed on the same syllables or not and also to determine whether there was a set pattern of deviance in the esophageal and tracheaoesophageal speech.

Subjective Analysis :-

The subjective analysis was done by the experimenter and one more judge who had experience in the analysis of the intonation contours of normals, esophageal and tracheoesophageal speakers by marking the stress level after listening to each sentence recorded.

Statistical analysis :-

Descriptive statistics consisting of mean, standard deviation and minimum and maximum values were obtained for all the parameters studied.

The values obtained were further subjected to the Mann-Whitney-U test (SPSS programme) to find out there is any significant difference between the normal, esophageal and tracheoesophageal speakers.

RESULTS AND DISCUSSIONS

The Present study was undertaken to compare the suprasegmental aspects in terms of Mean Fo in speech, Range of Fo in speech, Mean intensity in speech, Intensity range in speech, stress, intonation, rate of speech and pauses produced by normal, tracheoesophageal and esophageal speakers.

Mean Fundamental Frequency in Speech

The findings of fundamental frequency in speech for the esophageal, tracheoesophagal and normal groups of the present study are given in Table. 1 and Graph - 1.

Group	Mean (Hz)	S.D. (HZ)	Range (Hz)
Normal	149.26	36.6	107.95
Esophageal	95.74	28.9	56.79
TEP	140.07	16.7	100.09

Table - 1 : The mean, S.D. and range of fundamental frequency in speech (Hz) for esophageal, Tracheoesophageal and normal groups.

As a group the mean fundamental frequency in speech (149.26 Hz) for normal males of the study was similar to the mean Fo in speech for Indian population as reported by Gopal (1986). The esophageal group showed lowest mean fundamental frequency (95.74 Hz) in speech than normal and TEP group. The mean fundamental frequency in speech of the TEP group (140.07 Hz) approximated the values shown by normal laryngeal group. (149.26 Hz). The mean fundamental frequency for both TEP and esophageal group was higher than reported by other investigators (Table 2.). However the mean fundamental frequency in speech in esophageal speakers of the study corresponded with the report of Shipp (1967) and Rajashekhar (1991).

Investigator	**Mean[Fo Sp] (Hz)**	
	Esophageal group	**TEP group**
1. Damste (1958)	67.5	
2. Curry and Snidecor (1961)	63.0	
3. Shipp(1967)	94.38	
4. Hoops and Noll	65.59	
5. Weinbert and bennet (1971,1974)	57.40	
6. Torgerson and Martin (1980)	65.70	
7. Blood (1984)	64.60	88.3
8. Robbins et al (1984)	77.10	101.7
9. Pindzola and Cain (1989)	84.10	107.7
10. Rajashekhar et al (1990)	68.0	114.0
ll.Rajashekhar(1991)	91.80	136.7
12. Samyogeetha(1993)	185.90	

Table -l(a) : The mean fundamental frequency in speech (Hz) In esophageal and tracheoesophageal speakers as reported by various investigators.

Mann-Whitney-U test showed significant difference between the TEP and esophageal speakers and between normal and esophageal groups. However, there was no significant difference between the TEP and normal groups.

Thus, the hypothesis stating that there is no significant difference in terms of mean fundamental frequency in speech between esophageal and TEP and between esophageal and normal is rejected. And the hypothesis stating that there is no significant difference between TEP and normal groups is accepted.

The results of the present study thus indicates that the TEP speakers achieved speaking fundamental frequency similar to the normal laryngeal speakers and the esophageal speakers used much lower fundamental frequency for speaking.

Frequency range in speech

The mean and S.D. along with range of frequency range in speech were measured from the analysis of the story spoken by the esophageal, tracheoesophageal and normal speakers are presented in Table2. and Graph 1.

Group	Mean (Hz)	S.D. (Hz)	Range (Hz)
Normal	99.30	29.46	70.00
Esophageal	62.80	32.90	72.29
TEP	120.00	30.64	115.71

Table 2. The mean, S.D. and range of frequency range (Hz) in speech for esophageal, tracheoesophageal and normal groups.

The frequency range in Speech for the normal group of this study was similar to other reports (Hudson and Halbrook, 1981; Robbins et al, 1984; Pindzola and Cain, 1989; Gopal, 1986 and Rajashekhar, 1991).

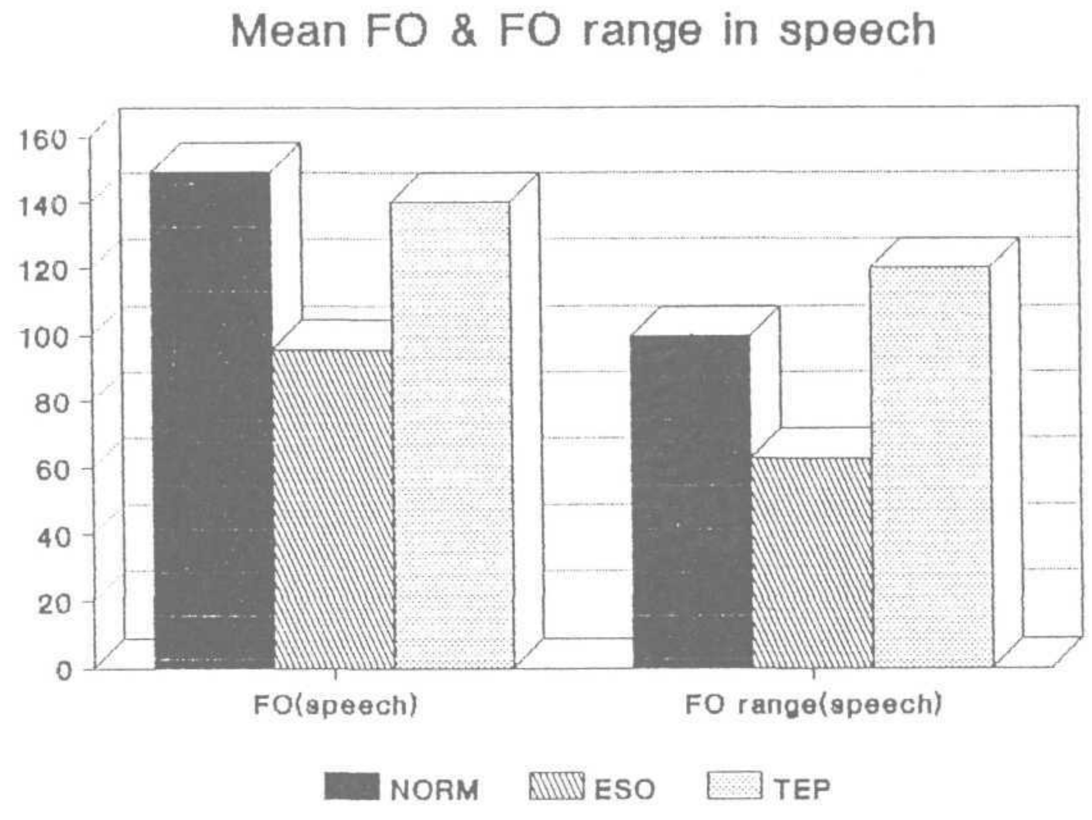
The esophageal and tracheoesophageal speakers had 120 Hz and of 62.8 Hz frequency range respectively which was lower than reported. The frequency range of speech in both esophageal and tracheoesophageal speakers was lower than the reported which was shown in the Table 2(a). However the findings of the present study correlated with the reports made by Rajashekhar (1991).

