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Original Research Article

Acoustic Features of Cry of Infants with High Risk Factors

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ABSTRACT

To determine the acoustic parameters which differentiate cries of high risk infants from normal infants, cry samples of 200 infants, which included 100 normal infants and 100 high risk infants were analyzed using PRAAT software. Results indicated that there were statistically significant differences between cries of infants with high risk factors and normal infants in Mean fundamental frequency, maximum fundamental frequency, jitter (Local), shimmer (Local), number of voice breaks and harmonic to noise ratio.

Key words: Infants, cry, and high risk factors.

INTRODUCTION

"Cry is a potent, early appearing, species-typical human vocal signal that is uttered in a similar way by members of all cultures and vocal communities". [1] It is a primary and powerful mode of communication. [2] It involves muscles of larynx, the autonomic and central control of arousal/inhibitory mechanisms and synchronization of cardio-respiratory activities. The complex interaction of anatomical structures, physiology and nervous system determines acoustic characteristics of the cry of infants. [3]

Many individuals who spend a lot of time with the newborn such as parents and nurses can perceive the differences in the cries of healthy and abnormal infants. Studies have reported that deviations in the complex sequence of events occurring during cry production leads to unusual cry. Hence, further analysis of cries of infants will help in detecting and locating the site of disturbance, which in turn helps in differential diagnosis of normal and abnormal infants, [4] thus leading to early identification of abnormalities in infants. The cry has been found to have diagnostic value, specifically, in the case of infants at risk. Many of these infants have been found to fail to develop normally. Even though there are other methods to determine the abnormality in infants later, there are no methods to identify the infants who may develop abnormally. Early identification program can be carried out to attenuate or improve the problem. [5] Analysis of cry of infants is related to basic neuro-physiological parameters; hence, it is an appropriate non-invasive method to assess neurological state of the newborn. [6]

According to Sheinkopf et al., [7] pain cries of at-risk infants had lot of variations and were high in fundamental frequency compared to low-risk infants. Similar findings were reported by Michelsson & Michelsson, [8] that the fundamental frequencies were more and the melody contour had variations in cries of abnormal and normal infants. In contrast, Chittora & Patil, [9] reported that the F0 features were not of significance in the newborn cry analysis and occurrences of voicelessness in the cry of infants varied with the maturity of central nervous system (CNS).

Studies have reported that there were significant differences between cries of normal infants and infants with high-risk factors in mean F0, maximum F0, harmonic to noise ratio, noise to harmonic ratio, formant 2, formant 4, [10] shimmer, shimmer in dB, number of voice-break. [11-13] Similar findings were reported by Shenoy [14] that there were significant differences in average F0, minimum F0, maximum F0, absolute jitter and shimmer in high-risk infants compared to normal infants. Sangeetha, [15] reported that the pain cries of normal and abnormal infants were significantly different in terms of average F0, high F0, low F0, standard deviation of F0, F0 tremor frequency, absolute jitter, F0 tremor intensity index, shimmer percent, amplitude perturbation quotient, smoothened amplitude perturbation quotient, peak amplitude variation, amplitude tremor intensity index, number of voice breaks and number of sub-harmonic segments.

According to Gopal & Gerber, [4] knowing the acoustics of cry in normal infants serves as a reference to compare and to identify the abnormal cry. In many infants, it may be possible to identify the underlying problem as the symptoms may not be exhibited immediately after birth. In such cases, acoustic analysis of cry of the at-risk infants may show various differences from that of the cries of normal infants. Further, it has been reported that, as cries of infants can be recorded immediately after birth and acoustic analysis of cries provide information that can be used for early diagnosis which will be useful in planning the treatment and provides information about the prognosis. Early assessment in those cases leads to possible early identification of high risk infants. However, from the review of literature it has been found that the acoustic parameters that provide information in differentiating infants at-risk from normal infants have not been conclusive. Hence, the present study attempts to identify acoustic parameters that may be useful in differentiating infants with high risk factors from normal infants.

Aim of the Study

The study was aimed at determining the differences between cry of infants with high risk factors and normal infants in terms of acoustic parameters.

