Electroglottography in dysphonics

Register No. 8503

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All India Institute of Speech & Hearing
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Dedicated

to

My Mother

who always inspires me towards higher academic achievements

and

My Father

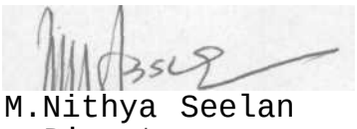
who is a constant source of moral support.

CERTIFICATE

This is to certify that the dissertation entitled

"ELECTROGLOTTOGRAPHY IN DYSPHONICS"

is the bonafide work in part fulfilment for the degree of Master of Science (Speech and Hearing), of the student with Register No.8503.



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CERTIFICATE

This is to certify that this dissertation entitled

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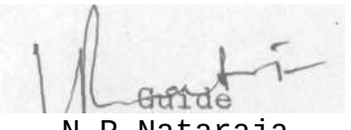
has been prepared under my supervision and guidance.



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DECLARATION

This dissertation is the result of my own study under the guidance of Mr. N.P.Nataraja, Reader and Head of the 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

Register No. 8503

Date:

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To all those

To whom I owe more than what I know.

CONTENTS

INTRODUCTION

"The treatment of patients suffering from- dysphonia depends upon the ability to assess initially the type and degree of voice impairment and also to monitor the patients' progress throughout the treatment" (Kelman, 1981).

Many have suggested various means of analysing voice to note the factors which are responsible for creating an impression a particular "voice" (Perkins, 1971; Michel & Wendhal, 1971, Jayaram, 1975; Hirano, 1981; Rashmi, 1985; Nararaja & Jayaram, 1982).

As suggested by Hanson, Gerratt, & Ward (1983) majority of the phonatory dysfunctions are associated with abnormal vibrations of vocal folds. Hence, analysis of the vibration of vocal folds in terms of different parameter constitutes an important aspect to be considered in the diagnosis and differential diagnosis of the voice disorders.

Several methods of analysing the vocal cord vibrations have been devised. Electroglottography (E.G.G.) is one of them.

E.G.G. is a technique for the indirect examination of vocal folds contact during vibration through measurement of electrical impedence changes. (Haji, Hariguchi, Baer & Gould, 1986)

Several investigators (Wechsler, 1977; Hanson et.al., 1983) have carried out studies using different parameters of E.G.G. on different clinical population.

However, no such studies have been reported regarding Indian clinical population, having different types of voice disorders. Hence, the present study was proposed to study different parameters of glottal wave forms in Indian clinical population, having different types of voice disorders.

Purpose of the Study

The study was designed to study the vocal cord vibrations using E.G.G. in male and female dysphonics, and compare them with normals.

The study was carried out to test the following hypothesis:

1. There will be no significant difference between normals and dysphonics (as a group) for vowels /a/, /i/, and /u/ in terms of

    a) Open Quotient .
    b) Speed Quotient
    c) Speed Index
    d) "S" Ratio
    e) Jitter
    f) Shimmer

2. There will be no significant difference between normals and dysphonics (with vocal nodules) for vowels /a/, /i/ and /u/ in terms of

    a) Open Quotient
    b) Speed Quotient
    c) Speed Index
    d) "S" Ratio
    e) Jitter
    f) Shimmer

3. There will be no significant difference between normals and dysphonics (with vocal cord paralysis) for vowels /a/, /i/ & /u/ in terms of

a) Open Quotient
b) Speed Quotient
c) Speed Index
d) "S" Ratio
e) Jitter
f) Shimmer

4. There will be no significant difference between normals and dysphonics (with glottal chink) for. vowels /a/, /i/ and /u/ in terms of

a) Open Quotient
b) Speed Quotient
c) Speed Index
d) "S" Ratio
e) Jitter
f) Shimmer

5. There will be no significant difference between normals and dysphonics (with functional high pitched voice) for vowels /a/, /i/ and /u/ in terms of

a) Open Quotient
b) Speed Quotient
c) Speed Index
d) "S" Ratio
e) Jitter
f) Shimmer

6. There will be no significant difference between normals and dysphonics (with functional hoarse voice) for vowels /a/, /i/ and /u/ in terms of

a) Open Quotient
b) Speed Quotient
c) Speed Index
d) "S" Ratio
e) Jitter
f) Shimmer

In this study 34 dysphonic subjects (17 male and 17 female) in the age range of 15-50 years were studied. For each subject six parameters of E.G.G. viz., Open Quotient, Speed Quotient, Speed Index, "S" Ratio, Jitter and Shimmer were measured for vowels /a/, /i/ & /u/ using Electroglottograph (Kay Elemetrics) and High Resolution Signal Analyzer (B & K 2033) instruments.

Limitations:

1. Only 34 dysphonic subjects were studied.
2. All types of dysphonics were not studied.
3. Only 5 consecutive cycles have been considered for analysis.
4. Only 6 parameters of E.G.G. have been considered in this study.

Implications:

1. It provides information regarding the vocal cords vibratory patterns in dysphonics.
2. It helps in diagnosis and differential diagnosis of dysphonics.
3. The pre-therapy and post-therapy E.G.G. recordings provides an objective information about the improvement in the vocal cords condition.

Definitions:

The following definitions have been used in the present study.

1. $$\text{Open Quotient (OQ)} = \frac{\text{Open phase}}{\text{Full period of vibration}}$$

2. $$\text{Speed Quotient (SQ)} = \frac{\text{Opening phase}}{\text{Closing phase}}$$

3. $$\text{Speed Index (SI)} = \frac{SQ - 1}{SQ + 1}$$

4. $$\text{"S" Ratio (SR)} = \frac{\text{Area of Open phase}}{\text{Area of Closed phase}}$$

5. Jitter (J) is cycle to cycle variation in period (in sustained phonation) in m.secs.

6. Shimmer (S) is cycle to cycle variation im amplitude (in sustained phonation) in dB (acoustical).

7. E.G.G. = Electroglottograph, same as Electro Laryngograph.

8. Lx wave forms or Laryngoram = The graph obtained by E.G.G.

9. Fo = Fundamental frequency of vocal cords.

REVIEW OF LITERATURE

The process of voice therapy depends upon "the diagnosis or appraisal" of the problem. "The treatment of patients suffering from dysphonia depends upon the ability to assess initially the type and degree of voice impairment and also to monitor the patient's subsequent progress throughout treatment". (Kelmen, 1981)

"Diagnosis is intended to define the parameters of the problem, determine etiology and outline a logical course of action". (Emerick and Hatten, 1974)

Inspite of the fact that there is a great need to understand the voice, its production, factors affecting it, basic issues like definitions of voice, normalcy in voice have not been resolved. They are vague and ambiguous.

Michel and Wendhal (1971) give a good account of problems in defining voice. Many have shown their concern regarding the need for defining and describing normal voice which forms the basis for defining or describing variations from normal i.e., supra or subnormal voice (Perkins, 1971; Laver and Hudson, 1982; Michel and Wendhal, 1971).

Many have suggested various means of analysing voice to note the factors which are responsible for creating an impression of a particular "voice". (Laver and Hunson, 1981; Perkins, 1971; Michel and Wendhal, 1971; Jayaram, 1975; Nataraja and Jayaram, 1979; Rashmi, 1984; Hirano, 1981).

According to Hirano (1981), with regard to phonation, various methods have been proposed and used by many-clinicians and researchers all over the world. Unfortunately, none of these methods appear to be standardized on an international basis. For some of these techniques a majority of investigators seems to be in agreement in terms of the significance of these tests and the interpretation of the data thereby obtained.

Hirano (1981) while hoping for standardization of clinical examination of voice suggests several methods like, E.M.G. of layngeal muscles, acoustic analysis of voice signal, aerodynamic tests, study of vocal fold vibrations, psychoacoustic evaluation of voice to examine phonatory ability, which would reflect different aspects of respiratory, phonatory and resonatory systems. These methods have been used by different investigators sometimes in combination, and sometimes only one or two of them to evaluate voice. However, as Hirano (1981) has pointed out there is no agreement regarding the findings and terms used. This may be because of the fact that some of these tests require sophisticated equipment, difference in methodology used or due to other reasons.

As suggested by Hanson, Gerratt and Ward (1983) majority of the phonatory dysfunctions are associated with

abnormal vibrations of the vocal cords. Hence, analysis of the vibrations of vocal fold in terms of different parameters constitute an important aspect to be considered in the diagnosis and differential diagnosis of voice disorders.

Several direct and indirect ways of analysing vocal cord vibrations have been devised. Some of them are:-

1. Electroglottography (E.S,G.)
2. Stroboscopy
3. Ultra high speed photography
4. Inverse filtering method
5. Photoglottography (P.G.G.)
6. Ultrasound/Echoglottography

"Electroglottography (E.G.G.) is a technique for the indirect examination of vocal fold contact during vibration through measurement of electrical impedence changes (Fourcin, 1974). The E.G.G. does not interfere with phonation (Fourcin, 1981; Kelman, 1981; Pederson, 1977). Whatever details it represents, E.G.G. certainly reflects the vibratory cycle of the vocal folds with fairly high fidelity. Irregularities of E.G.G. thus correspond to irregularities is the vibratory pattern of the vocal cords;. (Haji, Horiguchi, Baer and Gould, 1986)

Stroboscopy permits the clinician to view the vibrations of the vocal cords. However, providing the description of the condition and movements of the vocal cords depends on the ability of the clinician. Further, the use of stroboscopy many interfere with normal phonation and thus it may not provide information regarding the abnormalities of the vocal cords. (Hirano, 1981)

Though ultra high speed photography technique provides an objective information about vocal cords movements its clinical application is limited-

"as it is an invassive technique, it requires a greater cooperation from the patients" (Holmer, Kitzing, Lindstrom, 1973).

"this method is limited to the study of vibratory patterns of vocal folds in sustained phonation of vowels and nonspeech vocalization". (Harden, 1975)

"this technique is expensive and also consumes a lot of time and space". (Hanson et.al., 1983)

As suggested by Hanson et.al., (1983), the clinical application of inverse filtering method is reduced, as it becomes more difficult to choose the proper inverse filter parameters for studying dysphonic patients.

According to Hanson et.al., (1983), "Ultra sound or Echoglottography is not frequently used clinically, as it requires a special ultrasound transducer".

"Photoglottography method is better than stroboscopy as it provides graphical display and better than high speed photography as it is economical". (Hanson et.al., 1983)

Several investigators have used P.G.G. to study the vibratory pattern of the vocal folds in normals and dysphonics (Harden, 1975; Kitzing and Sonesson, 1974; Kitzing and Lofquist, 1979; Kitzing, 1982). However several investigators have pointed out limitations of P.G.G. technique. They are:-

i) P.G.G. yields sufficient information about only certain points of the vibratory cycle. (Dejonckere & Lebacq, 1985)

ii) In P.G.G. the point at which the glottal opening starts can often be difficult to locate. (Kitzing & Lofquist, 1979)

iii) According to Hanson et.al., (1983) P.G.G. wave forms may not represent accurately the glottal area of patients who adduct the ventricular folds during phonation and with patients who have significant assymetry of vocal cord closure P.G.G. signal may not reflect the glottal opening.

Several investigators have suggested, E.G.G. as an economical, non-invessive technique, which allows the patient for free conversation with minimal discomfort while testing. (Haji et.al. 1986; Fourcin, 1979)

Some of the other observations reported about E.G.G. are-

i) According to Dejonckere & Lebacq (1985), E.G.G. reflects the glottal condition more during the closed phase, as against P.G.G. which reflects more about the open phase of glottal cycle. As majority of laryngeal pathologies manifests abnormalities more during the closed phase, E.G.G. has been considered as a better technique for studying vocal fold movements of dysphonics .

ii) The presence or absence of glottal vibration can be readily determined, using E.G.G. technique. (Dejonckere & Lebacq, 1985)

iii) Dejonckere & Lebacq (1985) have suggested that, "the fundamental period of the glottal vibration is easily determined by using E.G.G. as the beginning of each closed phase is marked by a sharp rise in graphic display of Lx wave forms".

From this review of literature, the E.G.G. seems to be most appropriate method of studying the vibration of vocal cords.

Electroglottography (E.C.G.)

. This technique makes use of motion induced variation in the electrical impedence between two electrodes placed on the skin covering the thyroid laminae. A weak, high frequency signal, (0.5-10MHz) is applied to one electrode. The other electrode picks up the electrical current passing through the larynx. The transverse electrical impedence varies with the opening and closing of the glottis, and results in a variation of the electrical current in phase with the vibratory phase of the vocal folds.

This technique was first developed by Fabre (1957). Improvements in the apparatus and application of the technique to clinical investigations have been extensively performed by several investigators. (Fourcin and Abberton, 1971; Fourcin, 1981)

The detailed relation between the impedence curve of the electroglottogram and the underlying physiology of the vocal folds has been well documented by several authors (Pederson, 1977; Childres, Smith & Moore, 1984; Gilbert, Lecluse, Brocaer and Verschure, 1975).

Fourcin (1981) made simultaneous recordings of EGG's and airflow velocity curves for different modes of phonation and described the method to interprete the Lx wave forms. He also emphasised that the fundamental period of the vocal fold vibrations could be determined quite accurately using EGG.

Moore and Thampson (1965) reported that glottal wave forms produced by normal phonation consists of two conditions.

1) All the three phases of the vibratory cycle viz., opening phase, closing phase and closed phase.

2) The motion of the two cords tend to be relatively synchronous and equal in amplitude.

In order to study glottal wave forms various quotients and indices have been used based on the measurements of duration of different phases of the vibratory cycle. They are-

1. Open Quotient (O.Q.)

$$OQ = \frac{\text{Duration of the open phase}}{\text{Duration of full cycle}}$$

2. Speed Quotient (S.Q.)

$$SQ = \frac{\text{Duration of the opening phase}}{\text{Duration of the closing phase}}$$

3. Speed Indax (S.I.)

According to Hirano (1980), ". . . . Speed Index is an another useful measure of Lx wave form derived from Speed Quotient.

$$\text{Speed Index} - \frac{\text{Speed Quotient} - 1}{\text{Speed Quotient} + 1}$$

The SI values may vary from -1 or to +1.00. It is relative ratio, where positive values indicate more opening time and the negative values indicate more closing time of the vibratory cycle and zero indicate the equality of timing". (Hirano, 1981)

The Speed Index seems to have advantages over S.Q., according Hirano (1981). They are -

1) SI ranges from -1 to +1, whereas SQ ranges over larger values.

2) When two wave forms have the same triangular shape and one is reverse of the other (with respect to time), the S.I. takes equal absolute values with reverse signs. On the otherhand, the S.Q. takes two different values whose product is one.

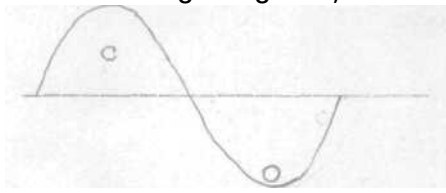
3) One can visualize the wave forms from S.I. values more easily than from S.Q. values.

4) S.I. has a simpler relationship with spectral characteristics of the wave form than S.Q.

4. "s" Quotient or -"S" Ratio (S.R)

Dejonckere and Lebacq (1985) in an attempt to quantify the shape of the glottal wave forms have introduced the 'S' quotient.

As shown in the following figure, S.R: values are

contact phase  open phase

calculated by dividing the area of the contact phase by the area of the open phase i.e.,

$$SR = \frac{\text{Area of the contact phase}}{\text{Area of the open phase}}$$

Dejonckere and Lebacq (1985) have pointed out that "S" quotient can be used as an indicator of the behaviour of the vocal cords in different pathological conditions. Except for this report there are no other reports of studies using this parameters to differentiate glottal wave forms of normals and dysphonics.

The bulk of published literature in relation with EGG deals with studying changes in EGG parameters in normal physiological process. (Hirano et.al., 1980; Hollien, Girard and Coleman, 1977; Kelman, 1981; Kitzing, 1982; Kitzing, Carlborg and Lofqvist, 1982; Perkins, 1971)

Sridhara (1986) studied Lx wave forms of young normal males and females during their production of vowels /a/, /i/ and /u/ at comfortable level. He reported values of different parameters of Lx wave forms as follows:

1- Open Quotient:

Mean values of OQ

	/a/	/i/	/u/
Male	0.69	0.71	0.72
Female	0.74	0.72	0.71

2. Speed Quotient:

Mean values of SQ

	/a/	/i/	/u/
Male	1.98	1.74	1.79
Female	2.25	2.28	2.30

3. Speed Index:

Mean values of SI

	/a/	/i/	/u/
Male	0.378	0.247	0.266
Female	0.377	0.361	0.362

4. "S" Ratio:

Mean values of SR

	/a/	/i/	/u/
Male	1.13	1.12	1.16
Female	1.13	1.10	1.09

5. Jitter (J):

Mean values of J (in msecs)

	/a/	/i/	/ú/
Male	0.065	0.11	0.067
Female	0.058	0.03	0.048

6. Shimmer (S):

Mean values of S (in dB)

	/a/	/i/	/u/
Male	0.033	0.066	0.15
Female	0.7	0.37	0.44

Some of the investigators have indicated the possibility of using E.G.G. in clinical assessment and treatment of voice disorders.

Dejonckere and Lebacq (1985) state that abnormal E.G.G. findings can be considered in five different ways.

a) Pitch characteristics (too high or low)

b) Vibration irregularities (jitter & shimmer) demonstrated by Fo histograms. (Kitzing, 1979; Fourcin, 1981)

c) Special features of the signal in the case of dyplophonics (Dejonckere & Lebacq, 1983).

d) Qualitative description of the modified wave form (Wechsler, 1977; Fourcin, 1981) and

e) Spectral analysis of the wave forms (Kelman, 1981).

Dejonckere and Lebacq (1985) in an attempt to quantify the shape of the E.G.G. signal, studied 25 normal females and 25 females with vocal nodules. They measured the values of "S" quotient for vowel /a/ phonated at 70dB SPL. They concluded that "S" quotient provides information combining the relative surface and duration of the vocal fold contact during one vibratory cycle. They reported the mean "S" quotient of 0.66, for normal females and 0.4 for females with vocal nodules. They attribute this reduction in the value of "S" quotient as an etiological factor for vocal nodules.

Childers et.al., (1984) reported, unusual change in the rising slope of the Lx wave forms in individuals with vocal nodules and extensive laryngeal cancer. They also observed double periodicity of Lx wave forms in a patient with unilateral paralysis of vocal cords. However, they also reported that EGG wave forms of certain individuals with vocal coard paralysis appeared normal and Lx wave forms of some normals appeared abnormal.

According to Fourcin (1981) ". . . . for rigorous breathy voice, the contact phase of the Lx wave form is distinguished by the presence of small, well defined, positive closure peak. In the case of creaky voice the Lx wave forms typically show pairs of vocal fold contact-separation sequence in which a small peak precedes a larger peak, both occuring with considerable temporal irregularities. The smaller peak has a relatively slower onset than the larger peak and the width of the larger peak indicates a very long closure duration".

Fourcin (1981) has reported that using o histograms methods, normals and individuals with laryngitis can be differentiated.

Fourcin and Abberton (1972) also reported that Lx wave forms in cases of different laryngeal pathologies like vocal polyp, unilateral vocal cord paralysis, vocal nodules varies from that of normal Lx wave forms. But they also observed that Lx wave forms are not necessarily impaired uniformly in laryngeal pathologies and one part of the utterance may be normal while the others are very disturbed.

Hanson et.al., (1983) reported E.G.G. findings with individuals having normal larynges, with distinct phonatory abnormalities like spastic dysphonia (adductor type), Parkinsonism and Arsenic poisoning.

They reported that the Lx wave forms of individuals with spastic dysphonia showed a relatively longer closure period, resulting in decreased open quotient. The SQ values are more than normal values, indicating the abnormally short closing time. They attribute this finding to the increased tension of vocal cords as compared to normals.

Lx wave forms of individual with parkinsonism indicated open phase longer than normals, incomplete glottal closure, which may explain the breathiness of their voice. They also report a large values of jitter and shimmer to be present.

Similarly Lx wave forms of individual who suffered acute arsenic poisoning indicated large values of jitter and shimmer, and very short or incomplete periods of glottal opening.