Investigator	**Frequency range in speech (Hz)**	
	Esophageal	**TEP**
1. Filter and Hyman (1975)	80.0	
2. Robbins et al(1984)	118.0	142.00
3. Pindzola and Cain (1989)	177.1	170.00
4. Rajashekhar (1991)	59.6	111.40 Hz
5. Sanyogeetha (1993)	144.2	

Table- 2(a) : The mean frequency range in esophageal and TEP speakers as reported by various investigators.

Mann-Whitney-U test showed significant difference between the esophageal, and normal groups and between tracheoesophageal and normal speakers whereas no significant difference between tracheoesophageal and esophageal groups in terms of frequency range in speech was noticed.

Hence hypothesis stating there is no significant difference in terms of Fo range between esophageal and normal laryngeal and between tracheoesophageal and normal speakers is rejected.



Graph 1. - Showing mean fundamental frequency and fundamental frequency range in speech for normal, tracheoesophagealand esophageal speakers.

The hypothesis stating that there is no significant difference between tracheoesophageal and esophageal group of speakers was accepted.

Mean Intensity :

The present study found that mean intensity was lower in esophageal and tracheoesophageal speakers than in the normal group. Normals showed greater variability on this parameters than the two other groups.

The findings of the mean intensity in speech for the esophageal and tracheoesophageal and normal groups of the present study are given in the Table 3. and Graph 2.

	Mean	**Range**	**S.D.**
Normal	72.29.	76.03	16.79
Esophageal	32.59	15.44	2.49
TEP	35.59	36.03	10.09

Table-3 : The mean, range, S.D. in mean intensity of speech in normal, esophageal and tracheoesophageal group.

The Mann-Whitney-U test found that there was significant difference between normal and esophageal group and between normal and tracheoesophageal group and no significant difference between esophageal and tracheoesophageal group.

Thus hypothesis stating that there is no significant difference between normal and esophageal and between normal and tracheoesophageal group is rejected. And the hypothesis stating that there is no significant difference between esophageal and tracheoesophageal group is accepted.

Intensity range in speech :

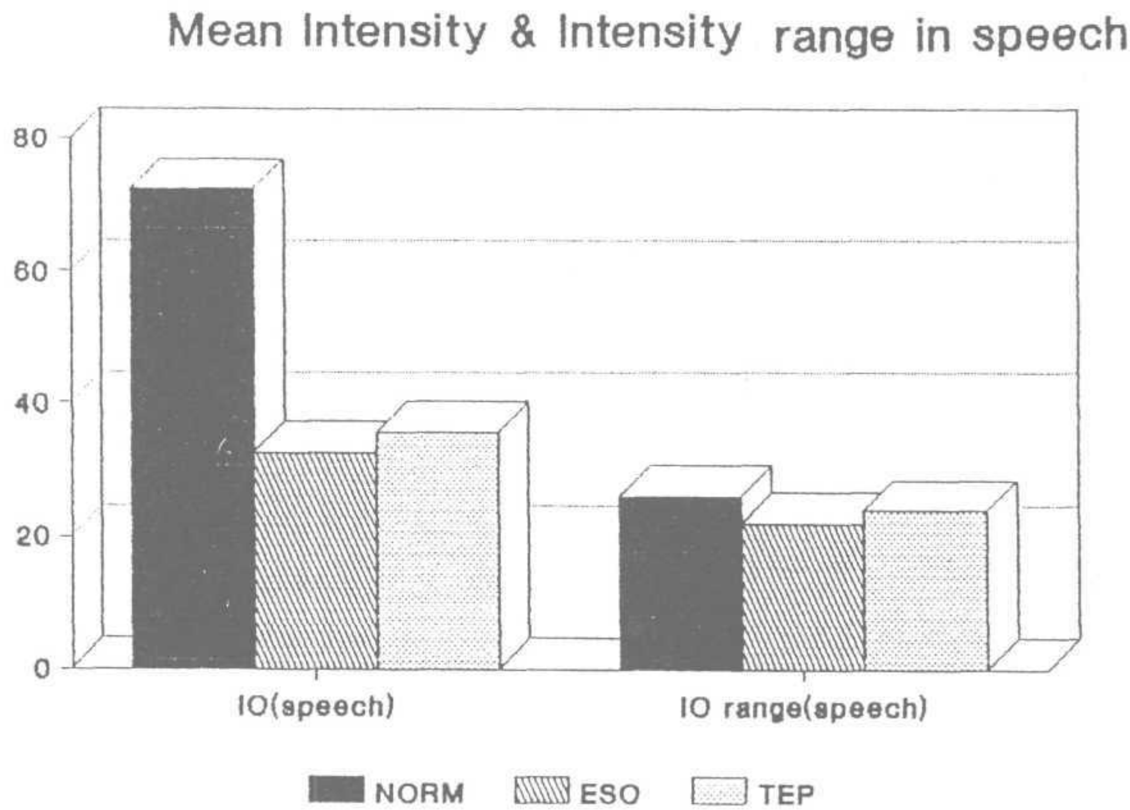
The intensity ranges in speech were obtained for the normal, esophageal and tracheoesophageal groups. The intensity range in speech obtained for the normal group in the present study was correlating with the findings of Nataraja, (1986) and Rajashekar (1991).