METHOD

Subjects - 200 infants, that is 100 infants with various high risk factors (12 infants with low birth weight, 13 preterm infants, 11 infants with asphyxia, nine asphyxia with low birth weight infants, 13 infants with consanguinity and 42 infants with multiple risk factors) and 100 normal infants were chosen from different hospitals based on the history that were collected from the mother of each infant and the medical records.

Procedure - Consent from the mother of each infant was taken concerning the participation of the infant in the study. The cry recordings were done in a quiet room in the presence of the infant's mother. The mother of the infant was instructed not to comfort the infant or make any noise during the recording of the cry sample.

The pain cries were elicited by using procedure followed in the earlier studies [11,14,16,17] i.e., the sole of the infant's foot was flicked with the index finger to evoke pain cries. The cry was elicited and recorded only after the infant was fed fully. From the presentation of pain stimulus indicated by the investigator by saying 'now' to the end of the cry was recorded using a digital recorder (Sony IC Recorder, ICD-UX533F) with its microphone positioned five cm away from the mouth of the infant. When the infant did not cry immediately or when the cry was not robust (strong and long) or if there was undesirable background noise, then, the infant was given pain stimulation again and the cry sample was recorded. After the data collection, each recorded sample was transferred and saved on the hard disk of a laptop (with 64 bit and Windows 8 operating system).

PRAAT software (version 6.0.36) was used to measure acoustic parameters from infants cry samples which were saved on the laptop. The settings and the procedure that were described in the PRAAT manual [18] were used to analyze parameters. "Each cry sample consisted of cry sequence of an infant which usually consisted of a series of relatively long expiratory cries separated by brief inspiratory intervals. This may contain many cry units, which is the sound that results during the passage of air past the vocal folds during a single inspiratory/ expiratory cycle. Each cry unit consists of one or more phonations. Phonation is a segment of cry unit that is periodic." [19] Each cry sample was displayed on the monitor of the laptop and then by visual and auditory inspection, the cursor was moved from the starting of the word 'now' uttered by the investigator, to the end of the cry. The highlighted portion was confirmed auditorily, then it was stored as a file. This was done for all the cry samples of all the groups of infants. The digitized cry samples of all the 200 infants were used for the analysis of acoustic parameters.

The waveform and spectrogram of each of the cry sample was displayed using PRAAT software. Each cry phonation was selected by moving the cursor from staring to the end of the Phonation. The highlighted portion was displayed on the entire screen by clicking 'sel' option. Then 'pulse' menu was clicked and from drop down menu ‘voice report’ was selected. The software displayed the values of the following acoustic parameters (i) average fundamental frequency (F0), (ii) Minimum fundamental frequency, (iii) Maximum fundamental frequency, (iv) Standard deviation (SD) of fundamental frequency, (v) Jitter (Local), (vi) Jitter (Absolute), (vii) Jitter (Rap), (viii) Jitter (PPQ 5), (ix) Jitter (DDP), (x) Shimmer (Local), (xi) Shimmer (dB), (xii) Shimmer (APQ 3), (xiii) Shimmer (APQ 5), (xiv) Shimmer (APQ 11), (xv) Shimmer (DDA), (xvi) Noise to Harmonic ratio, (xvii) Harmonic to Noise ratio, (xviii) Number of voice breaks, and (xix) Degree of voice breaks, as shown in the Figure 1. The values were noted. Using same procedure, all the phonations of the cry sample were analyzed. The values noted from all the phonations were averaged to get mean values of the parameters. Similarly, cry samples of all the infants were analyzed.