They further state that, "Glottographic techniques appear to offer some insight into more subtle vibratory and tension abnormalities that are associated with pathological phonation in otherwise normal appearing larynx. For example, glottography in our experience, relatively documents the presence of incomplete vocal cord closure. In some cases, this may be visible, laryngoscopically, but often is not detected without the analysis of ultra-high speed films. Similarly valuable diagnostic information, such as indications of abnormally increased vocal fold tension or cycle to cycle variability in the vibration of vocal cords, may be identified and measured from the Lx wave forms.

Wechsler (1977) also studied the Lx wave forms with individuals having different laryngeal pathologies like vocal nodules, unilateral paralysis, bowing of vocal cords, laryngitis, before, during and after the administration of voice therapy and/or surgical treatment.

They observed in majority of subjects the Lx wave forms shifting towards normalcy in its shape and Fx distributions after the remedial procedure. They also reported that the improvement in Lx wave forms was also correlated with the perceptual improvement in voice and also with improvement in the condition of the vocal folds as observed through laryngoscopic examination.

Jitter and Shimmer:

Variations in fundamental frequency and amplitude of successive glottal cycles are referred to as "Jitter" and "Shimmer" respectively. (Heiburgur and Horii, 1982)

Several investigators have reported the presence of small variations in fundamental frequency and/or amplitude of glottal vibrations in normal voice. (Horii, 1979, 1982, 1985; Hollien et.al., 1977, Sridhar, 1986)

Presence of excessive jitter and/or shimmer in the voice signal, gives an abnormal voice quality which are often identified as hoarse or harsh voice. (Michel & Wendhal, 1971; Iwata, 1972; Deal and Emanuel, 1978; Koike, 1969, Haji et.al., 1986)

According to Heiberger and Horii (1982), "the work done by Liberman and his colleagues (Liberman, 1961, 1963; Liberman and Michel, 1962; Smith and Liberman, 1969) probably represents the pioneering studies of laryngeal pathology detection by the analysis of jitter and shimmer values".

Moore and Thompson (1965) reported the jitter values of 0.3 msecs (4.9%) for severely hoarse voice and 0.06 msecs (1.4%) for a moderately hoarse voice.

Zemlin (1981) reported jitter values ranging from 0.2 to 0.9 msecs for a group of subjects with multiplesclerosis.

Deal and Emanuel (1978) suggested that, the cycle -to cycle variation in amplitude may provide a better index of perceived roughness of voice than cycle to cycle variations in period.

Sonesson (1967) reported that patients with laryngeal hemiparalysis, showed a large amount of shimmer values but normal jitter values.

Kitajima and Gould (1976) reported the shimmer values in subjects with vocal polyp to vary from 0.08 to 3.23dB.

These studies indicate the importance of shimmer values for diagnosis of the voice disorders along with the other measurements.

Kane and Wellen (1985) reported a very high positive correlation between jitter and shimmer values and rating of roughness in ten children with vocal nodules. They reported jitter values in these children to vary from 0.0023 to 0.0472 msecs, and shimmer values,of 0.0151 to 0.0911dB.

Majority of the studies on jitter and shimmer were done by analysing voice signal. Recently Haji et.al., (1986) suggested, that EGG can be considered as a more suitable technique than voice signal methods for perturbation analysis, as EGG wave forms are less complex than voice signal and is unaffected by the acoustic resonance of vocal tract".

They further reported that the frequency and amplitude perturbation of EGG, especially the amplitude perturbation can be a useful clinical adjunct for evaluating irregularities of vocal fold vibration in dysphonic subjects.

Thus, the review of literature indicates that very few studies of E.G.G. in dysphonic subjects are reported. None of these studies report the values of all the E.G.G. parameters in different dysphonic subjects.

Further, no report of E.G.G. studies of dysphonics in Indian population were reported.

Hence, the present study was planned to obtain the values of E.G.G. parameters in different dysphonic patients and compare those values with normal values.

MEIHODOLOGY

The present study employed the technique of E.G.G. to study the vibratory pattern of the vocal cords in dysphonic subjects.

The aim of the present study was to investigate whether the normals and dysphonic subjects can be differentiated by measuring different parameters of E.G.G.

Subjects:

The individuals who reported with complaints of voice problem to All India Institute of Speech and Hearing, Mysore were examined by the qualified Speech Pathologists, Audiologists and E.N.T. Specialists. Subjects who were diagnosed as having voice problems were considered as the subjects for the present study.

The details of the subjects in terms of age, sex, number and different pathological conditions are shown in Table-1.

Pathological condition of vocal cords	MALE Age range	MALE Number of subjects	FEMALE Age range	FEMALE Number of subjects
1. Congestion of vocal folds	50 yrs	1	29 yrs	1
2. Chronic laryngitis	--		35 yrs	1
3. Glottal chink	21-28 yrs	2	15-40 yrs	5
4. Vocal nodules -unilateral	15-51 yrs	7	16-21 yrs	3
5. Vocal cord paralysis -unilateral -bilateral	22-45 yrs	3	16-40 yrs	3
6. Unilateral vocal polyp	40 yrs	1	-	-
7. Spastic dysphonia adductor	32 yrs	1	32 yrs	1
8. Hoarseness without observable pathology of vocal folds	- -		18-37 yrs	3
9. High pitch voice with normal movements & appearance of vocal cords.	17-25 yrs	2	-	-
	Nl=	17	N2=	17

Table-I: Distribution of subjects, Age and problem wise.

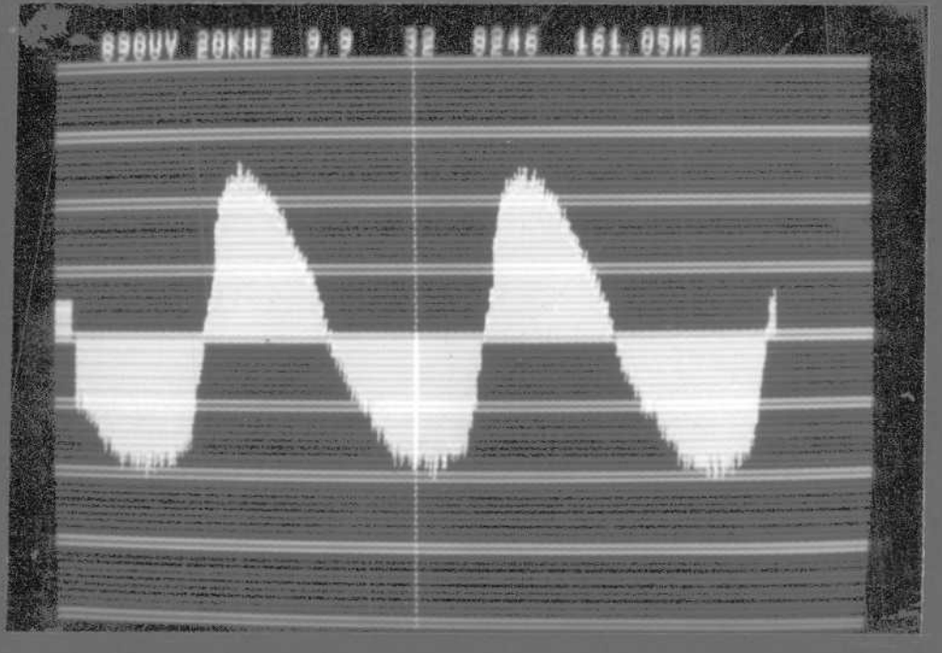
The Experimental Set up:

The following instruments were used for the study:

1. Electro Laryngograph (Kay Elemertrics Corporation)
2. High Resolution Signal Analyzer (HRSA) B & K type 2033.

The instruments were arranged as shown in the block diagram. (Fig. 1) and Photograph-1.

Photograph-1:High Resolution Signal Analyzer with Laryngograph.



Photograph-2:Lx wave form of normal male.

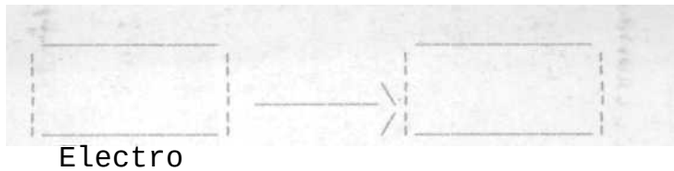


Fig. 1: Block diagram of the Instruments.

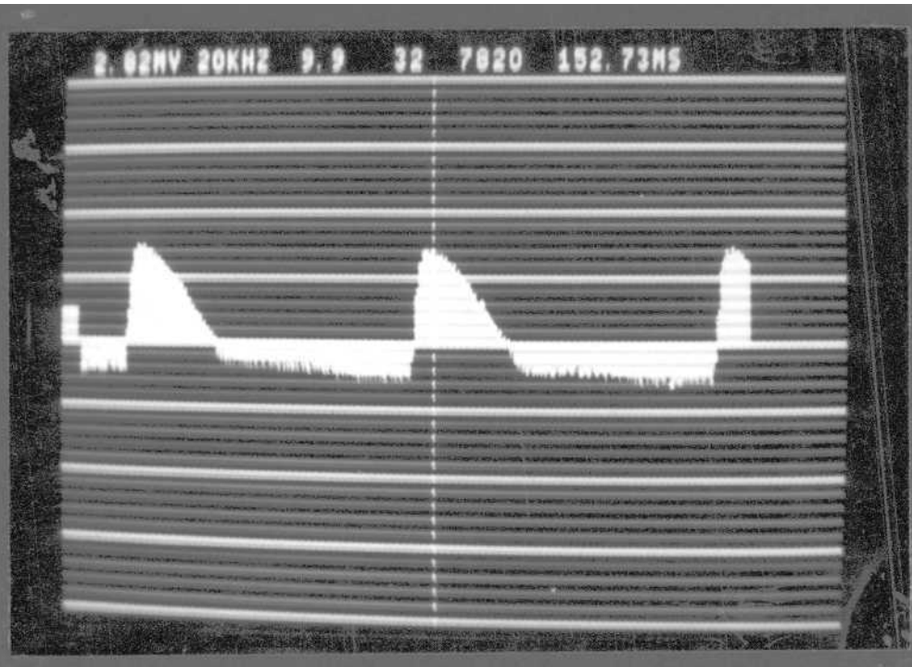
The signal from the laryngograph was fed to the HRSA to obtain the display of glottal wave forms which, were used to measure the different parameters of glottal wave forms. Fig.2, shows the glottal wave form obtained from different . dysphonic subjects.

The HRSA displays the glottal wave form signals in terms of time (in milliseconds) on X-axis and amplitude of the signal (in millivolts) on Y-axis. The time at any given point can be measured by moving the cursor horizontally.

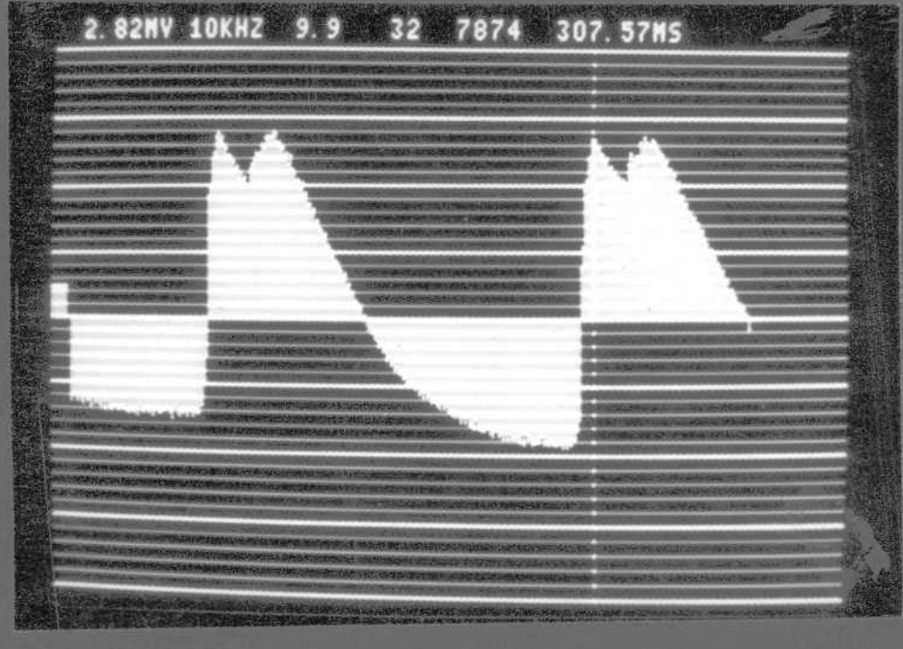
All the instruments were calibrated prior to the experiment and then periodically as per the instructions given in the manual of the instruments.

Additional care was taken to avoid 50Hz hum in the instrument by using grounding.

The subjects were seated comfortably in front of the instrument. The electrodes of the laryngograph were placed on the thyroid alae. The position of the electrodes were adjusted to obtain clear Lx wave forms on HRSA screen. Then each subject was asked to phonate vowel /a/ as long as possible at a comfortable pitch and loudness.



Photograph-3:Lx wave form of a male subject with unilateral vocal cord paralysis.



Photograph-4:Lx wave form of a male subject with vocal nodules.

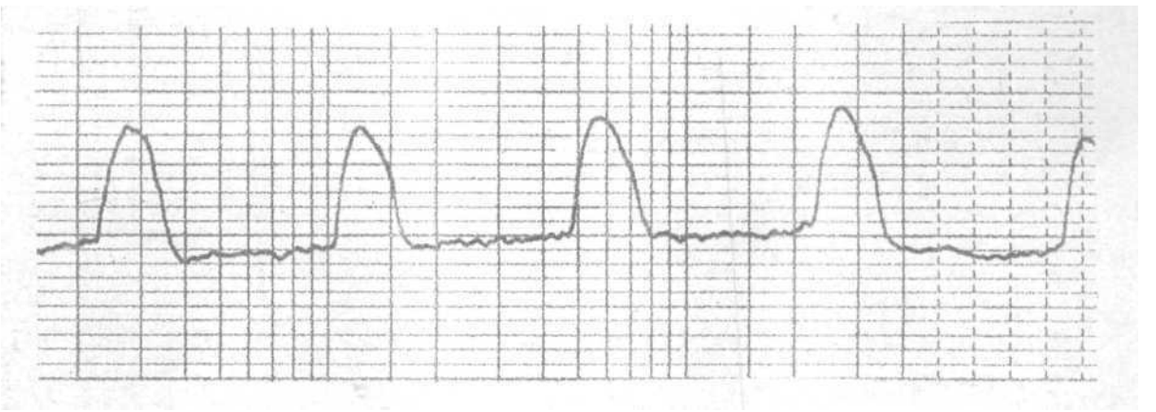


Figure 2.(a): Lx wave form in female subject with Unilateral vocal cord paralysis.

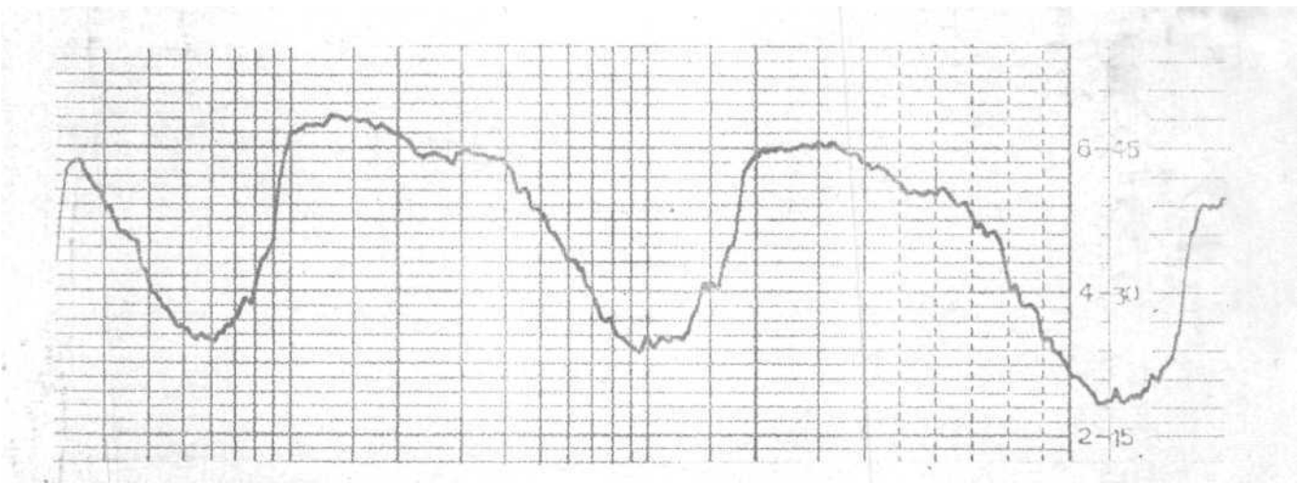


Figure 2(b): Lx wave form in male subject with Bilateral vocal cord paralysis.

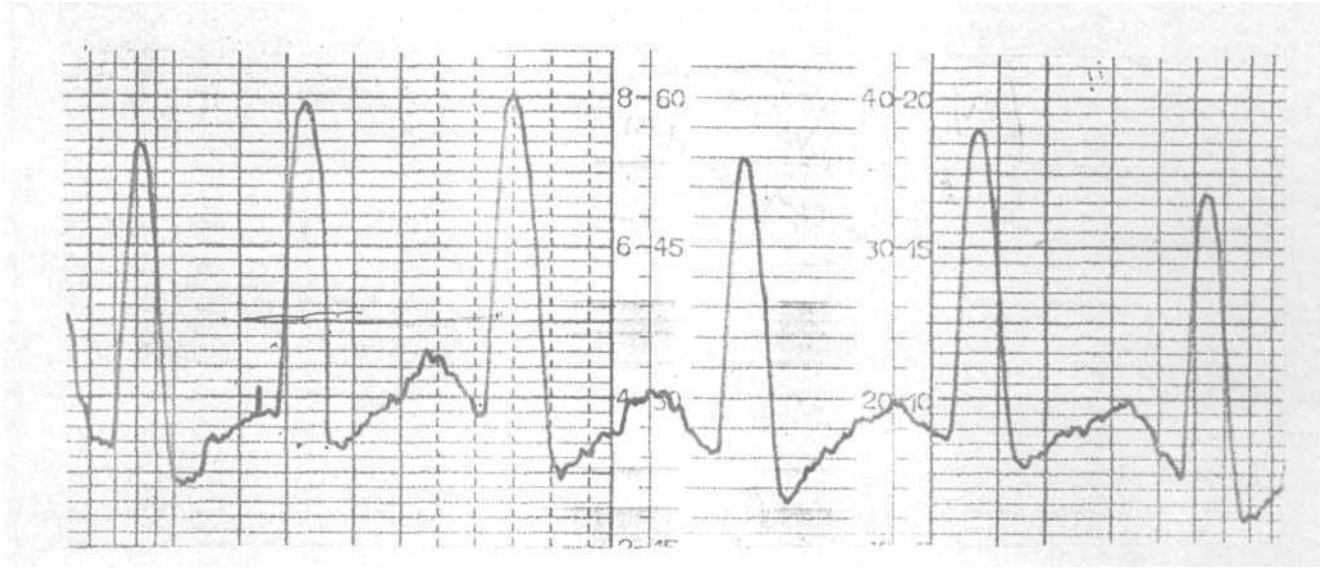


Figure 2(c): Lx wave form in female subject with congestion of vocal folds.