Intensity range in esophageal speakers was reduced than in the tracheoesophageal and normal groups. However, mean intensity of esophageal speakers approximated the value of normal and tracheoesophageal speakers.

Mann-Whitney-U-Test indicated that there was no significant difference between normal and tracheoesophageal But there was a significant difference between esophageal and normal, tracheoesophageal and esophageal speakers.

	Mean	**Range**	**S.D.**
Normal	26.07	14.42	3.455
Esophageal	22.01	7.06	2.47
TEP	23.91	14.91	4.77

Table - 4 : The mean, range, S.D. for intensity range in speech in normal, esophageal and tracheoesophageal speakers.



Graph 2. - Showing mean intensity and intensity range in speech for normal, tracheoesophageal and esophageal speakers

Thus the hypothesis stating that there is no significant difference in terms of intensity range between normal and esophageal was rejected, esophageal and tracheoesophageal was accepted and normal and tracheoesophageal was also accepted.

Results of the intensity range indicated that the T.E. speakers, did not differ significantly in terms of intensity range in speech. Hence implied that the ability of the tracheoesophageal speakers to maintain the intensity on part with the normal laryngeal speakers during speech i.e. tracheoesophageal speakers were capable of producing audible/loud speech like normals.

Intonation:

The analysis of intonation for each of the sentences of the story was carried out using the INTON programme. A difference of 20 Hz or more between two points was considered adequate for the production of 'rise' or 'fall'. Any change of less than 20 Hz was considered as 'flat'.

Each sentence was analyzed. Of the eleven sentences analyzed, the first six sentences were declarative sentences, other were emotions like anger. The two types of sentences were analyzed. The most common pattern of frequency variation seen in normal speakers were :-

Rise-fall-flat-Rise-Fall

and one obtained from the esophageal speaker were :-

Rise-fall-Rise-fiat

in tracheoesophageal speaker, it was observed that there was

Rise-fall-Rise-fall

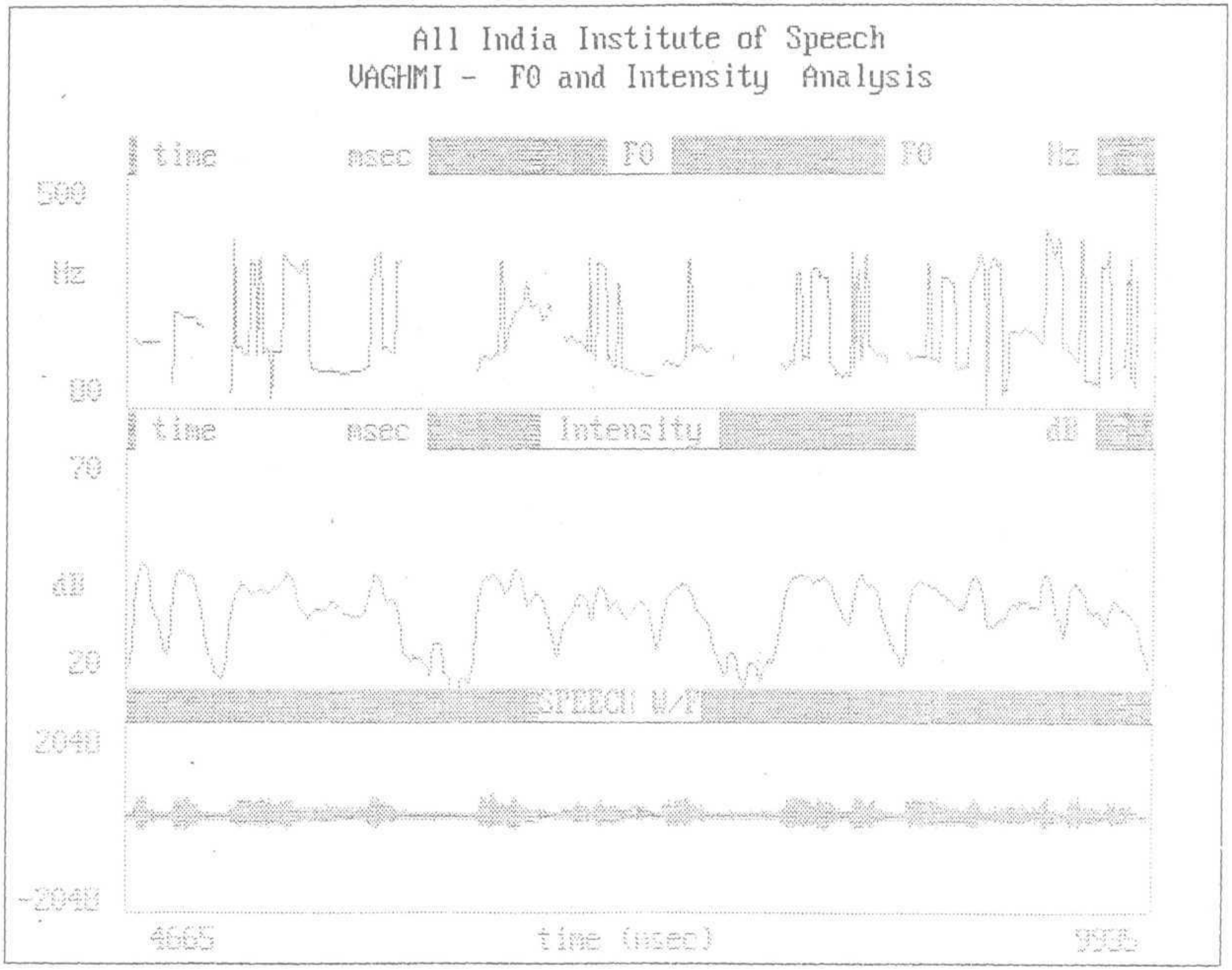


Fig 1:- Fo Int Graph for Normal Laryngeal Speaker

There was a fundamental frequency variation from 130 Hz to 470 Hz. for normals and TEP groups and for esophageal group the fundamental frequency variaitons was from 90 Hz to 280 Hz.