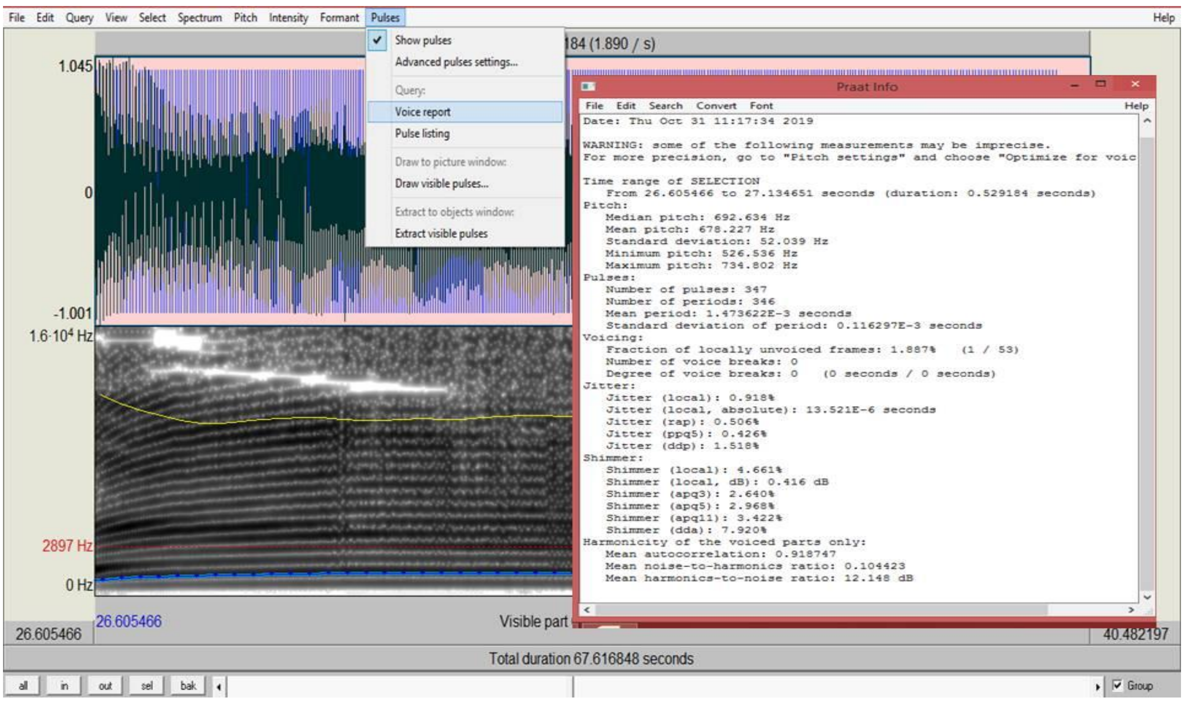

Figure 1: Shows the values of acoustic parameters as displayed by the PRAAT software.

To obtain the value of Formant 1, each phonation was highlighted by moving the cursor from beginning to the end of phonation by visual and auditory confirmation of the cry sample. From the menu, "formant" option was clicked and from the drop down menu "Get first formant" was selected. The value displayed by the software was noted. Similarly, "formant" option was selected from the menu and from the drop down menu "Get second formant" was clicked to obtain value of Formant 2. The value of Formant 2 was noted. Using same procedure, values of Formant 1 and Formant 2 were noted for all the phonations of the cry sample. All the obtained values were averaged to get mean values of Formant 1 and Formant 2 of the cry sample. Likewise, cry samples of all the infants were analyzed.

Statistical analysis using the SPSS-16 was carried out. The mean and standard deviation of all the parameters were calculated for each group. Between the groups comparisons were carried out by subjecting the data to Independent sample t-test. ‘p’ value of < 0.05 was considered as significant.

RESULTS AND DISCUSSION

Between both the groups comparisons for all the parameters were made using Independent sample t-test. Results indicated that there were statistically significant differences between groups in mean F0 [t(184)=-1.98, p = 0.049], maximum F0 [t(184)=-2.43, p = 0.016], Jitter (Local) [t(184)=-2.44, p = 0.016], Shimmer (Local) [t(184)=-1.93, p = 0.03], number of voice breaks [t(184)=-3.3, p = 0.01] and Harmonic to noise ratio [t(184)=2.43, p = 0.04].

The mean and standard deviation values for the parameters which exhibited statistically significant differences between infants with high risk factors and normal infants (Group 1 and Group 2 respectively) are shown in the Table 1. From Table 1, it can be seen that mean values for Mean F0, Maximum F0, Jitter (Local), Number of voice breaks and Harmonic to Noise Ratio were higher in infants with high risk factors compared to normal infants.