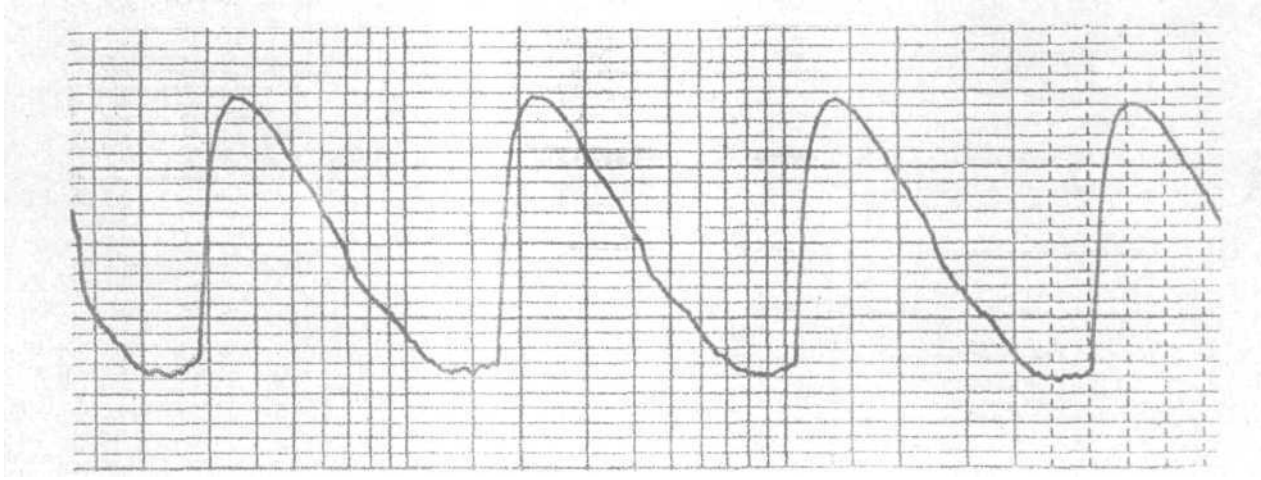


Figure 2(d): Lx wave form in female subject with glottal chink.

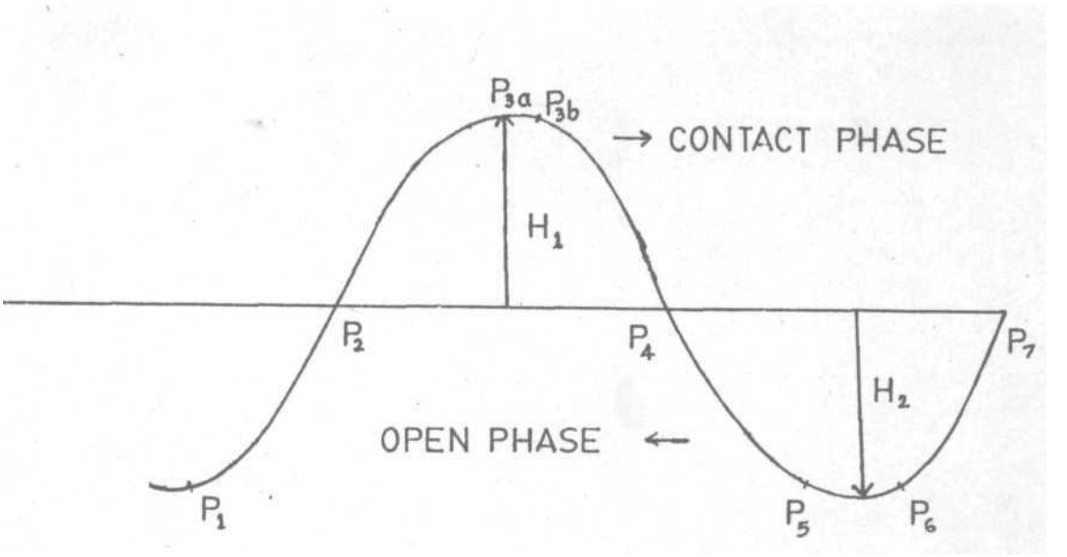


Fig.3: Showing different phases of vibratory cycle in m.sec.

P_{3a} -P_1 = Closing period.

P_{3b}-P_{3a} = Closing period (in normals P_{3a} ~ P_{3b})

P_5-P_{3b} = Opening period

P_6-P_5 = Opening period.

P_7-P_2 = Period of the vibratory cycle.

P_4 -P_2 = B_1 = Base of contact phase.

P_7-P_4 = B_2 = Base of open phase.

H_1 = Height of contact phase.

H_2 = Height of open phase.

Once the stable Lx wave forms were seen on HRSA screen, five successive cycles of glottal wave forms were selected for further analysis. Each cycle was analysed at different points as shown in Fig.(2) to obtain the duration of different phases of vocal fold vibrations.

After measuring the duration between different points on each cycle of glottogram, different parameters of Lx wave forms were calculated as follows:

$$\text{Open Quotient (OQ)} = \frac{\text{Open period}}{\text{Vibratory period}} = \frac{\text{P7-P4}}{\text{P7-P2}}$$

$$\text{Speed Quotient (SQ)} = \frac{\text{Opening period}}{\text{Closing period}} = \frac{\text{P5-P3b}}{\text{P3a-Pl}}$$

$$\text{Speed Index (SI)} = \frac{\text{SQ-1}}{\text{SQ+1}}$$

$$\text{Speech Ratio (SR)} = \frac{1/2 \times B1 \times HI}{1/2 \times B2 \times H2}$$

where Bl= base of the contact phase (i.e., P4-P2), converted into millimeters.

B2= base of open phase (i.e., P7-P4), converted into milimeters.

H1= height of contact phase, converted into millimeters.

H2= height of open phase, converted into millimeters.

$$\text{Jitter (J)} = \frac{(t1-t2)+(t2-t3)+(t3-t4)+(t4-t5)}{4} \text{(msecs)}$$

where tl, t2, t3, t4, t5 represents of periods of 5 consecutive glottal cycles.

$$\text{Shimmer (S)} = \frac{(a1-a2)+(a2-a3)+(a3-a4)+(a4-a5)}{4} \text{(dB)}$$

where al, a2, a3, a4, a5 represents amplitude of 5 consecutive Lx cycles.

Thus, (a) Fundamental Frequency
(b) Open Quotient
(c) Speed Quotient
(d) Speed Index
(e) Speech Ratio
(f) Jitter
(g) Shimmer

values were obtained for vowel /a/, for each subject. Further, using the same procedure and set up of instruments, all the measurements were obtained for the vowels /i/ and /u/ also. Thus, for all the subjects' all six parameters of E.G.G. were measured for all the three vowels.

Appropriate statistical procedures were administered to compare the different parameters of Lx wave forms obtained from dysphonic group to normals.

RESULTS AND DISCUSSION

The purpose of this study was to note the differences between the normals and dysphonic subjects (as a group) and also normals and subjects with different pathological condition of vocal cords in terms of different E.G.G. parameters.

The different E.G.G. parameters measured in this study were:

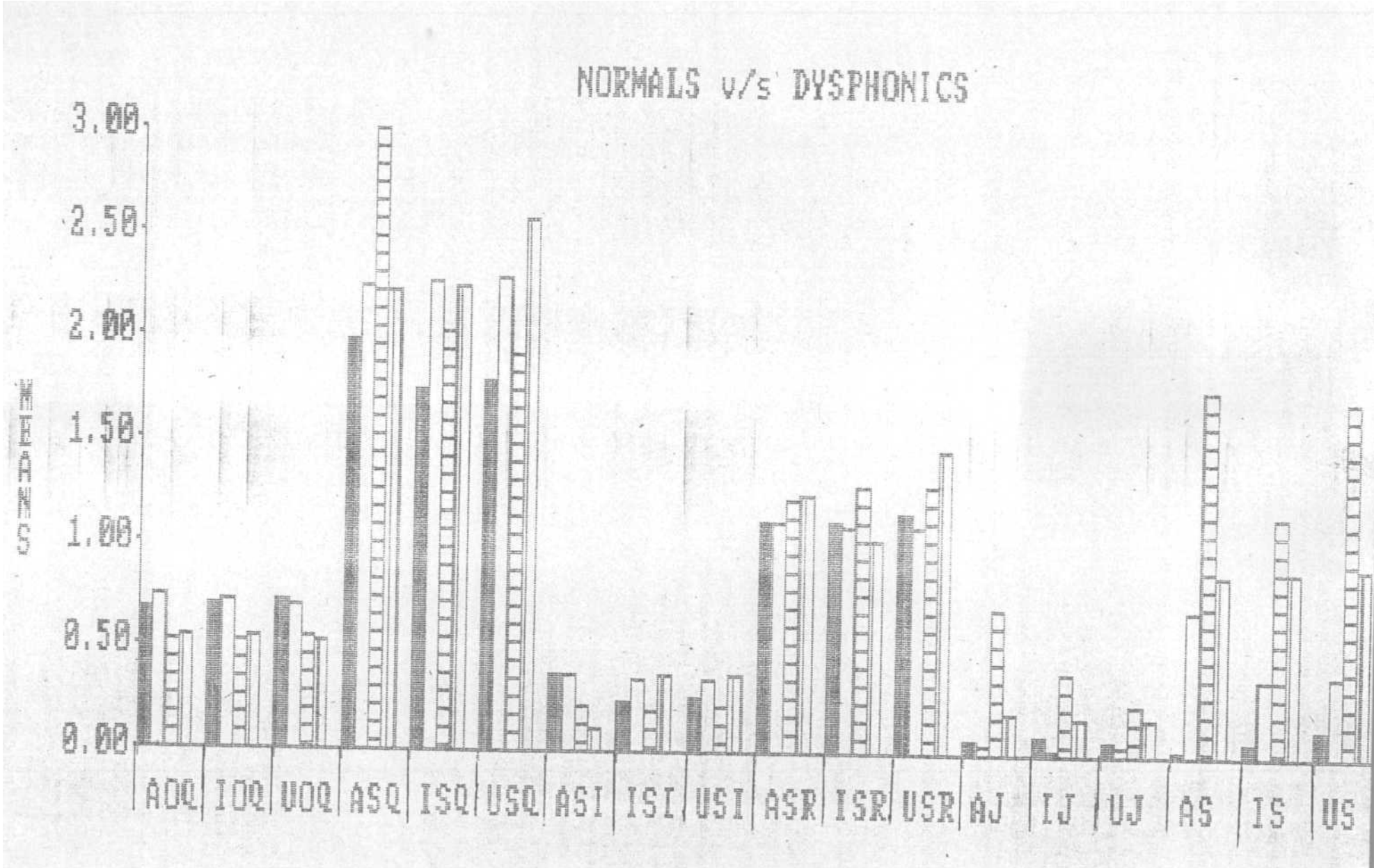
1. Open Quotient (OQ)
2. Speed Quotient (SQ)
3. Speed Index (SI)
4. "S" Ratio (SR)
5. Jitter (J)
6. Shimmer (S)

All these 6 parameters were measured for vowel /a/, /i/ and /u/.

Further fundamental frequency of these subjects were measured for all the three vowels and compared with normal values.

Comparision of dysphonic group with normal group:

From table-1, it was observed that Fo of female dysphonic subjects were less than normal values, but Fo of male dysphonic subjects were higher than normal values for all the three vowels.



Graph 1 EGG PARAMETERS

MALE-N FEMALE-N MALE-D FEMALE-D

	MEANS		
Vowels	/a/	/i/	/u/
Groups			
Normal males (NM)	116.3	120	117
Dysphonic males (DM)	154.5	151.7	172.8
Normal females (NF)	231.4	243	248
Dysphonic females (DF)	224.2	236.4	227.47

Table-1: Mean of fundamental frequency (in Hz) in normal and dysphonic males and females.

This difference in dysphonic subjects in comparision to normals may be due to the inclusion of wide variety of dysphonics in this study.

From table-2 and graph-1, it was observed that open quotient values in the dysphonics were less than the values seen in normals, both in males and females. Further, dysphonic group has shown greater range and variability than normals.

Groups	Vowels	Range	Mean	S.D.	Significance of difference between NM & DM / NF & DF		
					Vowels		
NM	a	0.23	0.69	0.097	a	+	+
	i	0.23	0.72	0.078	i	+	+
	u	0.2	0.72	0.065	u	+	+
DM	a	0.34	0.53	0.088			
	i	0.3	0.54	0.076			
	u	0.33	0.56	0.087			
NF	a	0.19	0.74	0.06	(Significance at 0.05) (level)		
	i	0.15	0.72	0.043			
	u	0.13	0.72	0.045			
DF	a	0.44	0.55	0.12			
	i	0.18	0.55	0.09			
	u	0.38	0.54	0.96			

Table-2: Range, Mean & S.D. of OQ values in normals & dysphonics and Significance of difference between them.

The statistical analysis using Mann Whitney "U" test has shown that there was a significant difference between the dysphonic and normal males and females.

Thus, the hypothesis l(a) stating that, "there will be no significant difference between normals and dysphonics (as a group) for vowels /a/, /i/ and /u/ in terms of OQ" was rejected with respect to both males and female subjects.

This reduction of OQ values in both males and females dysphonic subjects suggests that the vocal cords remained for lesser than normal duration in open phase (as described by Dejonckere and Lebacq, 1985) of each vibratory cycle.

Table-3 and graph-1, indicates the mean speed quotient values to be greater than normal values with male dysphonic subjects for all the three vowels. But the mean S.Q. values of the female dysphonic patients were less than the normal values for vowels /a/ and /i/.

Further, the dysphonic group has shown greater range and variability than normal groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference between NM & DM / NF & DF Vowels
MM	a	3.49	1.98	0.72	a - -
	i	1.91	1.74	0.55	i - -
	u	2.22	1.79	0.58	u - -
DM	a	13.36	3.00	3.12	
	i	5.37	2.04	1.49	
	u	4.47	1.90	1.27	
NF	a	0.89	2.25	0.37	(Significance at 0.05) (level)
	i	1.19	2.28	0.52	
	u	1.18	2.29	0.40	
DF	a	3.71	2.23	1.09	
	i	3.07	2.24	0.98	
	u	4.08	2.57	1.14	

Table-3: Range, Mean, S.D. of SQ values in normal and dysphonics & significance difference between them

The statistical analysis indicated that the difference in the mean "SQ" values between normals and dysphonic subjects were not significant with respect to both male and female groups.

Thus, the hypothesis l(b) stating that, "there will be no significant difference between normal and dysphonics for vowels /a/,/i/and /u/ in terms of SQ was accepted with respect to both male and female groups.

Form table-4 and graph-1, it was observed that the mean speed index values of male dysphonic subjects were less than the normal values for all the three vowels. But the mean S.I. values of the female dysphonic group were more than normal values for vowel /i/ and /u/.

It was further observed that the dysphonic groups showed a greater range and variability than normal groups.

Groups	Vowels	Range	Mean	S.D.	Significance of differance NM Vs DM Vowels	NF Vs DF
NM	a	0.46	0.39	0.34	a	- -
	i	0.45	0.25	0.13	i	- -
	u	0.41	0.27	0.11	u	- -
DM	a	1.27	0.23	0.34		
	i	1.24	0.21	0.33		
	u	0.81	0.23	0.27		
NF	a	0.50	0.38	0.07		
	i	0.29	0.36	0.09	(Significance at 0.05)	
	u	0.30	0.36	0.09	(level)	
DF	a	1.46	0.13	0.11		
	i	1.80	0.37	0.26		
	u	1.10	0.38	0.30		

Table-4: Range, Mean, S.D. of SI values in normal and dysphonics & significance of difference between them.

The statistical anlaysis indicated no significant difference in terms of S.I. values for vowels /a/, /i/ and /u/ between normal and dysphonics with respect to both males and females groups.

Thus, the hypothesis i(c) stating that, "there will be no significant difference between normals and dysphonics (as a group) in terms of S.I. for vowel /a/, /i/, /u/" was accepted with respect to both male and female subjects.

From table-5 and graph-1, it was observed that both male and female dysphonic subjects showed greater than normal mean "S" Ratio for all the three vowels.

The dysphonic subjects also indicated greater range and variabilities than normal subjects.

Groups	Vowels	Range	Mean	S.D.	Significance of difference NM Vs DM Vowels	NF Vs DF
NM	a	2.18	1.13	0.18	a	- -
	i	2.06	1.12	0.13	i	- -
	u	2.46	1.16	0.12	u	- -
DM	a	2.57	1.23	0.43		
	u	4.72	1.29	0.93		
	i	2.40	1.28	0.69		
NF	a	2.25	1.13	0.13		
	i	2.12	1.10	0.05	(Significance at 0.05)	
	u	2.04	1.09	0.07	(level)	
DF	a	3.40	1.24	0.56		
	i	3.54	1.14	0.75		
	u	2.35	1.46	0.56		

Table-5: Mean, Range, S.D. of SR values in normal and dysphonics & Significance of difference between them.

Statistical analysis showed that the difference in terms of "S" Ratio for vowels /a/, /i/, /u/ between normal and dysphonic subjects were not significant.

Thus, the hypothesis 1 (d) stating that, "there will be no significant difference between normals and dysphonics (as a group) for vowels /a/, /i/, /u/ in terms of "S" Ratio was accepted with respect to both male and female subjects.

From table-6 and graph-1, it was observed that both male and female dysphonic subjects showed greater than normal mean jitter values for all the three vowels.

The dysphonic subjects also showed greater range and variability than normal subjects.

Groups	Vowels	Range	Mean	S.D.	Significance of differance NM Vs DM Vowels	NF Vs DF
NM	a	0.16	0.065	0.04	a +	+
	i	0.56	0.11	0.06	i +	+
	u	0.11	0.07	0.04	u +	+
DM	a	3.50	0.70	0.94		
	i	3.91	0.41	0.92		
	u	0.75	0.25	0.24		
NF	a	0.10	0.058	0.04		
	i	0.06	0.03	0.021	(Significance at 0.05)	
	u	0.06	0.05	0.02	(level)	
DF	a	0.56	0.20	0.20		
	i	1.05	0.19	0.21		
	u	0.72	0.19	0.19		

Table-6: Mean, Range, S.D. of jitter values in normals and dysphonics & significance of difference between them.

Statistical analysis showed that the difference in the mean jitter values for vowel /a/, /i/, /u/ between dysphonics and normals were significant with respect to both male and female subjects.

Thus the hypothesis l(e) stating that, "there will be no significant difference between normals and dysphonics (as a group) in terms of jitter for vowel /a/, /i/, /u/" was rejected with respect to both male and female groups.

Table-7 and graph-1, indicates the mean shimmer values of dysphonics (both males and females) were greater than normal values.

Further it was observed that the dysphonics also showed a greater variability and range of shimmer values than the normals.

Groups	Vowels	Range	Mean	S.D.	Significance of difference NM VS DM / NF Vs DF Vowels	
NM	a	0.40	0.03	0.12	a +	+
	i	0.80	0.07	0.23	i +	+
	u	0.80	0.15	0.26	u +	+
DM	a	8.40	1.78	2.21		
	i	2.80	1.17	0.81		
	u	4.80	1.74	1.67		
NF	a	2.80	0.70	0.82		
	i	2.00	0.37	0.71	(Significance at 0.05)	
	u	1.20	0.44	0.50	(level)	
DF	a	3.20	0.87	0.89		
	i	2.20	0.91	0.61		
	u	2.20	0.92	0.61		

Table-7: Range, Mean, S.D. of shimmer values in normals and dysphonics & significance of difference between them.

The statistical analysis suggested that the difference between normals and dysphonic subjects in terms of mean shimmer values for vowel /a/, /i/, /u/ were significant with respect to both males and female groups.

Thus the hypothesis l(f) stating that, "there will be no significant difference between normals and dysphonics (as a group) in terms of shimmer values for vowel /a/, /i/, /u/" was rejected with respect to both males and female subjects.

Several investigators (Heiburger and Horii, 1982; Zyski et.al., 1984; Kitajima and Gould, 1976, Haji et.al., 1986) have reported the greater jitter and shimmer values in dysphonic subjects than normals.