The comparison of the above patterns revealed that esophageal and tracheoesophageal speakers used almost the same intonation patterns as normal laryngeal speakers, but not identical. But poor esophageal speakers were not able to produce the intonational patterns as that of the normals. The intonation contours in sentences spoken by esophageal and tracheoesophageal was discontinuous with numerous breaks and intermittent frequency tracings (Fig 1,2 & 3).

The intonation patterns used by normal,esophageal and tracheoesophageal group were found to have flat or falling intonation at the terminal part. The findings of the present study correlated with the reports made by Gandour and Weinberg (1983) and Sanyogeetha (1993).

Thus hypothesis stating that there is no significant difference between normal,TEP and esophageal in terms of intonation pattern is accepted.

Stress :

Syllable was considered the fundamental unit for analysis of stress, as in most of the studies on prosodic features. Hence, in the present study also, the syllable was considered the basic unit. Stressed syllables were identified on the basis of higher fundamental frequency, intensity and longer duration or a combination of these parameters (Fry, 1955; Libermann, 1960; Thorsen, 1980).

Both subjective and perceptual evaluation was done. Peak fundamental frequency and maximum intensity were considered to find out the stressed

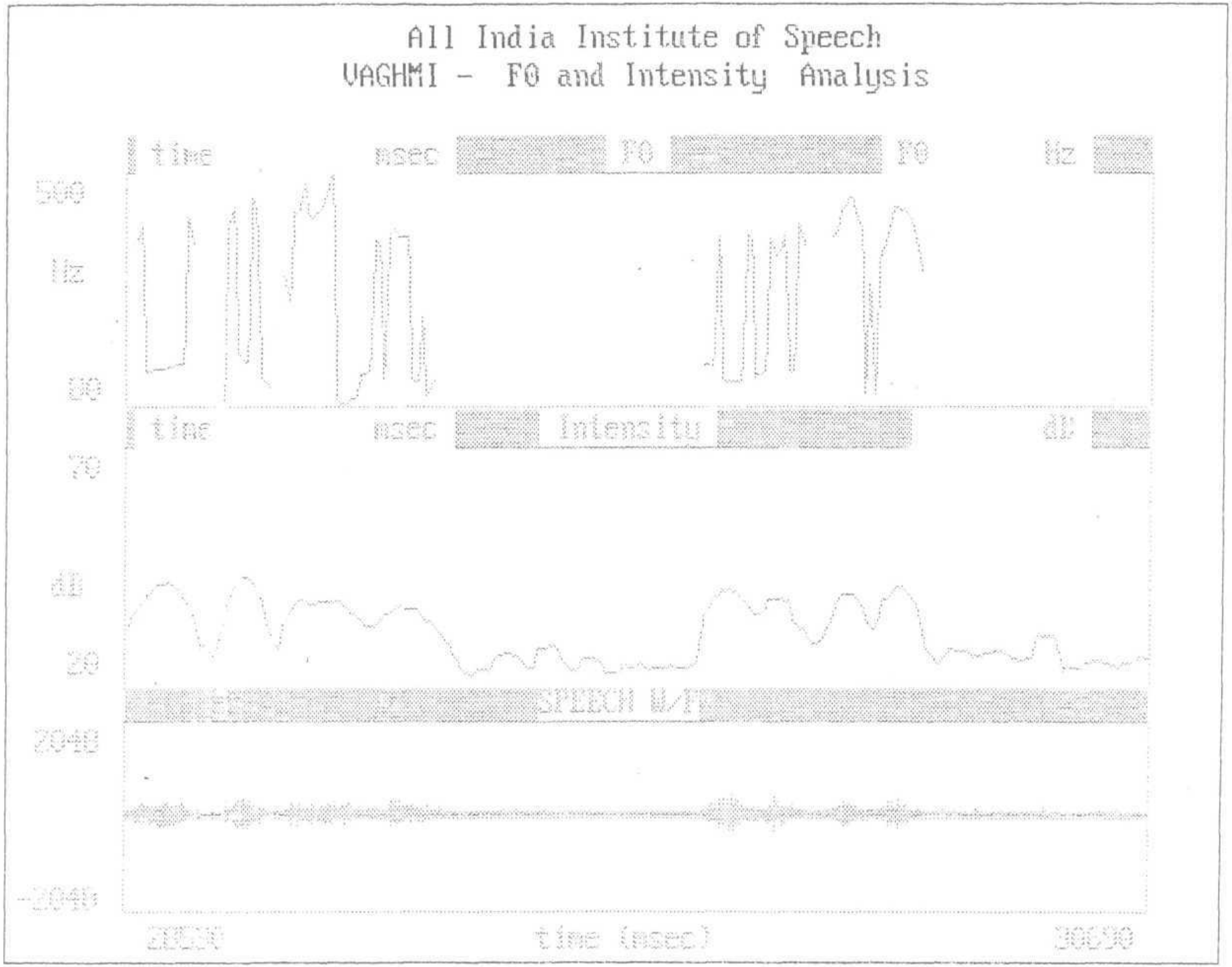


Fig 2:. Fo Int Graph for Esophageal Speaker

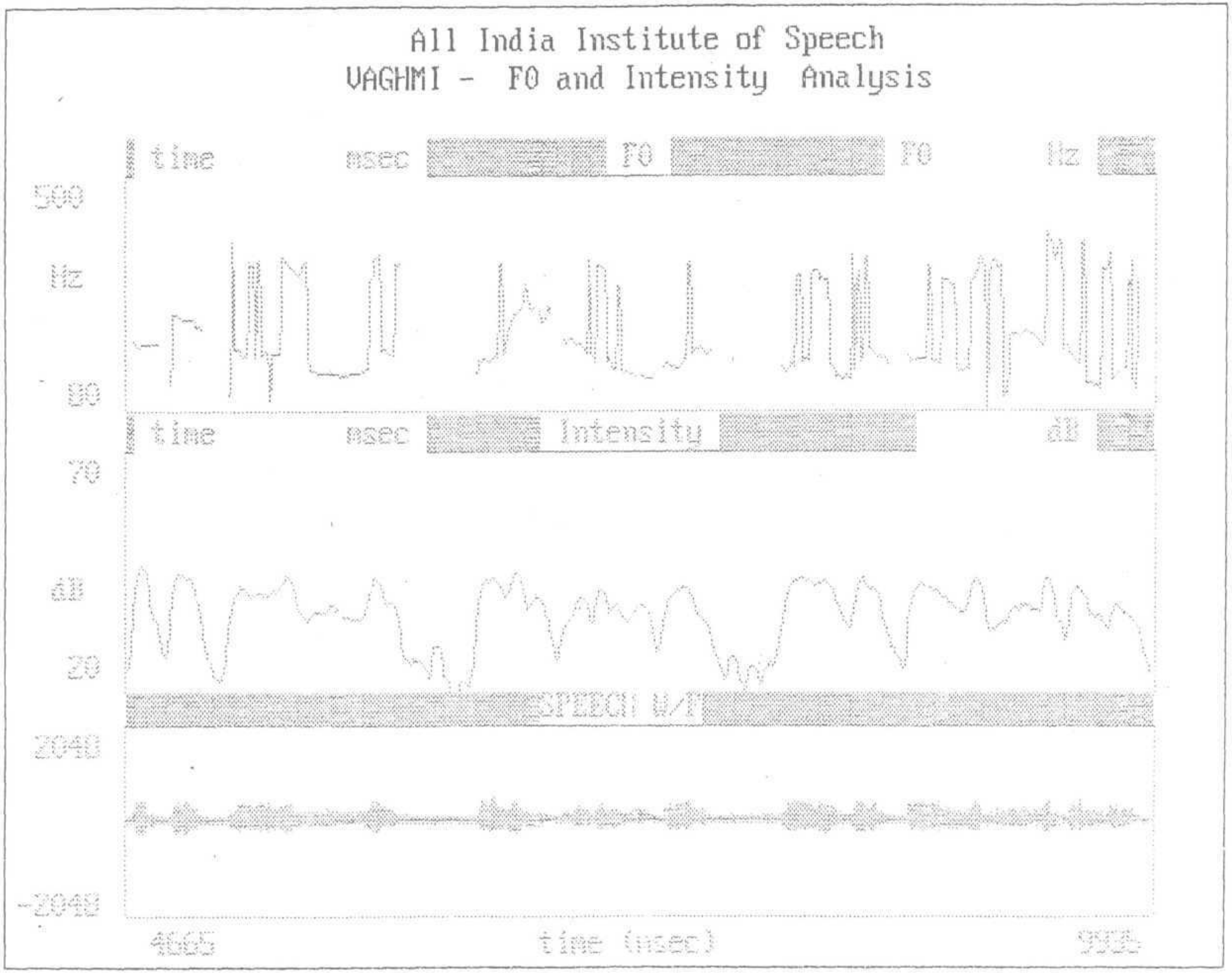


Fig 1 :- Fo Int Graph for Normal Laryngeal Speaker

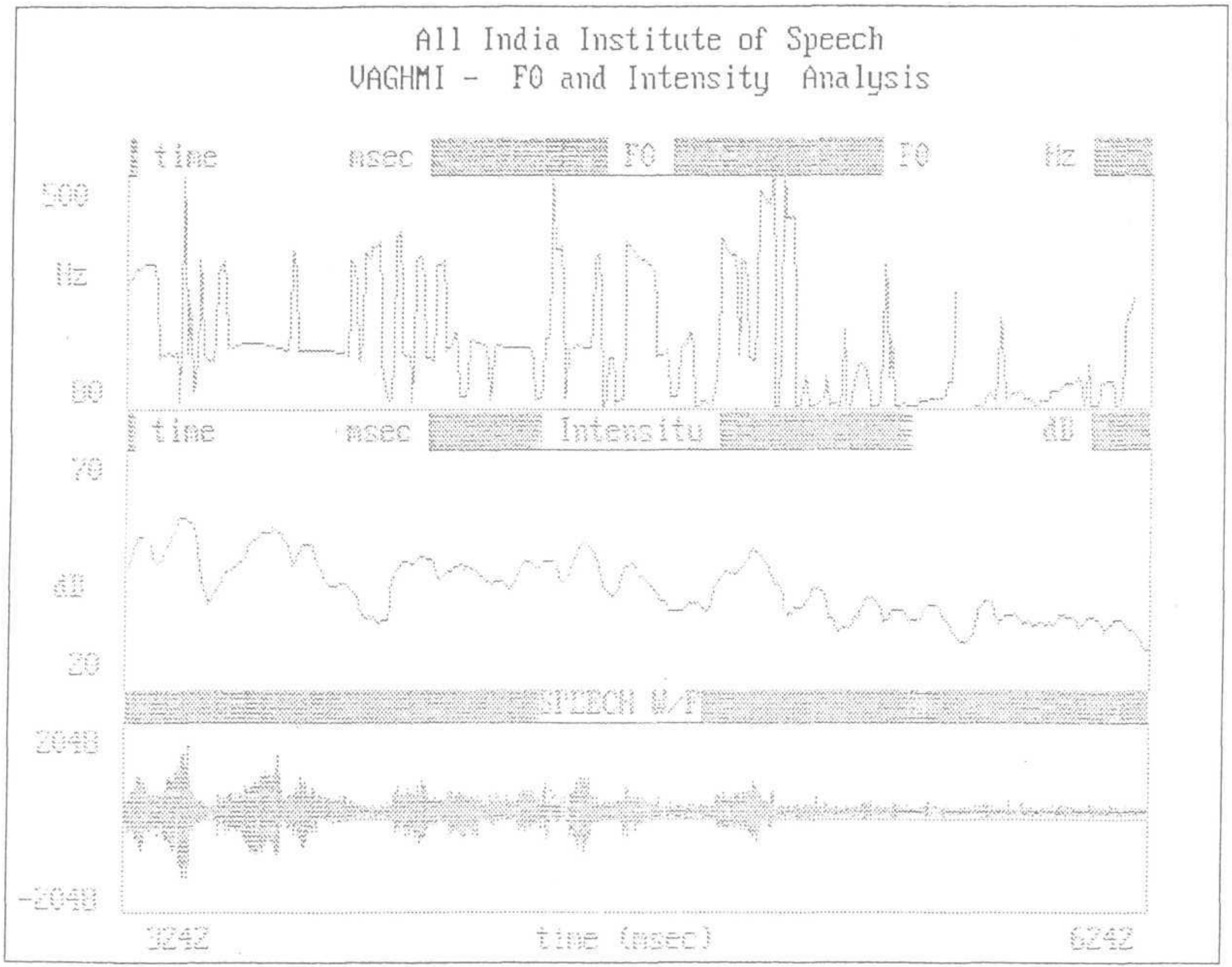


Fig 3 :· FO Int Graph for Tracheoesophageal speaker syllable. It was found that in normal speakers, the stressed syllable was found mostly in initial syllable of the word and it was found mostly in between the sentences. However, esophageal and tracheoesophageal speakers also produced stressed syllables as that of the normals. All normals, esophageal and TEP speakers produced a higher peak fundamental frequency, higher peak intensity for stressed syllable. But there was reduced peak fundamental frequency and peak intensity for the stressed syllable in esophageal speakers when compared to normal and TEP group. There was no difference between normal and TEP speakers. But minimal difference was observed between esophageal and normal groups. Thus present study correlated with study done by Gandour, Weinberg and Garzione (1983), Walker and Monies (1988).

