Glottal Waveforms in Normals *

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The production of voice is highly complex. Thorough understanding of the physiology of voice production needs proper measurement techniques. Abnormal oscillatory movements of vocal cords are known lo manifest in the form of phonatory disorder. The measurement and analysis of the vibratory pattern of vocal fold has the potential to provide detailed information on the patho-physiology of the vocal fold during phonation. Hence, study of vibratory movements is of great importance. Many researchers have attempted to study the vibratory pattern of vocal folds using various techniques. Electro-glottography (E.G.G.) or Electro-laryngography is one of the few methods used extensively now-a-days to quantify the glottal waveforms effectively.

Laryngograph measures the conductance of a high frequency (0-5 to 10 MHz), low voltage signal transmitted and detected by two electrodes placed on the skin adjacent to the thyroid cartilage. Changes in conductance depending on changes in the glottal area generate the laryngographic (Lx) waveform.

The bulk of the published literature in relation with EGG deals with physiological aspects, but some authors have suggested the possibility of using EGG in the clinical assessment of voice pathology (Van Michel, 1967 ; Weschler, 1977 ; Fourcin, 1981; Hanson *etal,* 1983 ; Childers *et al,* 1984). Recently, Dejonckere and Lebacq (1985) have used EGG with vocal nodules and they state that in contrast with ultra high speed cinematography, EGG is very suitable for absolutely physiological conditions of voice production.

The EGG provides information regarding different phases of vocal cord vibration. Basically, four major phases can be identified during a single vibratory cycle, *i.e.*, the opening time, the closing time, the open time and the closed time (Michel and Wendahl, 1971). Various kinds of indexes can be calculated by measuring the duration of different phases of vibratory cycle like open quotient, speed quotient, speed index, * S ' ratio, etc.

Methodology

The purpose of the present study was to analyze Lx waveforms and to" obtain data on various parameters of Lx waveforms in Indian population. 30 normal subjects (15 males and 15 females) in the age range of 17 to 30 years were taken for the study and the Lx waveforms were studied, for 5 consecutive cycles for each vowel [a], [i] and [u] in sustained phonation keeping the frequency and intensity constant, in terms of the following parameters :

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(1) The number of cycles required to reach steady amplitude of the Lx waves (N).

(2) The Open Quotient (O.Q.).

(3) The Speed Quotient (S.Q.) and the Speed Index (S.I.).

(4) The ' S' Ratio (S.R.).

(5) The Jitter (J).

(6) The Shimmer (S).

Procedure

The subjects were seated comfortably in front of the instruments and the two electrodes were placed on the skin adjacent to the thyroid cartilage. Subjects were asked to phonate vowel [a] in their natural speaking voice and sustain the phonation maintaining pitch and intensity. The signal from EGG was fed simultaneously to VISI Pitch (Kay Elemetrics Corporation, type 6087 D.S.), to note the pitch (Fundamental frequency or Fo) and intensity (approximately 60 dB) of phonation and to High Resolution Signal Analyzer (B & K type 2033) to obtain the display of Lx waveforms. By moving the cursor of H.R.S.A. duration of different phases of a vibratory cycle was measured in milliseconds.

Data collected on different parameters were subjected to statistical analysis to find out the mean, standard deviation, significance of difference to vowel groups and between males and females (Mann-Whitney U test). The coefficient of linear regression correlation was also calculated to find out the correlation between different parameters.

Results and Discussion

In males, the mean ' N ' for [a], [i] and [u] vowels were 7.53, 7.1 and 7 . 3 respectively and in females they were 9.0, 9.5 and 9.2 respectively. In a similar study Kitzing and Sonneson (1974) have found ' N' values ranging from 6 to 10 cycles. The ' N' values in the present study ranged from 4 to 12 cycles in males and from 6 to 15 cycles in females. Correlation analysis revealed that the mean ' N ' did not correlate with the Fo of voice in both males and females. The results also indicated that males required more time (61 m.secs.) compared to females (39 m.secs) to achieve steady amplitude of Lx waves. While the discrepancy between males and females can be attributed to the greater mass and inertia of the male vocal folds, as put forth by Kelman (1981), it cannot be attributed to the higher Fo of females because the correlation values in the present study do not agree with his viewpoint.