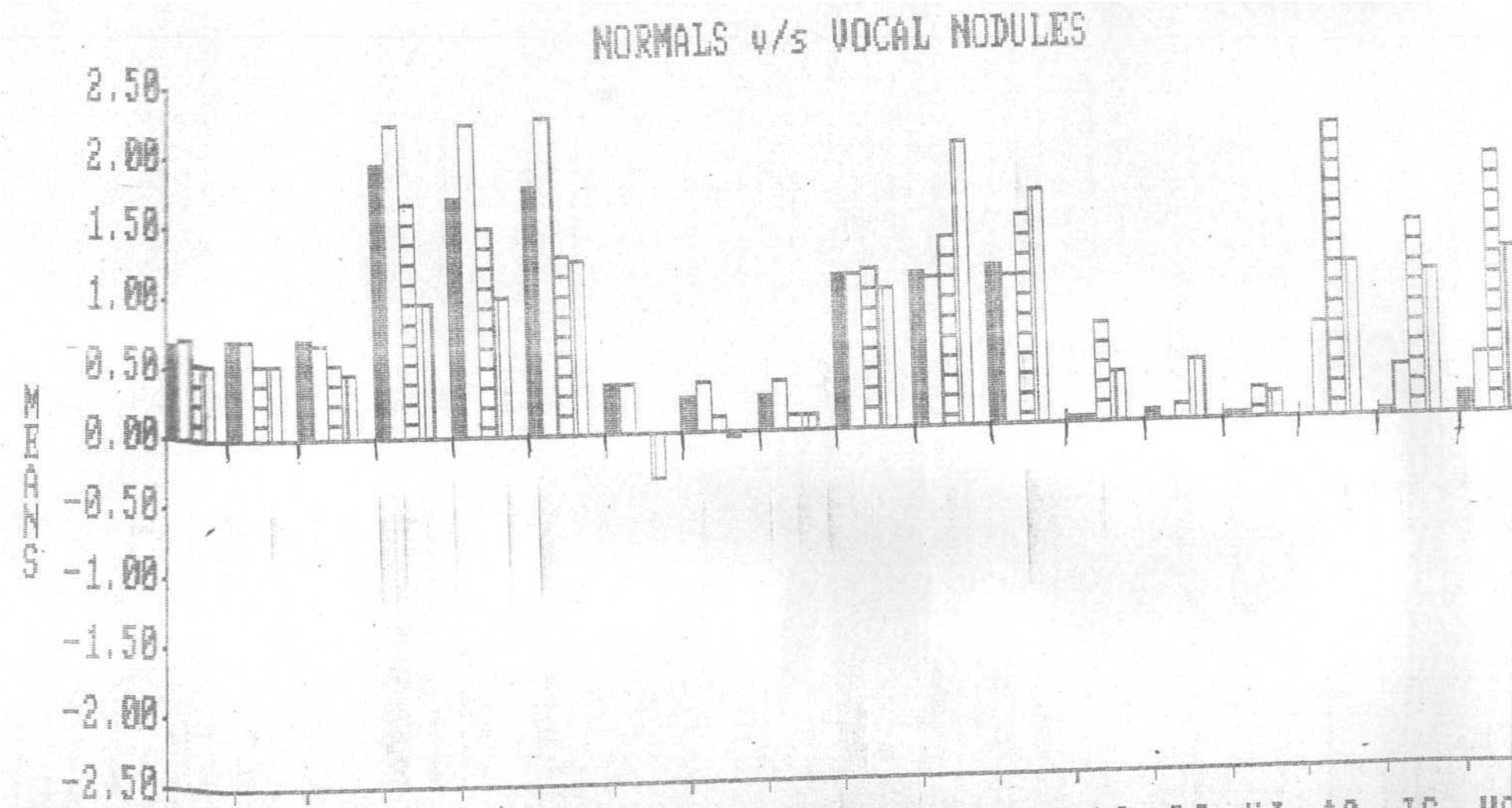
Parameters	OQ	SQ	SI	SR	J	S
Groups:						
NM Vs DM	+	-	-	-	+	+
NF Vs DF	+	-	-	-	+	+

Table-8: Significance of difference between normals and dysphonics on different parameters.

From the table-8, it was observed that dysphonic subjects were differentiated from normals in terms of open quotient, jitter and shimmer values.

Comparision of Dysphonics (with vocal nodules) with Normal group:

From table-9, it was observed that the fundamental frequency of male dysphonics to be higher than the normal values. Whereas the fundamental frequency of dysphonic females were found to be less than normal values.



Graph 2 EGG PARAMETERS

MALE-N FEMALE-N MALE-VN FEMALE-VN

Vowels / Groups	MEANS /a/	/i/	/u/
NM	116.3	120	117
DM	186	187	189
NF	231.4	243	248
DF	223	236	246

Table-9: Mean of fundamental frequency (in Hz) in normals and dysphonics (with vocal nodules)

Kitzing and Lofqvist (1979), also reported the reduction in fundamental frequency of a female subject with vocal nodules.

From table-10 and graph-2, it was observed that the mean open quotient in this group of dysphonic subjects (both males and females) were less than the normal values for all the three vowels.

Groups	Vowels	Range	Mean	S.D.	Significance difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.23	0.69	0.097	a	+	+
	i	0.23	0.71	0.078	i	+	+
	u	0.20	0.72	0.065	u	+	+
DM	a	0.16	0.54	0.05			
	i	0.29	0.54	0.10			
	u	0.32	0.54	0.10			
NF	a	0.19	0.74	0.061	(Significance at 0.05) (level)		
	i	0.15	0.72	0.044			
	u	0.13	0.71	0.045			
DF	a	0.19	0.57	0.08			
	i	0.32	0.57	0.014			
	u	0.20	0.50	0.08			

Table-10: Range, Mean, S.D. of OQ values in normal and dysphonics (with vocal nodules) & significance difference between them.

These differences were also observed to be statistically significant.

Thus the hypothesis 2(a) stating that, "there will be no significant difference between normals and dysphonics (with vocal nodules) in terms of OQ for vowel /a/, /i/, /u/" was rejected with respect to both male and female groups.

The reduction in OQ values in both male and female subjects with vocal nodules indicated that the vocal cords remains for a longer duration in contact phase, than normals.

Similar observations were reported by other investigators (Childers et.al., 1984; Kitzing and Lofquist, 1979).

From table-11 and graph-2, it was observed that the mean speed quotient values of subjects with vocal nodules were less than normal values in both male and female groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	3.49	1.99	0.71	a	-	+
	i	1.91	1.74	0.55	i	-	+
	u	2.22	1.79	0.59	u	-	+
DM	a	3.62	1.69	1.22			
	i	2.35	1.50	0.82			
	u	1.25	1.31	0.50			
NF	a	0.89	2.25	0.37			
	i	1.19	2.28	0.42	(Significance at 0.05)		
	u	1.18	2.30	0.41	(level)		
DF	a	0.55	0.99	0.24			
	i	0.58	1.03	0.25			
	u	0.44	1.27	0.20			

Table-11: Range, Mean, S.D. of SQ values in normal and dysphonic subjects & significance of difference between them.

However, the difference in mean SQ values between normal and dysphonics (with vocal nodules) were statistically significant in female group only. Thus, the hypothesis, 2(b) stating that, "there will be no significant difference between normals and dysphonics in terms of S.Q. for vowels /a/, /i/, /u/" was accepted with respect to male subjects but, rejected with respect to female subjects.

This reduction of SQ values in female subjects suggest the increased duration of closing phase in these subjects.

Childers et.al., (1984) also reported a similar findings in a subject with vocal nodule.

From table-12 and graph-2, it was observed that the mean "Speed Index" values of dysphonics were less than normal values, in both male and female groups.

But these differences were found to be statistically significant for the female subjects only.

Groups	Vowels	Mean	Range	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.46	0.378	0.34	a	-	+
	i	0.45	0.247	0.134	i	-	+
	u	0.41	0.266	0.107	u	-	+
DM	a	0.96	0.03	0.12			
	i	0.51	0.124	0.071			
	u	0.64	0.121	0.084			
NF	a	0.15	0.377	0.07			
	i	0.29	0.361	0.098	(Significance at 0.05)		
	u	0.30	0.362	0.093	(level)		
DF	a	1.02	-0.288	0.10			
	i	0.31	-0.001	0.10			
	u	1.50	0.134	0.073			

Table-12: Range,Mean,S.D, of SI values in normal and dysphonics & significance of difference between them.

Thus the hypothesis 2(c) stating that "there will be no significant difference between normals and dysphonics (with vocal nodules) in terms of SI for vowels /a/, /i/, /u/" was accepted with respect to male group, but rejected with respect to female group.

This reduced SI values for males and negative SI values in female subjects indicated that the duration of closing phase were longer than normal values in subjects with vocal nodules. (Hirano, 1981)

From table-13 and graph-2, it was observed that "S" Ratio values of subjects with vocal nodules (both males and females) to be greater than normal values, except for vowel /a/ in female subjects'.

But these differences were statistically not significant.

Groups	Vowels	Range	Mean,	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	2.18	1.132	0.179	a		
	i	2.06	1.118	0.131	i		
	u	2.46	1.158	0.112	u		
DM	a	0.39	1.156	6.146			
	i	2.98	1.369	1.019			
	u	3.84	1.496	0.821			
NF	a	2.25	1.126	0.031			
	i	2.12	1.103	0.049	(Significance at 0.05)		
	u	2.04	1.089	0.07	(level)		
DF	a	0.425	1.018	0.176			
	i	2.100	2.07	0.864			
	u	1.007	1.698	0.44			

Table-13: Range, Mean, S.D. of "S" ratio in normal and dysphonic & significance difference between them.

Thus the hypothesis 2(d) stating that, "there will be no significant difference between normals and dysphonics (with vocal nodules) in terms of "S" ratio for vowel /a/, /i/, /u/" was accepted with respect to both male and female groups.

However, Dejonckere and Lebacq (1985) reported the decreased "S" Ratio values in a group of female subjects with vocal nodules, in comparision to normal values for vowel /a/.

This disagreement in the results of the present study with Dejonckere and Lebacq's (1985) study may be because of differences in the method of investigation and types of cases studied.

From Table-14 and graph-2 it was observed that the mean jitter values for all the three vowels in the subjects with vocal nodules (both males and females) were greater than normal values.

Groups	Vowels	Range	Mean	S.D.	Significance of difference		
					Vowels	NM Vs DM	NF Vs DF
NM	a	0.155	0.065	0.043	a	+ -	
	i	0.558	0.108	0.065	i	-	+
	u	0.108	0.066	0.037	u	-	+
DM	a	1.82	0.727	0.797			
	i	0.45	0.133	0.153			
	u	0.75	0.24	0.28			
NF	a	0.1	0.058	0.039	Significance at 0.05 level		
	i	0.06	0.033	0.021			
	u	0.06	0.048	0.021			
DF	a	0.94	0.362	0.437			
	i	1.053	0.428	0.49			
	u	0.2	0.203	0.082			

Table-14: Range, Mean, S.D.,Significance difference of normal and dysphonic subjects in terms of Jitter.

Bysphonics also showed the range and variability of jiter values to be greater than normal values.

Statistical analysis however indicated that, the mean jitter difference between normals and subjects with vocal nodules were significant for only vowel /a/ in males and for vowels /i/ & /u/ in female subjects only.

Thus in general, the hypothesis 2(e) stating that, "there will be no significant difference between normal and dysphonics (with vocal nodules) in terms of jitter for vowels /a/, /i/, /u/" was accepted with respect to male group and was rejected with respect to female group.

It is interesting to note that the significant difference between normals and dysphonics (with vocal nodules) groups in terms of jitter was found only for vowel /a/ (in males), whereas female subjects showed significant difference for vowel /i/ & /u/. Factors contributing to this differences between males and female subjects with vocal nodules are not known. Only further studies with larger number of-subjects will be able to answer to this.

From table-15 and graph-2, it was observed that mean shimmer values of subjects with vocal nodules were greater than normal values with respect to both male and female groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.40	0.033	0.45	a	+ -	
	i	0.80	0.066	0.23	i	+ -	
	u	0.80	0.150	0.26	u	+ -	
DM	a	8.80	2.126	3.082			
	i	2.80	1.400	0.966			
	u	4.00	1.857	1.357			
NF	a	2.80	0.700	0.820			
	i	2.00	0.370	0.710	Significance at 0.05 levle		
	u	1.20	0.440	0.496			
DF	a	1.40	1.133	0.618			
	i	1.60	1.067	0.679			
	u	1.40	1.200	0.588			

Table-15: Range, Mean, S.D.,Significance of difference in normals & dysphonic subjects in terms of Shimmer.

But only male subjects showed greater range and variability than normals.

Statistical analysis indicated that the difference in mean shimmer values between normal and dysphonic (with vocal nodules) subjects were significant with respect to males only.

Thus the hypothesis 2(f) stating that, "there will be no significant difference between normals and dysphonics (with vocal nodules) in terms of shimmer for vowels /a/, /i/, /u/" was accepted with respect to female group and rejected with respect to male groups.

This difference in male and female subjects with vocal nodules in terms of shimmer values may be due to the differences in their fundamental frequency for vowels /a/, /i/, /u/.

Parameters	OQ	SQ	SI	SR	J	S
Groups		-		-	-	+
NM Vs DM	+	+	-	-	+	-
NF Vs DF	+		+			

Table-16: Significance of difference between normals & dysphonics (with vocal nodules) on different parameters.

From table-16, it was observed that male subjects with vocal nodules differed from normal male in terms of OQ & S values and whereas female subjects (with vocal nodules) differed from normal females in terms of OQ, SQ, SI and J values.

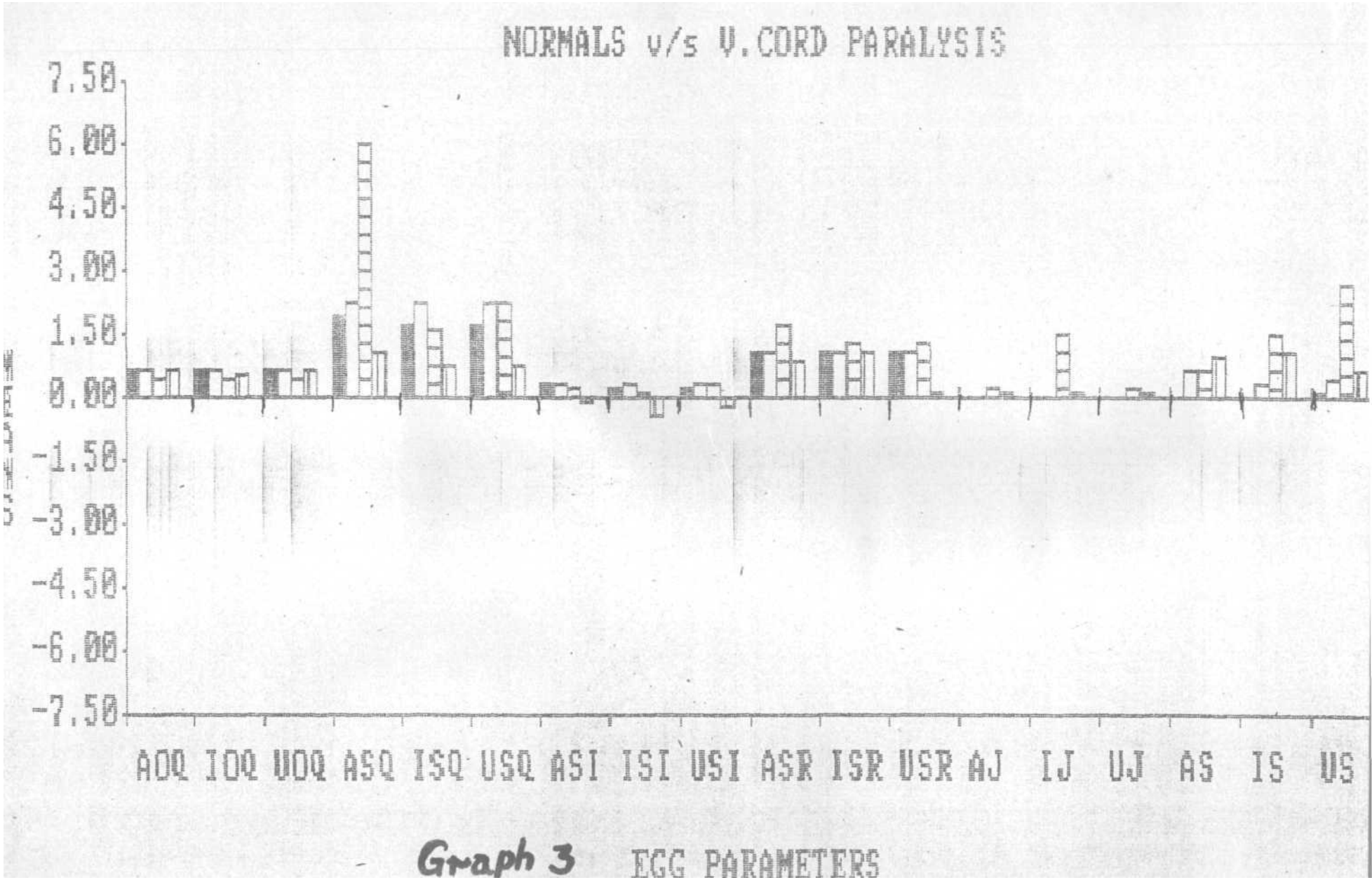
Comparision of dysphonics (with vocal cord paralysis) with normal subjects:

Groups	Vowels	MEANS /a/	/i/	/u/
NM		116.3	120	117
DM		101.0	100	101
NF		231.4	243	248
DF		220.0	229	228

Table-17: Mean of Fundamental frequency (in Hz) in normals & dysphonics (with vocal cord paralysis).

From table-17 it was observed that the fundmental frequency for vowels /a/, /i/, /u/ in these subjects (both males and females) with vocal cord paralysis were less than normal values.

Table-18 and graph-3, indicated that the mean OQ values of subjects with vocal cord paralysis were less than normal values, in both male and female groups, for all the three vowels.



Graph 3 EGG PARAMETERS

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.23	0.687	0.098	a	+	
	i	0.23	0.714	0.077	i	+	
	u	0.20	0.716	0.065	u	+	
DM	a	0.27	0.450	0.142			
	i	0.06	0.523	0.030			
	u	0.19	0.533	0.095			
NF	a	0.19	0.740	0.061	Significance at 0.05 level		
	i	0.15	0.716	0.043			
	u	0.13	0.713	0.044			
DF	a	0.244	0.656	0.104			
	i	0.35	0.623	0.145			
	u	0.24	0.689	0.102			

Table-18: Range, Mean, S.D., Significance of difference in normals & dysphonic subjects in terms of OQ.

But these differences were found to be statistically significant for only male subjects.

Thus the hypothesis 3(a) stating that, "there will be no significant difference between normals and dysphonics for vowel /a/, /i/ & /u/ in terms of OQ" was accepted with respect to female subjects, but was rejected with respect to male subjects.

This reduction in OQ values suggest that "the vocal cords remains shorter than normal duration in open phase (as described by Dejonckere and Lebacq, 1985).

Though no report of studies were available, which provides quantitative values of OQ in subjects with vocal cord paralysis, several investigators (Childers et.al., 1984; Fourcin and Abberton, 1972; Kitzing & Lofquist, 1979)

described the glottal wave forms in individuals with vocal cord paralysis which indicated that the vocal cords remains in open phase for a shorter duration than normals.

Results of the present study also indicated the same.

From table-19 and graph-3, it was observed that the mean SQ values of subjects with vocal cord paralysis were less than normals for all the three vowels in female group and for vowel /i/ only in male group.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	3.49	1.99	0.72	a	-	+
	i	1.91	1.74	0.55	i	-	+
	u	2.22	1.79	0.59	u	-	+
DM	a	12.48	6.10	0.75			
	i	1.78	1.68	0.924			
	u	2.08	2.25	0.943			
NF	a	0.89	2.248	0.372			
	i	1.19	2.283	0.423	Significance at 0.05 level		
	u	1.18	2.295	0.405			
DF	a	1.33	1.147	0.56			
	i	0.63	0.80	0.273			
	u	0.85	0.757	0.350			

Table-19: Range, Mean, S.D., Significance of difference in normals & dysphonic subjects in terms of SQ.

Statistical analysis indicated the significant difference in terms of mean SQ values in female subjects only.

Thus the hypothesis 3(b) stating that, . "there will be no significant difference between normals and dysphonics (with vocal cord paralysis) for vowels /a/, /i/, /u/ in terms of SQ" was rejected with respect to female group and accepted with respect to male group.

This reduction in SQ values for female dysphonic subjects suggests the possibility of reduction of duration of opening phase, in these subjects.