Thus the hypothesis stating that there is no significant difference between normal, TEP and esophageal speakers was accepted.

This finding indicates that the surgically reconstructed pharyngoesophageal segment, powered either by air insufflated in the esophagus or by diverted pulmonary air, provides an adequate air supply to non-conventional phonatory apparatus to enable the laryngectomized speakers to produce intonational contrasts. The findings that some alaryngeal speakers are able to produce prosodic patterns suggests that they were able to control and regulate voice fundamental frequency in speech.

Temporal Measures :-

Pause Duration :

The duration of interword, intraword and intersentence pause duration and the total duration of pauses for the representative speech sample were measured.

The findings of the interword pause for the normal, esophageal and TEP group of the present study are given in Table 5 (a). Graph 3

	Mean	**S.D.**	**Range**
Normal	0.8520	0.5523	1.21
Esophageal	21.68	9.91	
TEP	6.97	9.10	19.54

Table -5 (a) : The mean, S.D. and range for interword pauses in normal, esophageal and tracheoesophageal speakers.

Interword pause found to be more in esophageal and TEP group. There was a difference between esophageal and normal group.

The Mann-Whithney U test of significance showed that there was significant difference between normal and esophageal speakers and no significant difference between normal and tracheoesophageal group and tracheoesophageal and esophageal group in terms of interword pauses.

Thus the hypothesis that there is no difference between esophageal and normal speakers in terms of interword pause duration was rejected whereas there is no significant difference between normal and tracheoesophageal and tracheoesophageal and esophageal group is accepted.

Intraword pause was found to be more in esophageal speakers than in TEP and normal groups.

The findings of the intraword pause for the normal, esophageal and TEP group of the present study are given in Table 5(b). Graph 3.

	Mean	S.D.	Range
Normal	0	0	0
Esophgeal	0.38	0.09	2.00
TEP	0.031	0.01	1.55

Table- 5(b) :- The mean, Range and S.D for intraword pause duration in normal, esophageal and tracheoesophageal speakers.

The Mann-Whitney -U test of significance showed that there was significant difference between normal and esophageal speakers and TEP and esophageal speakers. There was no significant difference between TEP and normal groups.