The Open Quotient has been defined as the ratio of the open phase to the entire period of the vibratory cycle. O.Q. values were 0.52, 0.54 and 0.52 in males for [a], [i] and [u] respectively and in females they were 0.52 for all the three vowels. O.Q. ranged from 0.42 to 0.62 in males and from 0.44 to 0.61 in females. Comparison between male and female groups did not show any significant difference. The results also show that O.Q did not vary with the pitch of the voice, vowel or sex. However, changes in O.Q. with variation in frequency and intensity of voice (Kitzing and Sonneson, 1974), with different modes of vibration (Kitzing *et al.* 1982) and in pathological conditions (Hanson *et ah,* 1983) have been reported in the literature.

The Speed Quotient has been defined as the ratio of the opening period to the closing period of a vibratory cycle. The S.Q. values were 1.91, 1.80 and 1.80 for vowels [a], [i] and [u] respectively whereas in females they were 2.2C, 2.16 and 2.13 respectively. S.Q. ranged from 1.16 to 2.80 in males and 1.27 to 2.88 in females. Significant difference in the S.Q. values were observed with respect to sex and also between vowels. Correlation analysis revealed that Fo of voice and S.Q. were poorly correlated. However, changes in S.Q. with respect to pitch and intensity (Luchsinger, 1965 ; Timcke *etal.,* 1958 and Kitzing and Sonneson, 1974), in different voice registers (Kitzing, 1982), in abnormal vocal functions (Hanson *etal.,* 1983) have been reported in the literature. Kitzing and Lofquist (1979) used S.Q. to monitor voice therapy in their post-operative cases.

Another useful measure of Lx waveform—the Speed Index derived from S.Q. has been reported by Hirano *etal.* (1980). It is given by the formula :

$$S.I = \frac{S.Q - 1}{S.Q + 1}$$

In males S.I. was 0-29 and in females it was 0-36 and the difference between the two groups were significant. There was 'poor correlation between S.I. and Fo of voice.

The ' S' Ratio refers to the area ratio of open phase to the contact phase of a cycle. The S.R. values in males were 1.15, 1.09 and 1.12 for vowels [a], [i] and [u] respectively, whereas in females they were 1.15, 1.10 and 1.12 respectively. In males, S.R. ranged from 0.96 to 1.24 and in females it ranged from 0 .97 to 1 .35. 'It was also found that the S.R. values did not vary significantly with pitch of the voice or sex. Dejonckere and Lebacq (1985) who used this quotient for the first time claimed that using this index it was possible to differentiate normals from vocal nodule subjects.

Cycle to cycle variation in the period a cycle has been termed as Jitter. In males, the jitter values were 0.057, 0.054 and 0.067 m.sec for vowels [a], [i] ani [u] respectively, whereas in females they were 0.052, 0.030 and 0.053 m.sec. respectively. In males, jitter ranged from 0 .003 to 0.145 m.sec. whereas in females it ranged from 0 to 0.130 m.sec. In other words, jitter varied with vowels and sex. However, no correlation was found between mean Fo of voice and jitter in males and females.

It is interesting to note that males had a higher jitter value (0.060 m.sec.) than females (0.046 m.sec). It is presumed that greater mass and inertia of vocal folds in males may be responsible for the higher jitter values. Similar studies showing slightly different values of jitter have been reported in the literature in normals (Heiberger and Horii, 1982; Horii, 1985) and in pathological subjects (Moore and Thompson, 1965 ; Zemlin, 1962). The discrepancy in the values may be attributed to the methodological differences.

Shimmer refers to the cycle to cycle variation in the amplitude of a cycle. In males shimmer values were 0.079, 0.040 and 0.0240 dB for [a], [i] and [u] respectively, whereas in females they were 0.405, 0.325 and 0.415 respectively. The variations of shimmer values were very large. For instance, in males it ranged from 0 to 0 .92 dB and in females it ranged from 0 to 1.66 dB. It was also found that shimmer varied with respect to the vowel and sex but not with the Fo of the voice.

Similar studies have been reported in the literature using normals (Heiberger and Horii, 1982 ; Horii, 1985) and in pathological cases (Kitazima and Gould, 1976). However, there is large discrepancy in the values of the shimmer reported. Further investigation is warranted in order to find more reliable results.

Summary and Conclusions

As pointed out in the literature and by the present study the measurement and analysis of various parameters of the vibratory pattern of vocal folds has the potential to provide detailed information regarding normal vocal cord movement. This information can also be used to describe and differentiate various kinds of voice disorders. Thus the present study has both theoretical and practical utility.

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