Several investigators (Childers et.al., 1984; Fourcin and Abberton, 1972) reported the Lx wave forms obtained from subjects with vocal cord paralysis to show relatively shorter opening time than normal. Thus supporting the findings of the present study with female subjects.

From table-20 and graph-3, indicated that the mean SI values of dysphonics were less than normal values for all the three vowels in female subjects and for vowel /a/ & /i/ in male subjects.

Groups	Vowels	Range	Mean,	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.46	0.378	0.34	a	-	+
	i	0.45	0.247	0.134	i	-	+
	u	0.41	0.266	0.107	u	-	+
DM	a	0.37	0.32	0.187			
	i	0.50	0.193	0.022			
	u	0.84	0.35	0.191			
NF	a	0.15	0.377	0.07			
	i	0.29	0.361	0.098	Significance at 0.05 level		
	u	0.30	0.362	0.093			
DF	a	0.70	-0.012	0.003			
	i	0.43	-0.422	0.230			
	u	0.60	-0.172	0.010			

Table-20: Range, Mean, S.D., Significance ofdifference in normal & dysphonic subjects in terms of SI.

Statistical analysis indicated that the mean SI difference between normals and subjects with vocal cord paralysis were significant only with respect to female group.

Thus the hypothesis 3(c) stating that, "there will be no significant difference between normals and dysphonics (with vocal cord paralysis) in terms of SI for vowels /a/, /i/, /u/" was rejected with respect to female group, but was accepted with respect to male group.

The negative SI values in the female dysphonic subjects with vocal cord paralysis for all the three vowels indicated that in these subjects the duration of closing phase was greater than duration of opening phase.

These results agrees with the findings of other investigators (Childers et.al., 1984; Fourcin and Abberton, 1972).

From table-21 and graph-3, it was observed that the mean "S" Ratio values in subjects with vocal cord paralysis were less than normal values in female group but it was more than normal values in male group.

Groups	Vowels	Range	Mean	S.D.	Significance of difference		
					Vowels	NM Vs DM	NF Vs DF
NM	a	2.18	1.132	0.179	a	+	-
	i	2.06	1.118	0.131	i	-	-
	u	2.46	1.158	0.112	u	-	+
DM	a	0.84	1.773	0.421			
	i	1.16	1.377	0.620			
	u	1.18	1.353	0.624			
NF	a	2.25	1.126	0.031			
	i	2.12	1.103	0.049	Significance at 0.05 level		
	u	2.04	1.089	0.07			
DF	a	0.50	0.890	0.234			
	i	1.73	1.100	0.706			
	u	0.26	0.213	0.065			

Table-21: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects in terms of "S" Ratio

Statistical analysis indicated these differences to be significant for only vowel /a/ in male group, and for vowel /i/ in female group. So, in general, we can consider that there was no significant difference between normals and subjects with vocal cord paralysis in terms of "S" Ratio, in both males and females.

Thus the hypothesis 3(d) stating that, "there will be no significant difference between normals and dysphonics (with vocal cord paralysis) in terms of "S" Ratio for vowels /a/, /i/, /u/" was accepted with respect to both males and female groups.

No reports of studies were available regarding "S" Ratio in vocal cord paralysis subjects.

From table-22 and graph-3, it was observed that mean jitter values of subjects with vocal cord paralysis to be greater than normal values for all the three vowels in both male and female groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.16	0.015	0.043	a	+	+
	i	0.56	0.108	0.065	i	+	+
	u	0.10	0.066	0.037	u'	+	+
DM	a	0.44	0.303	0.248			
	i	3.83	1.563	0.168			
	u	0.12	0.233	0.001			
NF	a	0.10	0.058	0.039			
	i	0.06	0.033	0.021	Significance at 0.05 level		
	u	0.06	0.048	0.021			
DF	a	0.23	0.208	0.106			
	i	0.22	0.163	0.09			
	u	0.16	0.126	0.063			

Table-22: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects in terms of jitter values.

The dysphonic subjects also showed greater range and variablility than normal subjects.

Statistical analysis indicated the mean jitter differences between normals and subjects with vocal cord paralysis were significant for both male and female groups.

Thus the hypothesis 3(e) stating that, "there will be no significant difference between normals and dysphonics (with vocal cord paralysis) in terms of jitter for vowels /a/, /i/, /u/" was rejected with respect to both male and female subjects.

Several investigators (Iwata, 1972; Iwata and Van Leden, 1970, Liberman, 1963) have also reported greater jitter values in subjects with vocal cord paralysis, thus supporting the findings of the present study.

Table-23 and graph-3 indicated that the mean shimmer values of dysphonics (with vocal cord paralysis) were greater than normal values in both male and female groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.40	0.033	0.115	a	+ -	
	i	0.80	0.066	0.230	i	+ -	
	u	0.80	0.15	0.26	u	+ -	
DM	a	0.20	0.733	0.305			
	i	1.80	1.600	0.92			
	u	4.60	2.73	1.91			
NF	a	2.80	0.70	0.82			
	i	2.00	0.37	0.71	Significance at 0.05 level		
	u	1.20	0.44	0.50			
DF	a	0.20	1.07	0.094			
	i	2.00	1.13	0.900			
	u	1.20	0.67	0.53			

Table-23: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects in terms of shimmer values.

However, statistical analysis indicated that, the mean difference between normals and subjects with vocal cord paralysis to be significant in male group only.

Thus the hypothesis 3(f) stating that, "there will be no significant difference between normals and dysphonics (with vocal card paralysis) in terms of shimmer for vowels /a/, /i/, /u/" was accepted with respect to female group and was rejected with respect to female group.

The factors contributing to these difference in shimmer values between males and female dysphonic subjects were not known. Only further studies may answer this.

Parameters	OQ	SQ	SI	SR	J	S
Groups						
NM Vs DM	+	-	-	-	+	+
NF Vs DF	-	+	+	-	+	-

Table-24: Significance of difference between normals & dysphonics (with vocal cord paralysis) on different parameters.

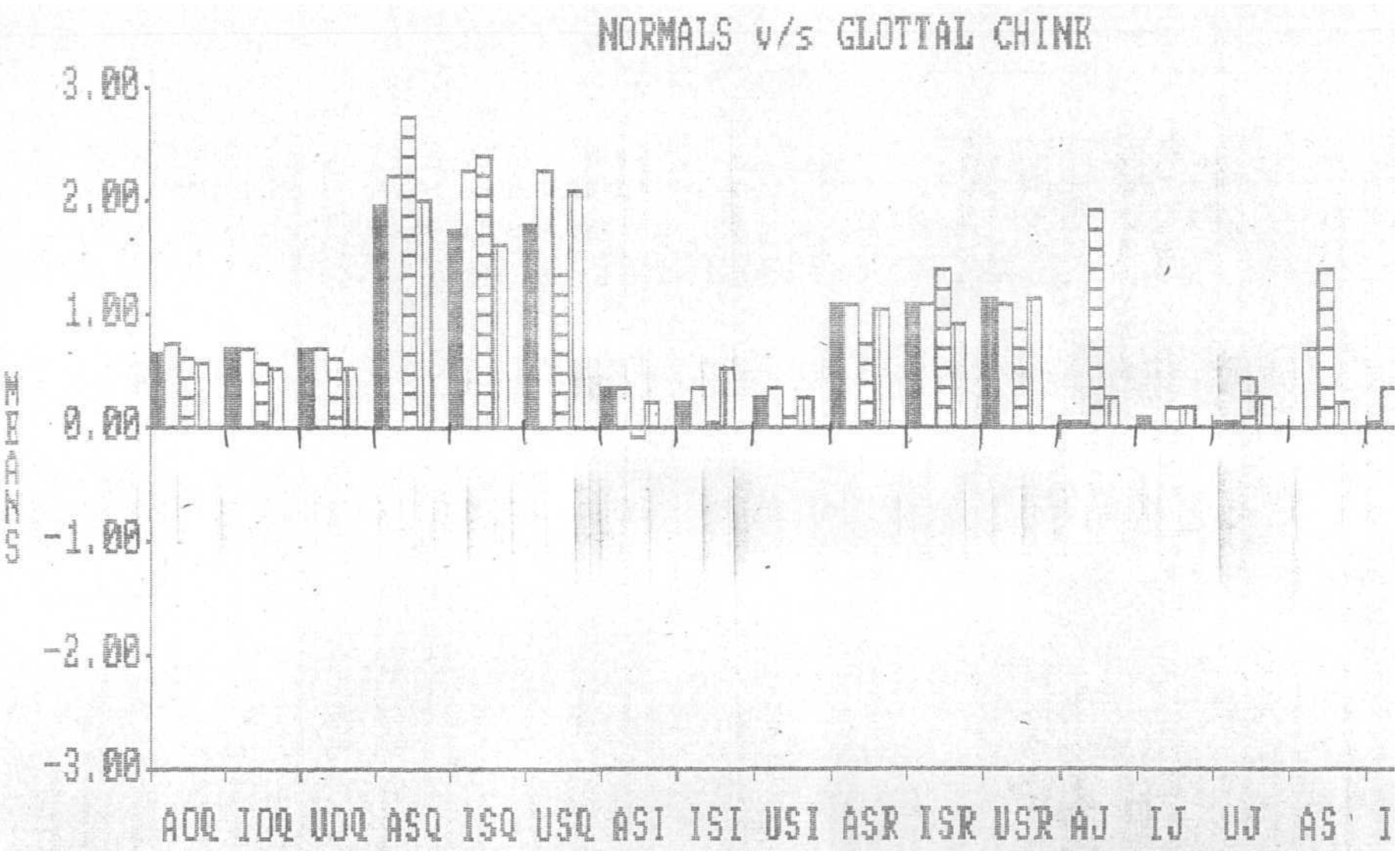
From table-24, it was observed that the normals and dysphonic males (with vocal cord paralysis) differed in terms of OQ, J and S. Dysphonic females (with vocal cord paralysis) differed from normals in terms of SQ, SI and J.

Comparision of dysphonics (with glottal chink) with normal group:

Table-25 indicated that the mean fundamental frequency of dysphonics were greater than normal values for all the three vowels in both male and female subjects.

	MEANS		
Vowels Groups	/a/	/i/	/u/
NM	116.3	120	117
DM	155	175	164
NF	231.40	243	248
DF	248	268	248

Table-25: Mean of Fundamental frequency (in Hz) in normals and dysphonics (with glottal chink)



Graph 4 EGG PARAMETERS

MALE-N FEMALE-N MALE-GC FEMALE-GC

From table-26 and graph-4, it was observed that mean OQ values of the subjects with glottal chink were less than normal values for all the three vowels in both male and female groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.23	0.687	0.98	a	-	+
	i	0.23	0.714	0.78	i	+	+
	u	0.20	0.716	0.66	u	+	+
DM	a	0.14	0.62	0.099			
	i	0.01	0.565	0.05			
	u	0.007	0.616	0.03			
NF	a	0.19	0.74	0.061			
	i	0.15	0.716	0.044	Significance at 0.05 level		
	u	0.13	0.713	0.045			
DF	a	0.17	0.584	0.069			
	i	0.17	0.554	0.083			
	u	0.17	0.525	0.064			

Table-26: Range, Mean, S.D., Significance of difference in normal & dysphonics (with glottal chink) in terms of OQ.

These dysphonics did not show greater than normal range and variability. Statistical analysis indicated the significant difference in mean OQ values between normals and dysphonics (with glottal chink) for all the three vowels in female group and for vowels /i/ and /u/ in male group.

Thus the hypothesis 4(a) stating that, "there will be no significant difference between normals and dysphonics (with glottal chink) for vowels /a/, /i/, /u/ in terms of OQ" was rejected with respect to both male and female groups.

These reduction in OQ values suggested, that the vocal cords remains for shorter than normal duration in open phase (as defined by Dejonckere and Lebacq, 1985) in these dysphonic subjects.

From table-27 and graph-4, it was observed that SQ values of subjects with glottal chink were less than normal values for all the three vowels in female group and for vowel /u/ in male group.

Groups	Vowels	Range	Mean	S.D.	Signficance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	3.49	1.988	0.718	a	-	-
	i	1.91	1.737	0.548	i	-	-
	u	2.22	1.789	0.586	u	- -	
DM	a	0.00	2.78	0.1			
	i	4.26	2.43	2.13			
	u	1.12	1.37	0.79			
NF	a	0.89	2.25	0.372			
	i	1.19	2.28	0.423	Significance at 0.05 level		
	u	1.18	2.29	0.405			
DF	a	3.35	2.04	1.43			
	i	2.29	1.65	1.036			
	u	3.686	2.108	1.419			

Table-27: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects (with glottal chink) in terms of SQ.

Female dysphonic subjects showed greater range and variability than normals for all the three vowels, but males showed greater range and variability than normals for vowel /i/ only.

However, statistical analysis indicated no significant difference between normals and subjects with glottal chink in terms of SQ for all the three vowels.

Thus, the hypothesis 4(b) stating that, "there will be no significant difference between normals and dysphonics (with glottal chink) for vowels /a/, /i/, /u/ in terms of SQ" was accepted with respect to both male and female groups.

From table-28 and graph-4, it was observed that the mean SI values for subjects with glottal chink were less than normal values for all the three vowels in male group and for vowels /a/ & /i/ in female group.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels NM Vs DM	NF Vs DF
NM	a	0.46	0.378	0.34	a -	-
	i	0.45	0.247	0.134	i -	-
	u	0.41	0.266	0.107	u -	-
DM	a	1.03	-0.045	0.100		
	i	1.18	0.05	0.100		
	u	0.42	0.11	0.21		
NF	a	0.15	0.377	0.07		
	i	0.29	0.361	0.098	Significance at 0.05 level	
	u	0.30	0.362	0.093		
DF	a	0.75	0.219	0.002		
	i	1.50	0.527	0.126		
	u	0.76	0.282	0.1		

Table-28: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects (with glottal chink) in terms of SI.

Dysphonics also showed greater than normal range for all the three vowels in both male and female groups.

However, statistical analysis indicated no significant difference between normals and dysphonics (with glottal chink) for vowels /a/, /i/, /u/ in terms of SI for both male and female groups.

Thus the hypothesis 4(c) stating that, "there will be no significant difference between normals and dysphonics (with glottal chink) in terms of SI for vowels /a/, /i/, /u/" was accepted with respect to-both male and female groups.

From table-29 and graph-4, it was observed that, the mean "S" Ratio values of dysphonics (with glottal chink) were less than normal values for vowels /a/ and /u/ in male groups and for vowels /a/ and /i/ in female groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	2.18	1.132	0.179	a	+	+
	i	2.06	1.118	0.131	i	+	-
	u	2.46	1.158	0.112	u	+	-
DM	a	0.69	0.735	0.49			
	i	0.26	1.42	0.78			
	u	0.75	0.895	0.53			
NF	a	2.25	1.126	0.031			
	i	2.12	1.103	0.049	Significance at 0.05 level		
	u	2.04	1.089	0.07			
DF	a	0.684	1.063	0.245			
	i	0.48	0.95	0.254			
	u	1.223	1.15	0.464			

Table-29: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects (with glottal chink) in terms of "S" Ratio.

These dysphonic subjects (both males and females) also showed greater than normal variability for all the three vowels.

However, statistical analysis indicated, the significant difference between normal and dysphonics (with glottal chink) in terms of "S" Ratio for all the three vowels in male group and for only vowel /a/ in female group.

Thus the hypothesis 4(d) stating that, "there will be no significant difference between normals and dysphonics (with glottal chink) for vowels /a/, /i/, /u/ in terms of "S" Ratio" was rejected with respect to male group and accepted with respect to female group.

These reduced "S" Ratio values suggested, the decreased area of contact phase in subjects with glottal chink.

No report of other studies which provides the information of "S" Ratio in subjects with glottal chink were available.

From table-30 and graph-4, it was observed that from the mean jitter values of the dysphonics (with glottal chink) were greater than normal values, in both male and female groups.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM	NF Vs DF
NM	a	0.16	0.065	0.043	a	+	-
	i	0.56	0.108	0.065	i	-	+
	u	0.108	0.07	0.037	u	-	+
DM	a	3.19	1.93	1.59			
	i	0.12	0.18	0.08			
	u	0.78	0.45	0.39			
NF	a	0.10	0.06	0.039			
	i	0.06	0.033	0.021	Significance at 0.05 level		
	u	0.06	0.048	0.021			
DF	a	0.47	0.27	0.193			
	i	0.142	0.19	0.16			
	u	0.71	0.29	0.31			

Table-30: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects (with glottal chink) in terms of Jitter values.

This dysphonic subjects (both males and females) showed greater than normal range and variability.

However, statistical analysis indicated the significant difference between normals and dysphonics (with glottal chink) in terms of jitter for only vowel /a/ in males and for vowel /i/ and /u/ in females.

Thus the hypothesis 4(e) stating that, "there will be no significant difference between normals and dysphonics (with glottal chink) for vowels /a/, /i/, /u/ in terms of jitter" was in general accepted for male subjects and rejected for female subjects.

From table-31 and graph-4, it was observed that, the mean shimmer values of dysphonics (with glottal chink) were greater than normal values for all the three vowels in male group and for vowels /i/ and /u/ in female group.

Groups	Vowels	Range	Mean	S.D.	Significance of difference		
					Vowels	NM Vs DM	NF Vs DF
NM	a	0.40	0.03	0.12	a	+ -	
	i	0.80	0.07	0.23	i	+	+
	u	0.80	0.15	0.26	u	+ -	
DM	a	1.92	1.40	0.60			
	i	0.60	0.60	0.50			
	u	4.00	2.80	2.00			
NF	a	2.80	0.70	0.82			
	i	2.00	0.37	0.71	Significance at 0.05 level		
	u	1.20	0.44	0.50			
DF	a	0.80	0.24	0.30			
	i	1.00	0.76	0.39			
	u	1.00	0.92	0.33			

Table-31: Range, Mean, S.D., Significance of difference in normal & dysphonic subjects (with glottal chink) in terms of shimmer values.

Male dysphonic subjects also showed greater than normal range and variability.

Statistical analysis indicated the significant difference between normals and dysphonics (with glottal chink) in terms of shimmer for all the three vowels in male group and for only vowel /i/ in female group.

Thus the hypothesis 4(f) stating that, "there will be no significant difference between normals and dysphonics (with glottal chink) for vowels /a/,/i/, /u/ in terms of shimmer" was rejected with respect to male subjects and was in general accepted for female group.

These variation in results of dysphonic subjects (with glottal chink) may be due to

- lack of clear indication of size and position of the glottal chink.
- some subjects having abnormalities of vocal cords like thickening of vocal cords in addition to glottal chink.

So further studies are warranted with this pathological group, to obtain better information about the different parameters of EGG in these subjects.

Parameters	OQ	SQ	SI	SR	J	S
Groups						
NM Vs DM	+			+		+
NF Vs DF	+	-	-	-	-	-

Table-32: Significance of difference between normals & dysphonics (with glottal chink) on different parameters.

The study of table-32, suggested that the dysphonic males (with glottal chink) differed from normal males in terms of OQ, SR and S values. Dysphonic female (with glottal chink) differed from normals in terms of OQ and J only.

Comparision of dysphonics (With functional high pitched voice) with normal group:

In this study two male subjects with functional high pitched voice were studied.

From table-33 it was observed that the fundamental frequency of these subjects were greater than normal values for all the three vowels.