Thus the hypothesis that there is no significant difference between normal and esophageal and TEP and esophageal speaker is rejected. Whereas no significant difference between TEP and normals in terms of intraword pause duration is accepted.

Intersentence pause duration was found to be more in esophageal speakers than TEP and normal groups.

The findings of the intersentence pause for the normal, esophageal and TEP group of the present study are given in Table 5(c). Graph 3.

The Mann-Whitney U test for significance showed significant difference between normal and esophageal speakers and normal and tracheoesophageal speakers. However, there was no significant difference between esophageal and tracheoesophageal speakers.

	Mean	Range	S.D
Normal	3.55	2.74	1.21
Esophageal.	15.56	---	10.23
TEP	10.31	7.90	3.62

Table- 5(c) :- The mean, Range and S.D for intersentence pause duration in normal, esophageal and tracheoesophageal speakers.

Thus, the hypothesis that there was no significant difference between esophageal and tracheoesophageal speakers was accepted. And the hypothesis stating that there is no significant difference between normal and esophageal and normal and TEP groups in terms of intersentence pause was rejected.

Total Pause Duration:

The total Pause duration was found to be more in esophageal and tracheoesophageal than the normals speakers. However it was found to be more in esophageal speakers than in the tracheoesophageal speakers.

The findings of the Total pause for the normal, esophageal and TEP group of the present study are given in Table 5(d). Graph .3

The Mann -Whitney-U test for significance showed significant difference between esophageal and normal groups and normal and tracheoesophageal groups. There was no significant difference between esophageal and tracheoesophageal speakers.

	Mean	Range	S.D.
Normal	3.52	4.45	1.62
Esophageal	32.02	33.11	13.85
TEP	16.21	17.14	7.57

Table- 5 (d) :- The mean, Range and S.D for total pause duration in normal, esophageal and tracheoesophageal speakers

Thus, the hypothesis that there was no significance difference between normal and esophageal and normal and tracheoesophageal speakers was rejected. And the hypothesis that there was no difference between esophageal and TEP group was accepted.

The present study thus supports the findings of Robbins et al (1984) who found total pause time and total number of pauses to be greater in esophageal than in normal laryngeal speakers. Diedrich (1968) attributes the greater total pause time shown by esophageal speakers and TEP speakers to their limited air reservoir.