Table 1: ***Mean and standard deviation (SD) values for the parameters which showed significant difference across both the groups.***

Parameters	Group 1	Group 2
Mean F0	644.63 (155.76)	600.87 (142.67)
Maximum F0	2414.92 (862.18)	2113.42 (816.93)
Jitter (Local)	2.07 (0.9)	1.74 (0.91)
Shimmer (Local)	9.98 (2.93)	8.38 (2.93)
Number of Voice breaks	0.87 (0.69)	0.58 (0.46)
Harmonic to noise ratio	13.14 (3.57)	12.43 (3.19)

The results of the present study are in accordance with the following studies. The cries of normal and high-risk infants were found to be significantly different in fundamental frequency. [12,13] Sreedevi et al., [10] have reported that there were significant differences between the cries of normal infants and infants with high-risk factors in mean F0, maximum F0 and Harmonic to Noise Ratio. In addition, significant differences were reported in shimmer, number of voice-break, [11] and absolute jitter. [14] Similar findings have been reported by Sangeetha, [15] that the cry parameters found to be useful in differentiating the normal and abnormal groups were average F0, high F0, absolute jitter, shimmer and number of voice breaks.

According to Truby and Lind, [20] pain cries can be either phonated, dysphonated or hyper-phonated. Hyperphonation is characterized by abrupt, upward shift in pitch, which can be up to 2000 Hz due to falsetto like vibration pattern of the vocal folds. Acoustical features and the normal range varies with respect to the particular mode of sound production. Previous spectrographic data shows that, in phonation, the maximum F0 seldom exceeds 550 to 600 Hz, whereas, in case of hyperphonation the Maximum F0 of 1500 to 1600 Hz can be noted. Wasz-Hockert et al., [21] reported that in normal infants, shifts are observed often in the starting of almost every third cry. Double shift commonly occurs in the middle or end of the phonation. Also, shift with a maximum pitch of 1000 to 2000 Hz is mostly noted. Hence, high maximum F0 reported in the present study might be due to presence of shifts.

Michelsson, [8] reported that the fundamental frequency is more and the melody contour has variations in infants with high risk factors compared to normal infants. Shinya, Kawai, Niwa, & Myowa-Yamakoshi, [22] reported that increased F0 in preterm infants were because of complex neuro-physiological states due to different intra-uterine and extra-uterine occurrence. Kheddache & Tadj, [23] have reported that the percentage of voiceless segments depends on pathology and the disparity in voice breaks between preterm infants and normal infants, which are due to immature innervations of the larynx in preterm infants.

According to Orlikoff & Baken (1989), [24] small variations or asymmetries in muscle tension, changes in subglottal pressure such as random airflow through the glottis or perturbations in muscular innervations lead to changes in Jitter and Shimmer values. Buder (2000) [25] reported that the irregularities in the rate or extent of vibration add inharmonic components to the acoustic signal, that is, noise. Air leaking through the glottis in case of incomplete vocal fold closure also adds noise to the signal. Aperiodicities and noise are noted as jitter and shimmer. Harmonic to noise ratio is a common measure of noise.

As seen from the results of the present study, the cry samples of infants with high risk factors have shown higher, mean fundamental frequency, maximum fundamental frequency, Jitter, Shimmer, number of voice breaks and the harmonic to noise ratio which indicate that the abnormal variations in tension of the muscles of the laryngeal system that leads to abnormal variations in the vibration as well as incomplete closure of the vocal folds in case of infants with high risk factors. This has also been explained by Turby and Lind (1965), [20] in the model of the infant cry. Thus, this study has clearly indicated that the acoustic analysis using freely available software, PRAAT, can be used for cry analysis and such an analysis is useful in differentiating the cry samples of infants with high risk factors from the cry samples of normal infants.

CONCLUSIONS

Thus, it was concluded that the acoustic parameters Mean F0, Maximum F0, Jitter (local), shimmer(Local), harmonic to noise ratio and number of voice breaks were useful in differentiating the cries of infants with high risk factors from normal infants. Hence, acoustic analysis of cry of infants can be used for early diagnosis and early intervention in infants with high risk factors. As, the study was carried out on 200 subjects and cry samples were analyzed using PRAAT software, which is a freely available. Hence, results of the study can be used to screen infants on a day to day basis.

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