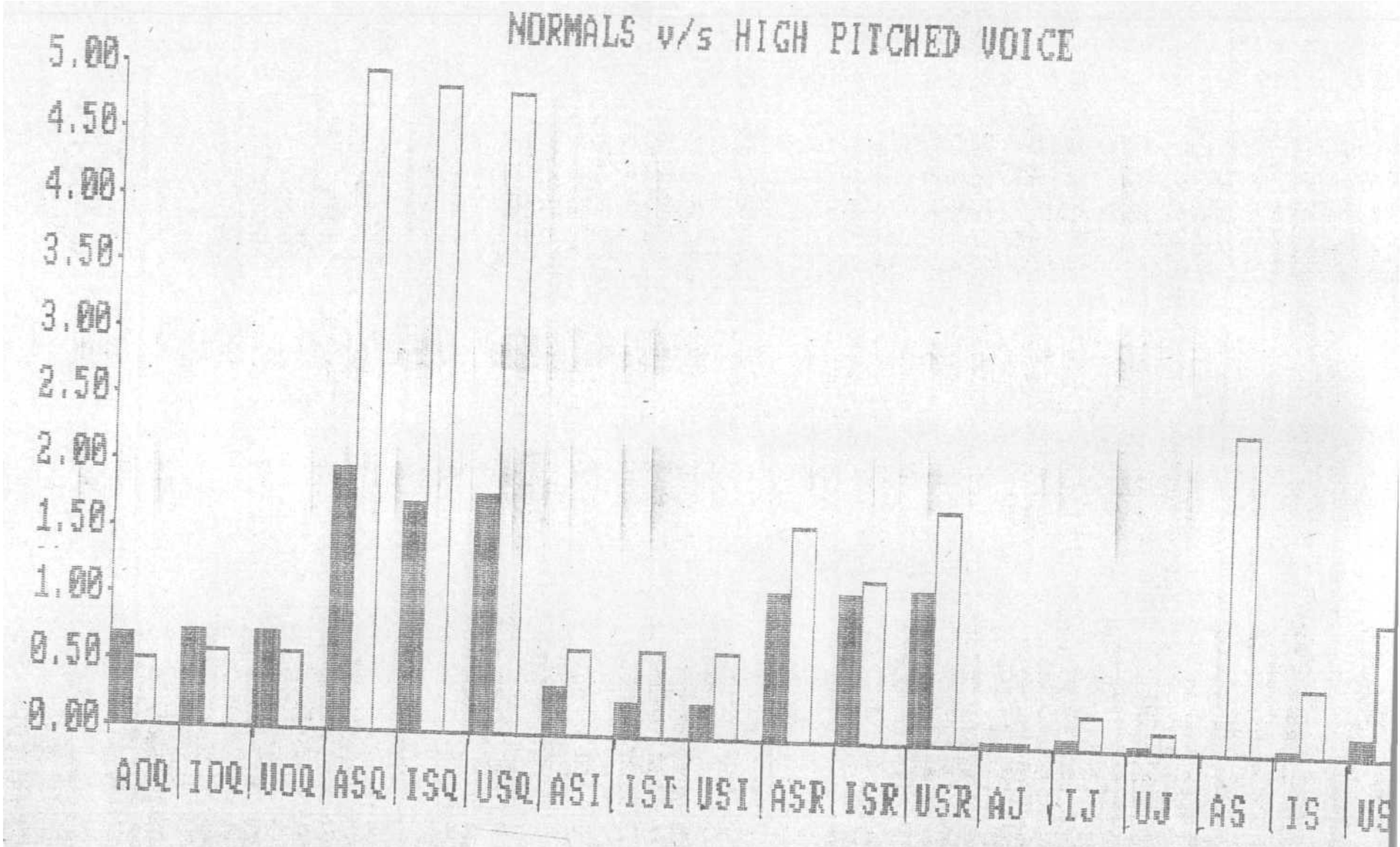
Groups \ Vowels	MEANS /a/	/i/	/u/
NM	116.3	120	117
DM	176	172	180

Table-33: Mean of Fundamental frequency (in Hz) in normals & dysphonics with functional high pitched voice.

From table-34 and graph-5, it was observed that the mean OQ values in this dysphonic subjects were less than normal values for males.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels NM Vs DM
NM	a	0.23	0.69	0.98	a -
	i	0.23	0.71	0.078	i -
	u	0.20	0.72	0.065	u -
DM	a	0.18	0.52	0.13	Significance at 0.05 level
	i	0.15	0.60	0.12	
	u	0.21	0.60	0.16	

Table-34: Range, Mean, S.D., Significance of difference in normal & dysphonic males (with functional high pitched voice) in terms of OQ.


NORMALS v/s HIGH PITCHED VOICE
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
AOQ
IOQ
UOQ
ASQ
ISQ
USQ
ASI
ISI
USI
ASR
ISR
USR
AJ
IJ
UJ
AS
IS
US
EGG PARAMETERS
MALE-N
MALE-FHP

Graph - 5

This dysphonic subjects also showed a greater variability for all the three vowels.

Statistical analysis however, indicated no significant difference between this group of dysphonics and normal males in terms of OQ for all the three vowels.

Thus, the hypothesis 5(a) stating that, "there will be no significant difference between normals and dysphonics (with functional high pitched voice) for vowels /a/,/i/, /u/ in terms of OQ" was accepted.

From table-35 and graph-5, it was observed that the mean SQ values of this group of dysphonics were greater than normal values of males, for all the three vowels.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels NM Vs DM
NM	a	3.50	1.99	0.73	a +
	i	1.91	1.74	0.55	i +
	u	2.22	1.79	0.59	u +
DM	a	2.21	4.98	1.56	Significance at 0.05 level
	i	1.62	4.86	1.15	
	u	0.69	4.83	0.49	

Table-35: Range, Mean, S.D. Significance of difference in normal & dysphonic males (with functional high pitched voice) in terms of SQ values.

These differences were also found to be statistically significant.

Thus, the hypothesis 5(b) stating that, "there will be no. significant difference between normals and dysphonics (with functional high pitched voice) for vowels /a/, /i/, /u/ in terms of SQ" was rejected.

From table-36, and graph-5, it was observed that the mean SI values for the subjects with high pitched voice were greater than normal values for all the three vowels.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM
NM	a	0.46	0.38	0.34	a	+
	i	0.45	0.25	0.134	i	+
	u	0.41	0.26	0.107	u	+
DM	a	0.12	0.65	0.085	Significance at 0.05 level	
	i	0.10	0.65	0.07		
	u	0.05	0.66	0.035		

Table-36: Range, Mean, S.D., Significance of difference in normal & dysphonic males (with functional high pitched voice) in terms of SI values.

These differences were also found to be statistically significant. Thus the hypothesis 5(c) stating that, "there will be no significant difference between normal males and dysphonic males (with functional high pitched voice) for vowels /a/, /i/, /u/ in terms of SI" was rejected.

These increase in SQ values and high positive SI values suggests that, the duration of opening phase was longer than normals in this dysphonic subjects.

From table-37 and graph-5, it was observed that mean "S" Ratio values of this dysphonic group were greater than normal values for all the three vowels.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM
NM	a	2.18	1.132	0.179	a	+
	i	2.06	1.118	0.131	i	+
	u	2.46	1.158	0.112	u	+
DM	a	0.43	1.605	0.215	Significance at 0.05 level	
	i	0.23	1.225	0.219		
	u	1.48	1.78	1.046		

Table-37: Range, Mean, S.D., Significance of difference in normal & dysphonic males (with functional high pitched voice) in terms of "S" Ratio.

These differences were also found to be statistically significant.

Thus the hypothesis 5(d) stating that, "there will be no significant difference between normals and dysphonics (with functional high pitched voice) for vowels /a/, /i/, /u/ in terms of "S" Ratio" was rejected.

This increase in "S" Ratio values indicated the increase in the area of contact phase in these subjects.

From table-38 and graph-5, it was observed that the mean jitter values in this group of dysphnics were greater than normal values for vowel /i/ and /u/ .

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM
NM	a	0.16	0.065	0.043	a	
	i	0.56	0.108	0.065	i	
	u	0.108	0.066	0.037	u	
DM	a	0.04	0.04	0.014	Significance at 0.05 level	
	i	0.47	0.27	0.24		
	u	0.20	0.16	0.14		

Table-38: Range, Mean, S.D., Significance of difference in normal & dysphonic males (with functional high pitched voice) in terms of jitter values.

But, the statistical analysis indicated no significant difference between these dysphonic subjects and normal males in terms of jitter for vowels /a/, /i/, /u/.

Thus the hypothesis 5(e) stating that, "there will be no significant difference between normals and dysphonics (with functional high pitched voice) for vowels /a/, /i/, /u/ in terms of jitter" was accepted.

From table-39 and graph-5, it was observed that the mean shimmer values of this group of dysphonic subjects were greater than normal values for all the three vowels.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NM Vs DM
NM	a	0.40	0.033	0.115	a	+
	i	0.80	0.066	0.23	i	+
	u	0.80	0.15	0.26	u	+
DM	a	1.80	2.40	1.40	Significance at 0.05 level	
	i	0.20	0.50	0.10		
	u	0.80	1.00	0.40		

Table-39: Range, Mean, S.D., Significance of difference in normal & dysphonic males (with functional high pitched voice) in terms of shimmer values.

These differences were also found to be statistically significant. Thus, the hypothesis 5(f) stating that, "there will be no significant difference between normal and dysphonics (with functional high pitched voice) in terms of shimmer for vowels /a/,/i/, /u/ was rejected.

These results suggest that in subjects with normal vocal cords with high pitched voice, vocal cord vibration did not show significant cycle to cycle period variation but showed significant cycle to cycle amplitude variation.

Parameters	OQ	SQ	SI	SR	J	S
Groups						
NM Vs DM	-	+	+	+	-	+

Table-40: Significance of difference between normals and dysphonics (with functional high pitched voice) on different parameters.

The study of table-40, suggested that the dysphonics (with high pitched Voice) differed from normal males in terms of SQ, SI, SR and S values.

Comparision of dysphonics (with functional hoarse voice) and normals:

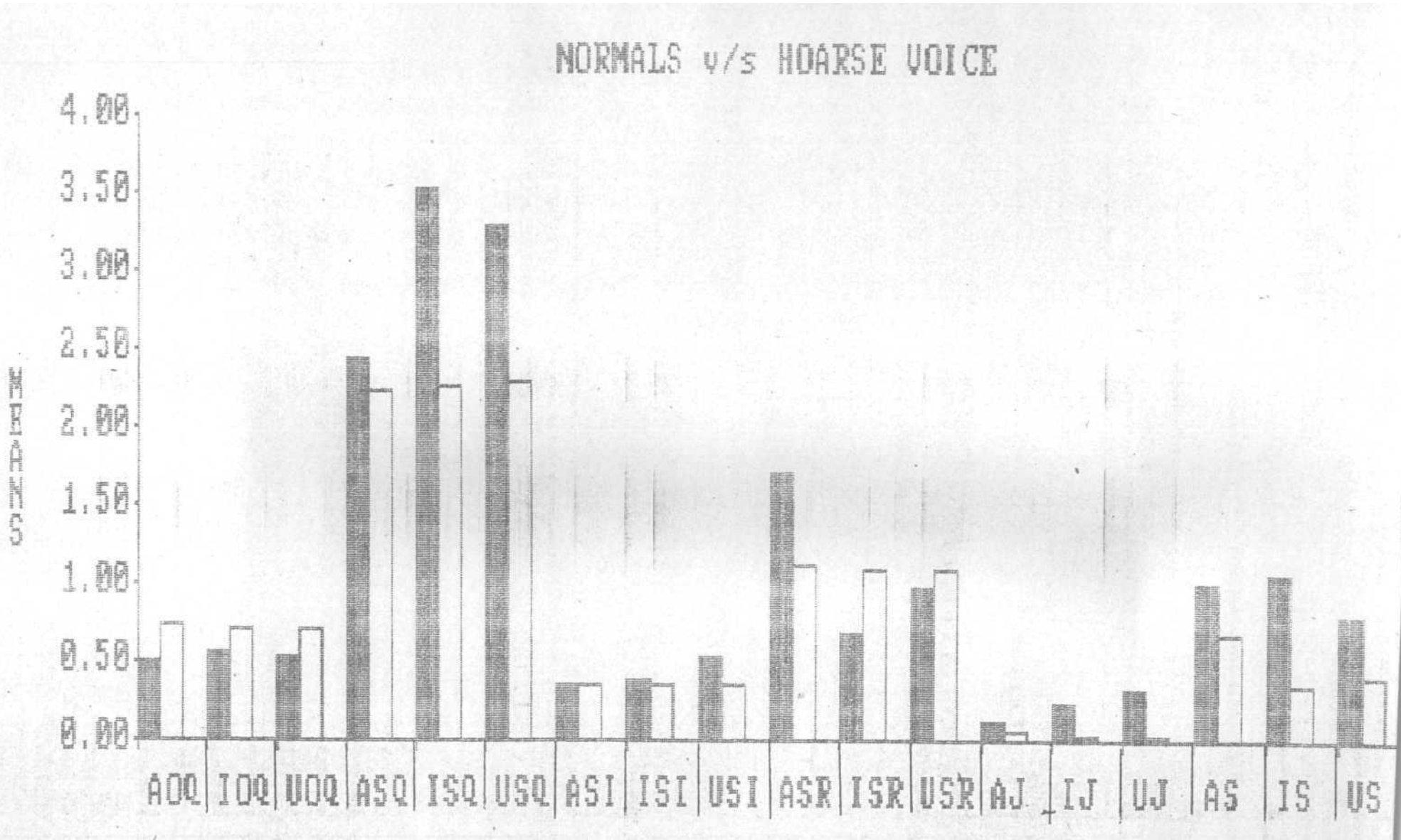
In this study three female subjects were diagnised to have hoarse voice by the speech pathologists and the otolaryngologists reported normal vocal cord appearance and movements in these subjects.

The E.G.G. findings of these subjects were compared with normal values for females.

The study of table-41, indicated that the mean fundamental frequency of these subjects were less than normal values in all the three vowels /a/, /i/, /u/.

	MEANS		
Vowels	/a/	/i/	/u/
Groups			
NF	231.4	243	248
DF	225.5	237	231.3

Table-41: Mean of fundamental frequency (in Hz) in normal and dysphonic females with hoarse voice.


NORMALS v/s HOARSE VOICE
MEANS
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
AOQ
IOQ
UOQ
ASQ
ISQ
USQ
ASI
ISI
USI
ASR
ISR
USR
AJ
IJ
UJ
AS
IS
US
EGG PARAMETERS
FEMALE-HV
FEMALE-N

Graph 6

From table-42 and graph-6, it was observed that OQ values in these subjects were less than normal values for all the three vowels.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NF Vs DF
NF	a	0.44	0.55	0.114	a	+
	i	0.18	0.55	0.094	i	+
	u	0.38	0.54	0.096	u	+
DF	a	0.26	0.50	0.105	Significance at 0.05 level	
	i	0.16	0.57	0.066		
	u	0.95	0.53	0.04		

Table-42: Range, Mean, S.D., Significance of difference in normal & dysphonic females (with hoarse voice) in terms of OQ.

This group of dysphonics also showed range and variability greater than normal values.

Statistical analysis indicated the significant difference between the dysphonic subjects and the normals in terms of OQ values for all the three vowels.

Thus the hypothesis 6(a) stating that, "there will be no significant difference between normals and dysphonics (with functional hoarse voice) for vowels /a/, /i/, /u/ in terms of OQ" was rejected.

This reduced OQ values suggests the decreased duration of open phase (as described by Dejonckere and Lebacq, 1985) in these dysphonic subjects.

From -table-43 and graph-6, it was observed that the mean SQ values of this group of dysphonic subjects were more than normal SQ values for females.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NF Vs DF
NF	a	0.89	2.25	0.372	a	
	i	1.19	2.28	0.423	i	
	u	1.18	2.29	0.405	u	+
DF	a	2.68	2.44	1.10	Significance at 0.05 level	
	i	1.90	2.54	0.804		
	u	0.24	3.30	0.11		

Table-43: Range, Mean, S.D., Significance of difference in normal & dysphonic females (with hoarse voice) in terms of SQ.

But these differences were found to be statistically significant for vowel /u/ only. Thus, the hypothesis 6(b) stating that, "there will be no significant difference between normals and dysphonics (with functional hoarse voice) for vowels /a/, /i/, /u/ in terms of SQ" was accepted.

From table-44 and graph-6, it was observed that mean SI values of this group of dysphonics were greater than normal values for vowel /i/ and /u/ only. But these differences were found to be statistically significant for vowel /u/ only.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NF Vs DF
NF	a	0.15	0.37	0.07	a -	
	i	0.29	0.36	0.098	i -	
	u	0.30	0.36	0.093	u	+
DF	a	0.56	0.36	0.24	Significance at 0.05 level	
	i	0.36	0.40	0.16		
	u	0.07	0.55	0.03		

Table-44-: Range, Mean, S.D., Significance of difference in normal & dysphonic females (with functional hoarse voice) in terms of SI values.

Thus the hypothesis 6(c) stating that, "there will be no significant difference for vowels /a/, /i/, /u/ in terms of SI" was accepted.

The results of SQ and SI values in this group of dysphonics indicated no significant difference between this group of dysphonics and normals in terms of duration of opening phase and closing phase.

The study of Table-45 and graph-6, indicated that the "S" Ratio values of this group of dysphonics were less than normal values for vowels /i/ and /u/, but it was more for vowel /a/.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NF Vs DF
NF	a	2.25	1.13	0.03	a	+
	i	2.12	1.103	0.05	i	+
	u	2.04	1.09	0.07	u	-
DF	a	2.10	1.72	0.89	Significance at 0.05 level	
	i	0.56	0.68	0.24		
	u	0.41	0.98	0.18		

Table-45: Range, Mean, S.D., Significance of difference in normal & dysphonic females (with functional hoarse voice) in terms of SR values.

These dysphonic subjects also showed greater variability than normals.

Statistical analysis indicated the significant difference between this group of dysphonics and normal females in terms of "S" Ratio for vowels /a/ and /i/, but not for vowel /u/.

Thus the hypothesis 6(d) stating that, "there will be no significant difference between normals and dysphonics (with functional hoarse voice) for vowels /a/, /i/, /u/ in terms of "S" Ratio" was rejected.

From table-46 and graph-6, it was observed that the mean jitter values of this group of dysphonics were greater than normal values for all the three vowels.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels	NF Vs DF
NF	a	0.10	0.058	0.04	a	+
	i	0.06	0.033	0.021	i	+
	u	0.06	0.05	0.021	u	+
DF	a	0.095	0.133	0.04	Significance at 0.05 level	
	i	0.49	0.25	0.22		
	u	0.70	0.35	0.32		

Table-46: Range, Mean, S.D., Significance of difference in normal & dysphonic females (with functional hoarse voice) in terms of jitter values.

The dysphonic subjects also showed greater range and variability than normals. Statistical analysis indicated the difference between normals and this gorup of dysphonics in terms of jitter were significant for all the three vowels.

Thus, the hypothesis 6(e) stating that, "there will be no significant difference between normals and dysphonics (with functional hoarse voice) for vowels /a/, /i/, /u/ in terms of jitter" was rejected.

From table-47 and graph-6, it was observed that, this group of dysphonics showed greater mean shimmer values for all the three vowels than normals.

Groups	Vowels	Range	Mean	S.D.	Significance of difference Vowels NF Vs DF
NF	a	2.80	0.70	0.82	a -
	i	2.00	0.37	0.71	i -
	u	1.20	0.44	0.50	u -
DF	a	2.20	1.00	0.99	Significance at 0.05 level
	i	1.60	1.07	2.50	
	u	0.80	0.80	3.30	

Table-47: Range, Mean, S.D., Significance of difference in normal & dysphonic females (with functional hoarse voice) in terms of shimmer values.

But these differences were found to be statistically not significant.

Thus, the hypothesis 6(f) stating that, "there will be no significant difference between normals and dysphonics (with functional hoarse voice) for vowels /a/, /i/, /u/ in terms of shimmer values" was accepted.

Parameters	OQ	SQ	SI	SR	J	S
Groups NF Vs DF	+	-	-	+	+	-

Table-48: Significance of difference between normals and dysphonics (with functional hoarse voice) on different parameters.

The study of table-48 indicated that the dysphonics (with functional hoarse voice) differed from normals in terms of OQ, SR and J values.

Comparision of dysphonics (with congestion of vocal folds) and normal groups:

Only one female and one male subject with congestion of vocal folds were studied. So values of different E.G.G. parameters obtained in these subjects were compared with normal mean values.

Groups	Vowels	MEANS /a/	/i/	/u/
NM		116.3	120	117
DM		147	157	146
NF		231.4	243	248
DF		281	267	212

Table-49: Mean of fundamental frequency (in Hz) of normals and dysphonics (with congestion of vocal folds).