Rate of Speech :

The rate of speech was expressed in terms of syllables per second (RT) in the present study. The mean, S.D. and range of speech rate for the three groups are given in Table 6. Graph 3.

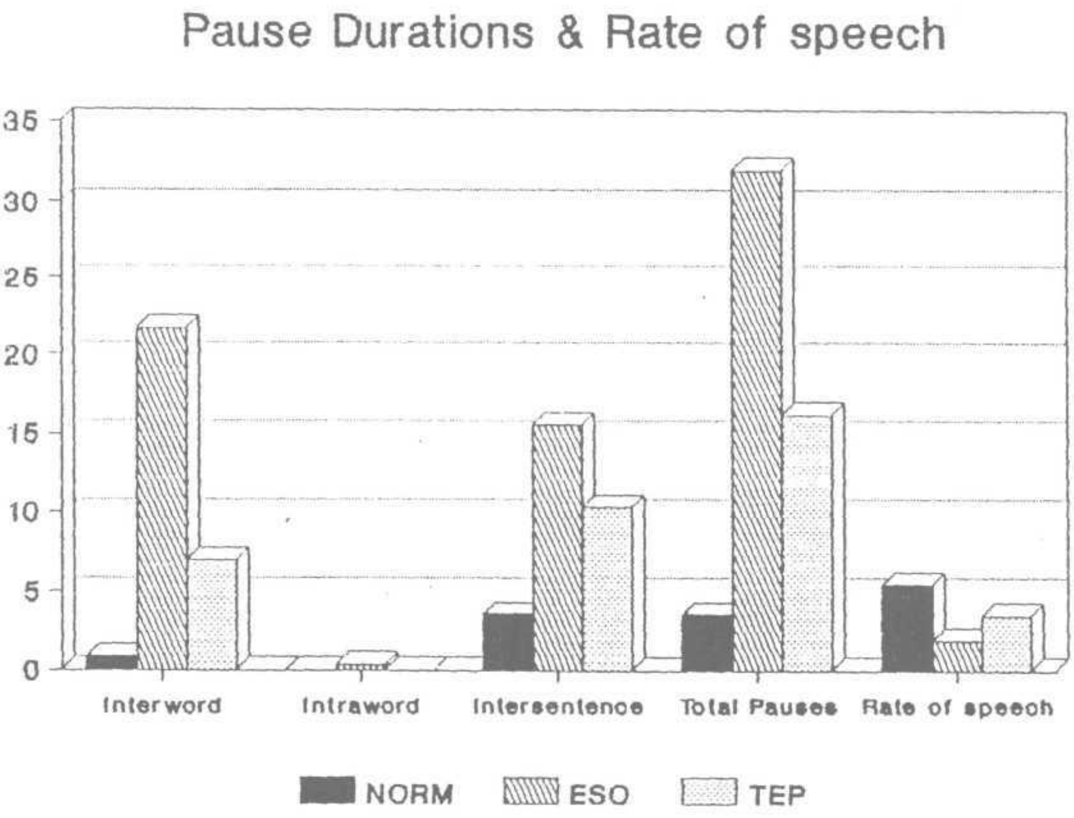
Group	Mean	S.D.	Range
Normal	5.43	0.6188	1.24
Esophageal	1.85	0.7386	1.66
TEP	3.44	1.0085	2.08

Table-6 :- The mean, Range and S.D for rate of speech (RT) in syllables/sec for normal, esophageal and tracheoesophageal groups.

The mean rate of speech in the esophageal group and TEP group was less than the values obtained for the normal group. The average rate of speech in normals was greater than in the esophageal group and tracheoesophageal group

Robbins et al (1984) was stated that the slower rate in esophageal speakers indicated limited volume of insufflated air in the esophagus in contrast to the entire pulmonary volume available for the laryngeal speaker. Whereas the faster rate of speech in T.E. and laryngeal speakers reflected the use of pulmonory system. Pindzola and Cain (1989) attributed the reduced rate of speech in esophageal speakers to the increased pause time needed to insufflate the pseudoglottis.They also attributed the increased rate of speech in tracheoesophageal group to fewer pauses than in the speech of esophageal group owing to their access to larger respiratory volumes. Rajashekhar (1991) also attributed the reduced rate of speech in esophageal speakers to the frequency of pausing for air insufflation into the esophagus. The present study thus supports the findings of reduced rate of speech in esophageal speakers and by Robbins, (1984) , Pindzola and Cain, (1989) and Rajashekhar (1991).

64 (a)



Graph 3.- Showing pause durations (Intraword, Interword, intersentence and Total pause durations) and Rate of speech.

The Mann-Whitney-U test demonstrated significant differences between the esophageal and normal groups in the rate of speech. Also demonstrated significant difference between the tracheoesophageal and normal group in the rate of speech. However there was no significant difference between esophageal and tracheoesophageal group.

Hence the hypothesis stating that there is no significant difference between the esophageal and normal and tracheoesophageal and normal groups in the rate of speech was rejected. And the hypothesis stating that there was no significant difference between esophageal and tracheoesophageal was accepted.

Thus , the results of this study emphasized the availability of air in determining the rate of speech i.e. pulmonary air available in case of tracheoesophageal speakers as against the insufflated air in esophageal speakers permits greater rate of speech in tracheoesophageal speakers. The greater air supply available to the tracheoesophageal group had enhanced their ability to maintain voicing thus reducing pauses in connected speech.

The need to pause more frequently to insufflate the air deptued esophagus in the case of esophageal speakers brings down the speech rate. It was also observed that tracheoesophageal speakers unable to provide adequate digital occlusion of stoma and puncture needed more time, thus increasing the pauses which resulted in subsequent reduction in the rate of speech.

The results of the present study indicated that the two alaryngeal speaker groups were different from the normal laryngeal group and between themselves in some of the parameters.

On the whole the results of the present study it could be stated as :-

1. The fundamental frequency in speech of esophageal speaker was considerably low.
2. The rate of speech of the esophageal speech considerably reduced when compared with that of the normal and TEP speakers.
3. Intonation pattern and stress produced by the esophageal and TEP speakers was similar to that of the normal, but not identical. Hence it was found that surgical removal of the larynx does not impair or disturb the linguistic form of speaker's message.
4. Pauses were more in esophageal and TEP speakers than the normal group.