From the table-49, it was observed that the fundamental frequency of both male and female dysphonic subjects were more than normals.

From table-50 and graph-7, it was observed that the OQ values of male dysphonic subjects were less than the normal values for all the three vowels and the female dysphonic subject showed lesser than the normal mean OQ values for vowel /i/ and /u/.

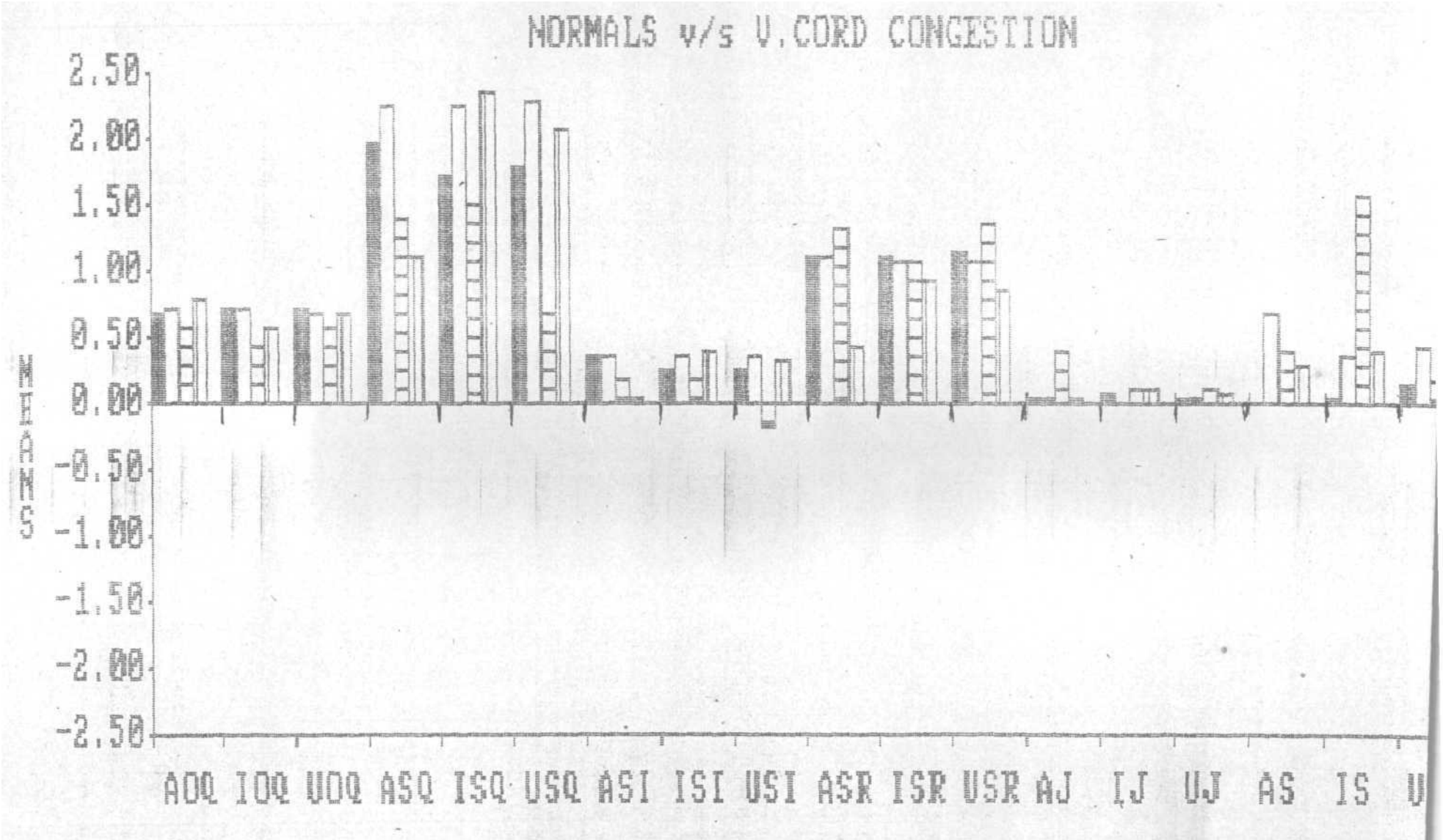
Groups	Vowels	Mean
NM	a	0.69
	i	0.71
	u	0.72
DM	a	0.59
	i	0.45
	u	0.60
NF	a	0.74
	i	0.72
	u	0.71
DF	a	0.80
	i	0.59
	u	0.68

Table-50: Comparision of mean values for normal and dysphonic subjects (with congestion of vocal folds) in terms of OQ values.

This reduced OQ (in general) for both male and female subject with congestion of vocal cords suggested the reduction in duration of open phase in these subjects.

Kitzing and Lofquist (1979) also reported a similar reduction in OQ values in a patient with edena/congestion of vocal folds.

From table-51 and graph-7, it was observed that both male and female dysphonic subjects showed SQ values less than normal mean values for all the three vowels.



Graph 7 EGG PARAMETERS

MALE-N FEMALE-N MALE-Cg FEMALE-Cg

Groups	Vowels	Mean
NM	a	1.988
	i	1.737
	u	1.789
DM	a	1.42
	i	1.52
	u	0.70
NF	a	2.25
	i	2.283
	u	2.30
DF	a	1.143
	i	2.368
	u	2.096

Table-51: Comparision of mean values for normal & dysphonic subjects (with congestion of vocal folds) in terms of SQ values.

From table-52 and graph-7, it was observed that both male and female dysphonic subject showed SI values less than normal mean values for all the three vowels.

Groups	Vowels	Mean
NM	a	0.378
	i	0.247
	u	0.266
DM	a	0.18
	i	0.20
	u	-0.17
NF	a	0.377
	i	0.361
	u	0.362
DF	a	0.067
	i	0.406
	u	0.354

Table-52: Comparision of mean values of normal & dysphonic subjects (with congestion of vocal folds) in terms of SI values.

These reduced SQ and SI values suggested that, the duration of opening phase were shorter than normal values in these subjects.

From table-53 and graph-7, it was observed that "S" Ratio values of male subject was almost equal to normal mean value for vowel /i/ and higher than normal mean value of "S" Ratio for vowel /a/ and /u/. But in case of female subject "S" Ratio values were less than normal mean values for all the three vowels.

Groups	Vowels	Mean
NM	a	1.132
	i	1.12
	u	1.16
DM	a	1.35
	i	1.09
	u	1.38
NF	a	1.13
	i	1.10
	u	1.09
DF	a	0.46
	i	0.93
	u	0.87

Table-53: Comparision of mean values of normal & dysphonic subjects (with congestion of vocal folds) in terms of "S" Ratio.

No report of studies, which provides information about "S" Ratio values in subjects with congestion of vocal folds were available.

From table-54 and graph-7, indicated that the jitter values of both male and female subjects with congestion of vocal folds were greater than normal mean jitter values for all the three vowels.

Groups	Vowels	Mean
NM	a	0.065
	i	0.108
	u	0.066
DM	a	0.42
	i	0.13
	u	0.14
NF	a	0.058
	i	0.033
	u	0.046
DF	a	0.068
	i	0.14
	u	0.09

Table-54: Comparision of mean values of normal & dysphonic subjects (with congestion of vocal folds) in terms of Jitter values.

Table-55 and graph-7, indicated that the shimmer values in the male dysphonic subject were higher than normal mean shimmer values, but in female subject the shimmer values for vowel /a/ and /u/ were less than normal mean values, and shimmer value of vowel /i/ was greater than the normal mean shimmer value.

Groups	Vowels	Mean
NM	a	0.033
	i	0.066
	u	0.15
DM	a	0.40
	i	1.60
	u	0.20
NF	a	0.70
	i	0.37
	u	0.44
DF	a	0.32
	i	0.40
	u	0.20

Table-55: Comparision of mean values of normal & dysphonic subjects (with congestion of vocal folds) in terms of shimmer values.

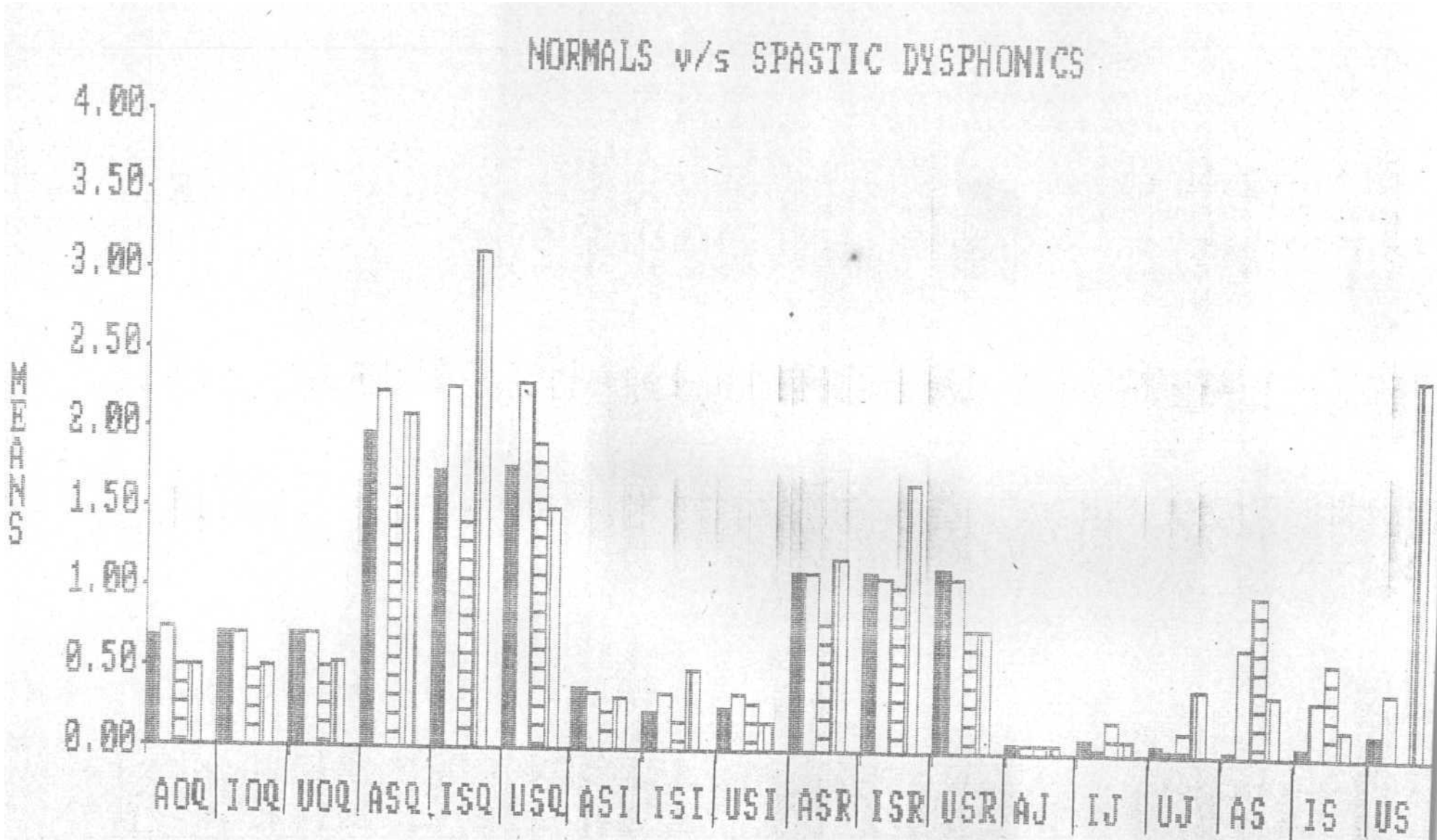
Parameters	OQ	SQ	SI	SR	J	S
Groups						
NM Vs DM	+	+	+	+	+	+
NF Vs DF	+	+	+	+	+	+

Table-56: Difference between normals & dysphonic subjects with vocal fold congestion.

From table-56, it was observed that both male and female dysphonics (with vocal cords congestion} differed from normals in terms of all the six parameters.

Comparision of dysphonics (with adductor spastic dysphonia) and normal groups:

Only one female and one male subject with adductor spastic dysphonia were studied. So, the values of different E.G.G. parameters obtained in this dysphonic subjects were compared with mean values of normals.



Graph 8 EGG PARAMETERS

MALE-N FEMALE-N MALE-SD FEMALE-SD

From table-57, it was observed that fundamental frequency of male dysphonic subject was greater than normal mean fundamental frequency values.

Groups	Vowels	MEANS /a/	/i/	/u/
NM		116.3	120	117
DM		146	160	139
NF		231.4	243	248
DF		198	227	220

Table-57: Mean of fundamental frequency (in Hz) in normal & dysphonic subjects (with spastic dysphonia).

But in female subject the fundamental frequency was less than normal mean fundamental frequency values.

From table-58 and graph-8, it was observed that OQ values of both male and female dysphonic subject were less than normal mean OQ values for all the three vowels.

Groups	Vowels	Mean
NM	a	0.687
	i	0.714
	u	0.716
DM	a	0.500
	i	0.49
	u	0.50
NF	a	0.55
	i	0.55
	u	0.54
DF	a	0.5
	i	0.5
	u	0.55

Table-58: Comparision of mean values in normal & dysphonic subjects (with spastic dysphonia) in terms of OQ values.

This suggested that the duration of open phase for all the three vowels were less than normal in these dysphonic subjects.

From table-59 and graph-8, it was observed that the SQ values of male dysphonic subject were slightly less than normal mean SQ values in males for vowels /a/, /i/ only and in female subject SQ values were less than normal mean value for vowel /a/ and /u/ only.

Groups	Vowels	Mean
NM	a	1.988
	i	1.737
	u	1.789
DM	a	1.62
	i	1.42
	u	1.94
NF	a	2.25
	i	2.283
	u	2.295
DF	a	2.093
	i	3.12
	u	1.512

Table-59: Comparision of mean values in normal & dysphonic subjects (with spastic dysphonia) in terms of SQ values.

Table-60 and graph-8 indicated that the SI values of the dysphonic male subjects were reduced for all the three vowels but SI values of female subject were found to be reduced for vowel /a/ and /u/.

Groups	Vowels	Mean
NM	a	0.378
	i	0.247
	u	0.266
DM	a	0.24
	i	0.18
	u	0.32
NF	a	0.377
	i	0.361
	u	0.362
DF	a	0.353
	i	0.515
	u	0.203

Table-60: Comparision of mean values in normal & dysphonic subjects (with spastic dysphonia) in terms of SI values.

This reduction in SQ and SI values suggested that the duration of opening phase was shorter in these subjects than normals.

From table-61 and graph-8, it was observed that the "S" Ratio values of the male and dsyphonic subjects were less than normal mean "S" Ratio values for all the three vowels. But "S" Ratio values were found to be greater than normal mean "S" Ratio values in females for vowels /a/ and /i/.

Groups	Vowels	Mean
NM	a	1.13
	i	1.12
	u	1.16
DM	a	0.80
	i	1.04
	u	0.78
NF	a	1.13
	i	1.11
	u	1.09
DF	a	1.23
	i	1.69
	u	0.77

Table-61: Comparision of mean values in normal & dysphonic subjects (with spastic dysphonia) in terms of "S" Ratio.

These reduced "S" Ratio values in males suggested the reduction in contact phase area in males. But in females the "S" Ratio values suggested an increased contact phase area.

No report of studies, which reports "S" Ratio values in spastic dysphonia patients were available.

Table-62 and graph-8, indicated that the jitter values of the both male and female dysphonic subjects were less than normal mean values.

Groups	Vowels	Mean
NM	a	0.065
	i	0.108
	u	0.066
DM	a	0.08
	i	0.23
	u	0.16
NF	a	0.058
	i	0.033
	u	0.048
DF	a	0.06
	i	0.1
	u	0.43

Table-62: Comparision of mean values in normal & dysphonic subjects (with spastic dysphonia) in terms of jitter values.

Table-63 and Graph-8 indicated that the shimmer values of male subjects were greater than normal mean values for vowel /a/ and /i/ and less than normal value for vowel /u/. Female dysphonics showed shimmer values less than normal mean values for vowel /a/ and /i/, for vowel /u/ the shimmer value was greater than normal values.

Groups	Vowels	Mean
NM	a	0.033
	i	0.066
	UL	0.15
DM	a	1.00
	i	0.60
	u	0.00
NF	a	0.70
	i	0.37
	u	0.44
DF	a	0.40
	i	0.20
	u	2.40

Table-63: Comparision of mean values in normal & dysphonic subjects (with spastic dysphonia) in terms of shimmer values.

From table-64, it was observed that both male and female dysphonic subjects (with adductor spastic dysphonia) differed from normals on all the six parameters of E.G.G.

Parmaeters	OQ	SQ	SI	SR	J	S
Groups						
NM Vs DM	+	+	+	+	+	+
NF Vs DF	+	+	+	+	+	+

Table-64: Difference between normals & dysphonics (with adductor spastic dysphonia) on different parameters.

Comparision of a dysphonic subject with Chorinc Laryngitis with normal group:

In this dysphonic group only one female subject was studied. The fundamental frequency and values of different E.G.G. parameters of this subject were compared with normal mean values for females.

Table-65, indicated that the Fundamental frequency values of this dysphonic subject were less than normal values for all the three vowels.

	MEANS		
Vowels	/a/	/i/	/u/
Groups			
NF	231.4	243	248
DF	174	191	207

Table-65: Mean of fundamental frequency (in Hz) in normals & dysphonic female with chronic laryngitis.

Table-66 and Graph-9, indicated that the OQ values of this patient were less than normal mean 0Q values for all the three vowels. This reduced OQ values suggested that, the vocal cords remains for shorter duration in open phase than in normals.

Groups	Vowels	Mean
NF	a	0.74
	i	0.71
	u	0.71
DF	a	0.54
	i	0.49
	u	0.44

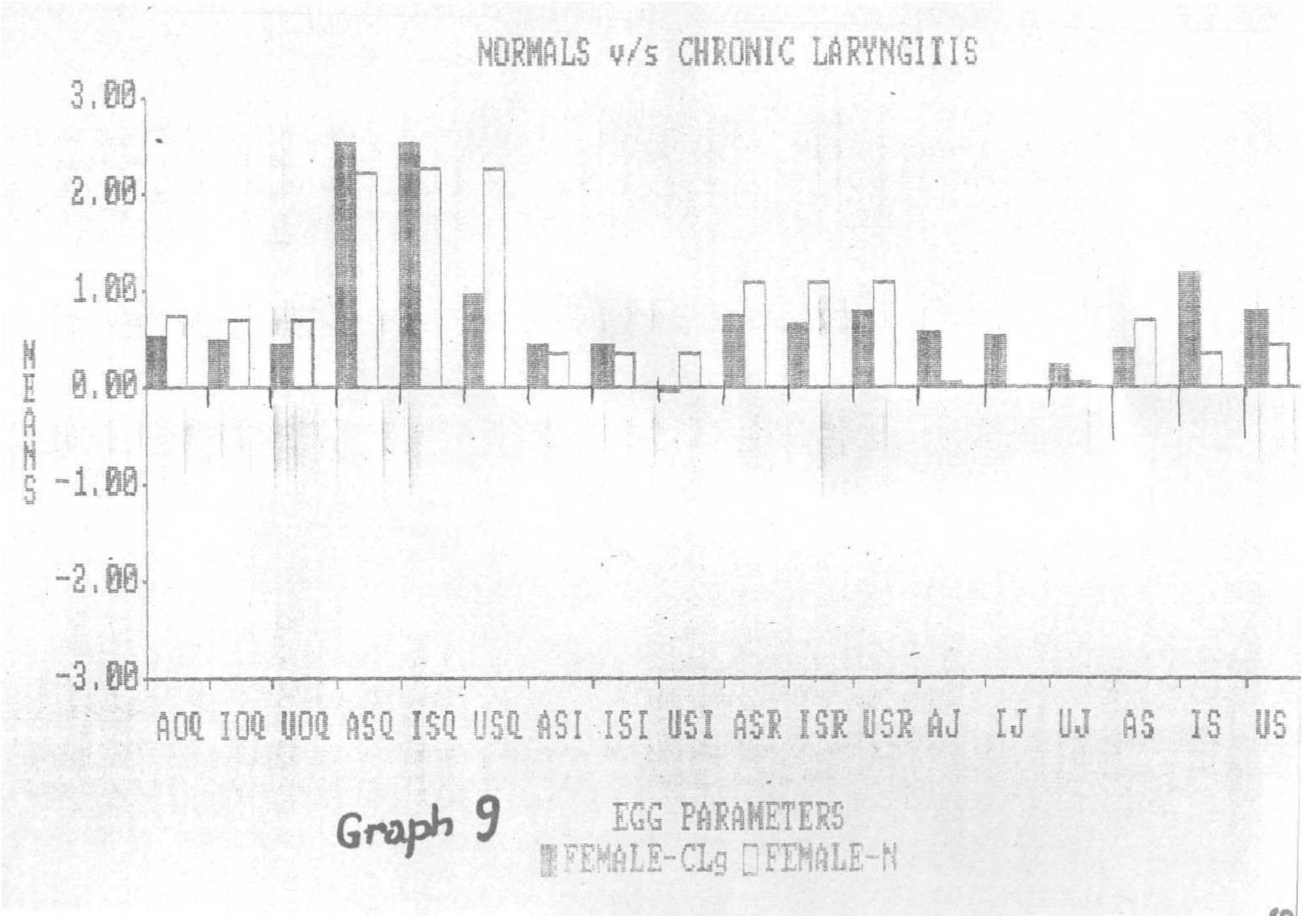
Table-66: Comparision of mean values in normals & dysphonic female (with chronic laryngitis) in terms of OQ values.