Based on the above results the following conclusions were drawn :

Generally, increasing the rate of speech and reducing the stoma noise would improve the alaryngeal speech. Therapy programme for esophageal speakers should concentrate on elimination of klunks and reduction of stomal noise. The fundamental frequency in speech of the esophageal speakers being considerably low, therapeutic strategy to achieve higher fundamental frequency needs to be evolved. This aspect takes a lower priority in TEP speakers as majority of them achieve speech fundamental frequency comparable to normals.

Hence, TEP speech is directly related to the speaker's access to pulmonary air. Pulmonary air permits a substantially increased capacity for excitation of the PE segment for a larger period. Thus, speech of the TEP speakers approximated those of the normal speakers. This also allows the speaker to exhibit more natural speech prosody and the ability to systematically effect associated linguistic changes.

Intonation pattern and stress were not impaired in TEP speakers. In esophageal speakers the changes in Fo and Io were not as much as in TEP speakers. Hence therapy need to be concentrate on improving the prosodic aspects separately in esophageal speakers.

Thus, speech therapy programs should aim at improving the parameters found deviant from normals in this study, which would help in improving the overall acceptability and intelligibility in alaryngeal speech.

SUMMARY AND CONCLUSION

The primary goal of rehabilitation after laryngectomy is to return the patient as nearly as possible to his preoperative physiological,social and economic status. Achieving this goal depends significantly on the patients ability to communicate effectively. Esophageal speech, though traditionally considered the method of choice is acquired as an effective mode of communication by a mearge percentage of pateints involving considerable therapy time and variant speech proficiency. With the development of tracheoesophageal technique (Singer and Blom, 1980) , tracheoesophageal speech has become a widely accepted method of a laryngeal speech rehabilitation. Tracheoesophageal speech is achieved when pulmonary air is diverted through the prosthesis to vibrate PE segment thereby producing voice. The majority of patients who undergo tracheoesophageal puncture and placement of voice prosthesis will benefit from a brief program of speech therapy. The aim of speech therapy will be to bring the esophageal and tracheoesophageal speech more towards normal and natural. Prosodic features includes intonation, stress, tempo, and rhythm and basis for these are fundamental frequency and intensity.

The speech samples from five esophageal and five tracheoesophageal and five normal subjects matched for age, sex were collected. They were made to narrate the story in a eleven preformed sentences. All the subjects were native speakers of the kannada language and analysed using computer programs.

The intonation pattern and stress were determined with the help of frequency and intensity curves of each sentence uttered by the subjects along with mean Fo, Mean Io, range of Fo and Io, rate of speech and pauses.

The results of the study indicated the following :-

1. There was significant difference between esophageal and normal group and TEP and normal group in terms of rate of speech. Rate of speech of the esophageal speech was reduced than the normals and TEP.

2. There was significant difference in speech of esophageal and normal and esophageal and TEP in terms of fundamental frequency in speech and fundamental frequency range in speech.

3. There was significant difference between esophageal and normal and esophageal and TEP in terms of intensity and intensity range.

4. There was significant difference in terms of interword, intraword and intersentence pause duration and total pause duration between esophageal and normal group ad normal and TEP group.

5. Comparison of intonation contours used by normals, esophageal and tracheoesophageal speakers revealed that both esophageal and tracheoesophageal speakers do produce the intonation contours as that of the normals. But the change in frequency is discontinuous in esophageal speakers.
6. Comparison of stress used by normals, esophageal and tracheoesophageal speakers revealed that that both esophageal and tracheoesophageal speakers produced stressed syllable, but not identically on the same syllable.

From the results of the present study it could be concluded that surgical removal of larynx had not impair the linguistic contrast (intonation and stress) form of the alaryngeal speaker's message. Improving rate of speech and removing pauses should be the goals and priority of these goals in TEP and esophageal speakers are warrented.

Recommendations

- Other parameters may be considered for further study .
- The parameters may be studied on a larger group.

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APPENDIX II

Background Information of Esophageal Speakers

Age	**Sex**	Surgical Notes	Duration of Therapy
63	Male	T.L.	3 Months
67	Male	T.L.	2 Months
31	Male	T.L.	4 Months
55	Male	T.L.	2 Months
56	Male	T.L.	1 Week

T.L. - Total Laryngectomy

APPENDIX - III

ಒಬ್ಬ ಬಕ್ಕ ತಲೆಯ ಮನುಷ್ಯನಿದ್ದ. ಬೇಸಿಗೆಯಲ್ಲಿ ಒಂದು ದಿನ ಅವನು ಕೆಲಸ ಮಾಡಿ ಸಾಕಾಗಿ ಕುಳಿತುಕೊಂಡ. ಆ ಸಮಯಕ್ಕೆ ಸರಿಯಾಗಿ ಒಂದು ನೊಣ ಬಂದು ಅವನ ನುಣ್ಣನೆಯ ತಲೆಯ ಸುತ್ತ ಹಾರಾಡುತ್ತಾ ಬಕ್ಕ ತಲೆಯನ್ನು ಕಚ್ಚಲಾರಂಭಿಸಿತು. ನೊಣವನ್ನು ಹೊಡೆಯಬೇಕೆಂದು ಅವನು ಕೈಯೆತ್ತಿ ಹೊಡೆದ. ಆಗ ನೊಣ ತಪ್ಪಿಸಿಕೊಂಡಿತು. ಏಟು ಅವನ ತಲೆಗೆ ಬಿತ್ತು. ನೊಣ ತಿರುಗಿ ಬಂತು. ಅವನು ತಿರುಗಿ ಹೊಡೆದ. ಪುನಃ ಅವನ ತಲೆಗೆ ಏಟು ಬಿತ್ತು. ಆಗ ಅವನಿಗೆ ಬುದ್ಧಿ ಬಂತು. ಕ್ಷುದ್ರ ಪ್ರಾಣಿಗಳನ್ನು ಗಮನಿಸುವುದರಿಂದ ನಮಗೇ ಹಾನಿ ಎಂದುಕೊಂಡ.