Table-67 and Graph-9, indicated that the SQ values of this subject were greater than normal values for vowels /a/ and /i/ , but for vowel /u/ it was less than normal values.

Groups	Vowels	Mean
NF	a	2.25
	i	2.28
	u	2.30
DF	a	2.54
	i	2.54
	u	1.00

Table-67: Comparision of mean values in normals & dysphonic female (with chronic laryngitis) in terms of SQ values.

Table-68 and Graph-9, indicated that the SI values for this dysphonic subject were greater than normal values for vowel /a/ and /i/, but for vowel /u/ it was less than normal values.


NORMALS v/s CHRONIC LARYNGITIS
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
MEAN SCORES
AOQ IOQ UOQ ASQ ISQ USQ ASI ISI USI ASR ISR USR AJ IJ UJ AS IS US
EGG PARAMETERS
FEMALE-CLg FEMALE-N

Graph 9

Groups	Vowels	Mean
NF	a	0.38
	i	0.36
	u	0.36
DF	a	0.44
	i	0.44
	u	-0.023

Table-68: Comparision of mean values in normals & dysphonic female (with chronic laryngitis) in terms of SI values.

The factors contributing for the differential effect on vowels in terms of SQ and SI for this subject was not known.

Only further studies with larger number of subjects may answer this.

Table-69 and Graph-9, indicated that the "S" Ratio values were reduced for all the three vowels in this subject, thus suggesting the reduction of area of contact in this subject.

Groups	Vowels	Mean
NF	a	1.13
	i	1.10
	u	1.09
DF	a	0.77
	i	0.66
	u	0.82

Table-69: Comparision of mean values in normals & dysphonic female (with chronic laryngitis) in terms of "S" Ratio values.

From table-70 and Graph-9, it was observed that this subject showed greater than normal values of jiter for all the three vowels.

Groups	Vowels	Mean
NF	a	0.058
	i	0.033
	u	0.048
DF	a	0.600
	i	0.540
	u	0.240

Table-70: Comparision of mean values in normals & dysphonic female (with chronic laryngitis) in terms of jitter values.

From table-71 and Graph-9, it was observed that, this subject showed greater than normal values of shimmer for vowels /i/ and /u/.

Groups	Vowels	Mean
NF	a	0.70
	i	0.37
	u	0.44
DF	a	0.40
	i	1.20
	u	0.80

Table-71: Comparision of mean values in normals & dysphonic female (with chronic laryngitis) in terms of shimmer values.

These greater /amount of jitter and shimmer values suggested the excessive irregularity of vocal cord vibration, in this subject.

Parameters	OQ	SQ	SI	SR	J	S
Groups NF Vs DF	+	+	+	+	+	+

Table-72: Difference between normals & a female dysphonic subject with chronic laryngitis on different parameters.

From table-72, it was observed that the female subject with chronic laryngitis differed from normals on all six E.G.G. parameters.

Comparision of a case with unilateral vocal polyp with normal group:

Only one male subject with unilateral vocal polyp was studied.

Table-73, indicated that the Fundamental frequency of this patient were less than normal values for all the three vowels.

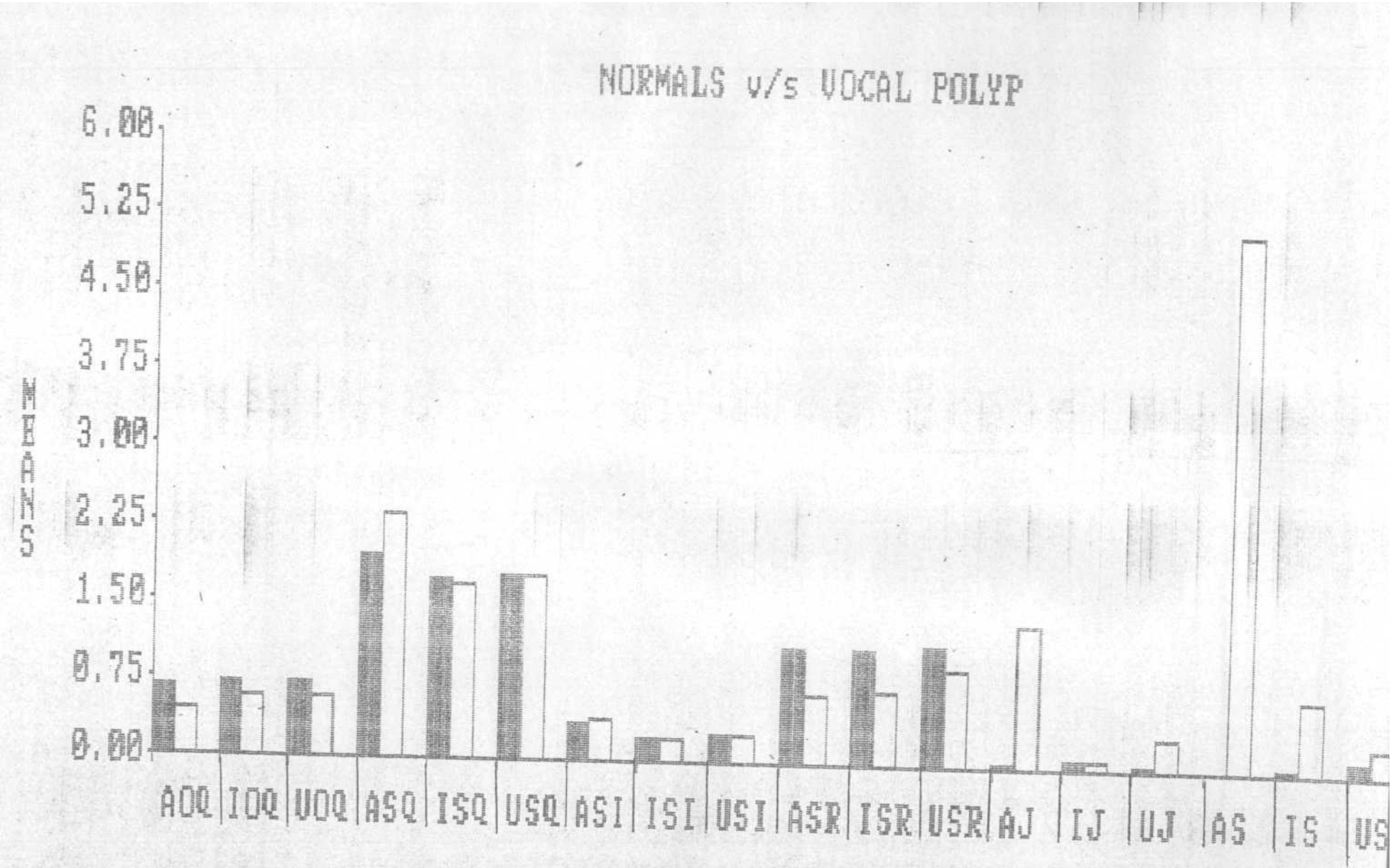
Groups	Vowels	MEANS /a/	/i/	/u/
NM		116.3	120	117
DM		107	109	108

Table-73: Mean of fundamental frequency (in Hz) in normals & dysphonic (with vocal polyp).

Table-74 and Graph-10, indicated that the OQ values of this subject Were less than normal values for all the three vowels. This reduced OQ values suggested that the vocal cords remains for lesser duration in open phase in this subject than normals.

Groups	Vowels	Mean
NM	a	0.68
	i	0.71
		0.72
DM	a	0.48
	i	0.59
	u	0.58

Table-74: Comparision of mean values in normals & dysphonic male (with vocal polyp) in terms of OQ values.


NORMALS v/s VOCAL POLYP
MEANS
6.00
5.25
4.50
3.75
3.00
2.25
1.50
0.75
0.00
AOQ
IOQ
UOQ
ASQ
ISQ
USQ
ASI
ISI
USI
ASR
ISR
USR
AJ
IJ
UJ
AS
IS
US
EGG PARAMETERS
MALE-N
MALE-V.Plp

Graph:10

Table-75 and Graph-10, indicated that the SQ values of this subject were more than normal values for vowel /a/ & /u/ but-less than normal values for vowel /i/.

Groups	Vowels	Mean
NM	a	1.99
	i	1.74
	u	1.79
DM	a	2.34
	i	1.70
	u	1.80

Table-75: Comparision of mean values in normals & dysphonic male (with vocal polyp) in terms of SQ values.

Table-76 and Graph-10, indicated that the SI values of this subject were greater than normal mean SI values for males.

Groups	Vowels	Mean
NM	a	0.38
	i	0.25
	u	0.27
DM	a	0.41
	i	0.26
	u	0.29

Table-76: Comparision of mean values in normals & dysphonic male (with vocal polyp) in terms of SI values.

This increase in SQ and SI values suggested that the duration of opening phase to be longer than normal values.

From Table-77 and Graph-10, it was observed that "S" Ratio of this subject was less than normal mean values for all the three vowels. These suggested the reduction in the area of contact phase in this subject.

Groups	Vowels	Mean
NM	a	1.130
	i	1.120
	u	1.150
DM	a	0.67
	i	0.72
	u	0.95

Table-77: Comparision of mean values in normals & dysphonic male (with vocal polyp) in terms of "S" Ratio.

Table-78 and Graph-10, indicated that the jitter values of this subject were greater than normal values for all the vowels /a/ and /u/ & almost equal to normal value for vowel /i/.

Groups	Vowels	Mean
NM	a	0.065
	i	0.108
	u	0.066
DM	a	1.40
	i	0.09
	u	0.32

Table-78: Comparision of mean values in normals & dysphonic male (with vocal polyp) in terms of jitter values.

From table-79 and Graph-10, it was observed that this subject showed greater shimmer values than normals for all the three vowels.

Groups	Vowels	Mean
NM	a	0.033
	i	0.066
	u	0.150
DM	a	5.20
	i	0.72
	u	0.30

Table-79: Comparision of mean values in normals & dysphonic male (with vocal polyp) in terms of shimmer values.

Kitajima and Gould (1976) also reported the shimmer values to vary from 0.08 to 3.23dB in subjects with vocal polyp.

These greater jitter and shimmer values suggested irregular vibration of vocal cords in this subject.

Parameters	OQ	SQ	SI	SR	J	S
3roups NM Vs DM	+	+	+	+	+	+

Table-80: Difference between normals and dysphonic male (with vocal polyp) on different parameters.

From table-80, it was observed that the male dysphonic subject (with unilateral vocal polyp) differed from the normals in terms of all the six parameters of E.G.G.

Parameters	OQ	SQ	SI	SR	J	S
Groups						
Dysphonics as a group						
Male	+	-	-	-	+	+
Female	+	-	-	-	+	+
Vocal nodules		-	-	-	-	
Male	+	+	+	-	+	+
Female	+					-
Vocal cord Paralysis		-	-			
Male	+	+	+	-	+	+
Female	-			-	+	-
Glottal chink		-			-	
Male	+	-	-	+	+	+
Female	+		-	-		-
Functional high pitch voice	-				-	
Male		+	+	+		+
Functional hoarse voice			-			-
Female	+	—		+	+	

Table-81: Significant difference between normals & dysphonics on different parameters of E.G.G.

The study of Table-81, indicated that male dysphonics

- as a group showed significant difference from normals in terms of OQ, J and S values.
- with vocal nodules showed significant difference from normals in terms of OQ and S values.
- with vocal cord paralysis showed significant difference from normals in terms of OQ, J and S values.
- with glottal chink showed significant difference from normals in terms of OQ, SR and S values.
- with functional high pitch voice showed significant difference from normals in terms of SQ, SI, SR & S values.

This suggests that male dysphonic subjects (as a group) and also in different subgroups differed from normals as different parameters of E.G.G., thus permitting the differential diagnosis of different dysphonic conditions in males using E.G.G.

The study of Table-81, indicated that female dysphonic subjects

- as a group showed significant difference from normals in terms of OQ, J & S values.
- with vocal nodules showed significant difference from normals in terms of OQ, SQ, SI & J values.
- with vocal cord paralysis showed significant difference from normals in terms of SQ, SI & J values.
- with glottal chink showed significant difference from normals in terms of OQ and J values.
- with functional high pitch voice showed significant difference from normals in terms of OQ, SR & J values.

This suggested that the female dysphonic subjects as a group and also in different subgroups differerd from normals on different E.G.G. parameters, thus permitting the differential diagnosis of different dysphonic conditions in females using E.G.G.

Table-81, further indicated that as a group male and female dysphonics showed significant difference from normals on OQ, J and S values. In all subgroups (vocal nodules, vocal cord paralysis and glottal chink) the male and female dysphonics showed significant difference from normals on different E.G.G. parameters i.e., males showed significant difference on certain parameters whereas, the females showed significant difference on some other parameters. In other words, males and females with same pathological conditions of vocal cords did not show significant difference on the same parmeters of E.G.G. For example, males with vocal nodules significantly differed from normals in terms of OQ and S values only. Whereas, the females with vocal nodules significantly differed from normals in terms of OQ, SQ, SI and J values.

Parameters	OQ	SQ	SI	SR	J	S
Groups: Spastic dysphonia Male	+	+	+	+	+	+
Female	+	+	+	+	+	+
Congestion of vocal folds Male	+	-'+.	+	+	+	+
Female	+	+	+	+	+	+
Chronic laryngitis Female	+		+	+	+	+
Vocal polyp Male	+	+	+	+	+	+

Table-82: Difference between normals & different dysphonic groups on different parameters of E.G.G.

From Table-82, it was observed that the dysphonic subjects with different pathological conditions of vocal folds viz., congestion of vocal folds, adductor spastic dysphonia, chronic laryngitis and vocal polyp differed from normals on all the six parameters of E.G.G. As a number of subjects were less in these subgroups, further studies are suggested to verify the results obtained in the present study.

SUMMARY AND CONCLUSION

As majority of phonatory dysfunctions are associated with abnormal vibrations of the vocal cords, analysis of the vibration of the vocal cords in terms of different parameters constitute an important aspect to be considered in the diagnosis and differential diagnosis of voice disorders. (Hanson et.al. 1983)

Several direct and indirect methods have been developed with the object of studying the movements of the vocal cords. One of them is Electroglottograph (E.G.G.). E.G.G. has many advantages over the other techniques mainly because, it is a non-invasive technique and quantification of the vocal cord vibration is possible.

As there was very limited information available about E.G.G. in dysphonics and also no data of E.G.G. in dysphonics was available in Indian population, the present study was attempted.

In this study 34 dysphonic subjects (17 males and 17 females) in the age range of 15 to 50 years were studied using Electroglottograph (Kay Elemetrics Corporation), and High Resolution Signal Analyzer (B & K type 2033). The measurement for the following parameters were obtained for three vowels /a/, /i/, /u/, phonated at comfortable pitch and loudness.

1. Open Quotient (OQ)
2. Speed Quotient (SQ)
3. Speed Index (SI)
4. "S" Ratio (SR)
5. Jitter (J)
6. Shimmer (S)

The data obtained was compared with normative data given by Sridhara, (1986), on E.G.G. parameters using the same instruments and procedures.

The statistical analysis using Mann Whitney 'U' test was carried out to find out the significance of difference between normals and dysphonics (as a group) and dysphonics (with particular kind of vocal cord pathology) in all the six E.G.G. parameters.

Parameters	OQ	SQ	SI	SR	J	S
Groups:						
Vocal nodules		-	-		-	
Male	+	+	+	-	+	+
Female	+			-		-
Vocal cord paralysis		-	-	-		
Male	+	+	+	-	+	+
Female	-				+	-
Glottal chink					-	
Male	+	-	-	+	+	+
Female	+	-	-	-		-
Functional high pitch voice	-					
Male		+	+	+	—	+
Functional hoarse voice		-	-			-
Female	+			+	+	
*Congestion of vocal folds						
Male	+	+	+	+	+	+
Female	+	+	+	+	+	+

*Spastic dysphonia						
Male	+	+	+	+	+	+
Female	+	+	+	+	+	+
* Chronic laryn-gitis						
Female	+	+	+	+	+	+
* Vocal polyp						
Male	+	+	+	+	+	+
Dysphonics						
Male.	+	-	-	-	+	+
Female	+	-	-	-	+	+

Table-11: Comparision of different dysphonic groups with normal groups on different E.G.G. parameters.

+ --- presence of significant difference between means
--- absence of significant difference between means
* --- In these groups as the number of subjects were less, only comparision of mean values with normal mean values were done.

The following conclusions have been drawn from the results obtained.

1. Male dysphonics
   - as a group showed significant difference from normals in terms of OQ, J & S values.
   - with vocal nodules showed significant difference from normals in terms of OQ and S values.
   - with vocal cord paralysis showed significant difference from normals in terms of OQ, J & S values.
   - with glottal chink showed significant difference from normals in terms of OQ, SR and S values.
   - with functional high pitched voice showed significant difference from normals in terms of SQ, SI, SR and S values.

This suggests that male dysphonic subjects (as a group) and also in different subgroups differed from normals on different parameters of E.G.G., thus permitting the differential diagnosis of different dysphonic conditions in males using E.G.G.

2. Female dysphonics
   - as a group showed significant difference from normals in terms of OQ, J and S values.
   - with vocal nodules showed significant difference from normals in terms of OQ, SQ, SI and J values.
   - with vocal cord paralysis showed significant difference from normals in terms of SQ, SI and J values.
   - with glottal chink showed significant difference from normals in terms of OQ and J values.
   - with functional hoarse voice showed significant difference from normals in terms of OQ, SR and J values.

This suggests that the female dysphonic subjects as a group and also in different subgroups differed from normals on different E.G.G. parameters , thus permitting the differential diagnosis of different dysphonic conditions in females using E.G.G.

3. Male and Female dysphonics as a group showed significant difference from normals on OQ, J and S values. In subgroups (vocal nodules, vocal cord paralysis and glottal chink) the male and female dysphonics showed significant difference from normals on different E.G.G. parameters i.e., males showed significant difference on certain parameters, whereas, females showed significant difference on some other parameters. In other words, males and females with the same pathological condition did not show significant difference on the same parameters of E.G.G. For example, Males with vocal cord paralysis showed significant difference from normals in terms of OQ, J and S values only. Whereas, females with.vocal cord paralysis showed significant difference from normals in terms of SQ, SI and J values.

Factors contributing to this variation of E.G.G. results in male and female dysphonics were not known. Only further studies may answer this.

4. Dysphonic subjects with different pathological conditions of vocal cords viz., congestion of vocal folds, spastic dysphonia, chronic laryngitis and vocal polyp differed from normals on all the six parameters of E.G.G. As the number of subjects were less in these subgroups, further studies are suggested to verify the results obtained in the present study.

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