Speech-6

by

Introduction

Infant cry is the actual means of communication of the baby in the first month of life that raises questions of interpretation in the adult parent/caretaker. Cry is the combination of the functions of brain, the larynx and oral cavity. Cry as a social behaviour, has powerful effects on the parent-child relationship that elicits strong emotions in parents. Infant cry analysis for clinical purposes has been gearing up with its importance in the area of communication disorders in terms of early identification and prevention of communication disorders.

Studies on acoustic analysis of infant cries in the clinical population such as hearing impairment has revealed significant difference in spectral parameters such as fundamental frequency (F0) and the dominant frequency in infants (Várallyay, 2004). In other conditions such as autism, deviancies in spectral parameters such as F0 were observed and many have opined that this kind of an atypical vocal signature could lead to early identification of the conditions (Esposito & Venuti, 2010). Michelsson in 1971 reported no difference in the cry characteristics of LBW infants compared to full term infants with normal birth weight.

Studies had investigated developmental outcome for preterm children and showed a greater incidence of intellectual functioning deficits in early and middle childhood (Caputo, Goldstein & Taub, 1981) as well as increased occurrence of motor dysfunction, learning disabilities, behavioral disorders, difficulties in language comprehension and expression and phonological development (Hunt, Tooley, & Harvin 1982; Brown,Bendersky & Chapman 1986; Grunau, Kearney & Whitfield 1990; Aram, Hack, Hawkins, Weissman, & Borawski-Clark 1991)

Briscoe, Gathercole and Neil Marlow (1998) offered three possible explanations for poor speech and language outcomes in preterm infants. The first one attributes poor outcome to overall poorer intellectual development. The second possibility is that the preterm infant's eventual speech and language behavior is a result of poorer environmental support, with a tendency for premature birth to be associated with lower socioeconomic status. The third possibility states the neurophysiological disturbances arising from complications of premature birth as the reason for the presence of speech language difficulties in them. This would suggest that preterm infants demonstrate a neurophysiological disorder at birth, which may have a detrimental impact on their eventual communicative behavior. Assuming an infant's vocal output is closely regulated by the child's neurophysiology (Golub & Corwin, 1985; Lester, 1987), it is conceivable that abnormalities may be present in the earliest of vocal behaviors i.e. infant cry.

Cry results of the truly premature infants differed from the cry of the normal healthy full term infants and the study revealed that more the premature infant, higher the fundamental frequency, shorter the duration, and more of high pitched (Michelsson, Raes, Thoden & Wasz- Hockert, 1982). Long time average spectrum (LTAS) characteristics of 10 full term and 10 preterm infants revealed significant difference in parameters such as higher first spectral peak (FSP) values in preterm babies which indicated a higher vocal F0 (Goberman & Robb, 1999). However, similar attempt by Chen,Yang, Lin, Chieh Lin (2014) showed contrast finding of lower mean FSP and lower fundamental frequency in preterm infants than full-term infants.

If crying behavior relies on the same anatomical systems that regulate speech, then identification of abnormalities in the crying of preterm infants may provide potentially useful information related to speech outcome. Sangeetha (1999) compared 29 acoustic parameters using Multidimensional Voice Programme (MDVP) in normal children as well as in high-risk babies including premature babies. The study indicated that the most of the acoustic parameters including frequency related, intensity related parameters can differentiate normal and abnormal cries of newborns.

In the international arena, previous work has shown a significant variation in acoustic characteristics of cries of infants with neurological damage, prematurity, medical conditions, SIDS and many other risk factors. However, there is a dearth of research in Indian context to identify communication disorders through acoustic analysis of infant cries that can facilitate early identification of communication disorders. Early assessment of crying behaviour may help to predict the developmental outcome of infants at risk for communication disorders. Thus, the present study aimed to compare the acoustic characteristics of cries in wellborn nursery babies and babies with preterm low birth weight.

Method

Participants

A total of 30 newborns with equal number of wellborn nursery and preterm LBW newborns within seven days of birth were considered for the study. All the infants were born at a government hospital in Mysuru city in the state of Karnataka. The wellborn babies fulfilled the screening criteria, as the babies were full term healthy with no other pre/peri/post complications as observed and reported in the medical case file. Newborns with preterm low birth weight include babies with birth weight of less than 1800 gram and gestational age of less than 37 weeks at birth. All of the preterm LBW infants were recipients of intensive care within the neonatal intensive care unit (NICU). The primary diagnoses for infants were low birth weight with prematurity.

Procedure

The pain induced cries in the wellborn babies were recorded after it received a routine intramuscular immunization (Hepatitis B). During the procedure, the newborns did not receive any kind of behavioral and/or pharmacological approach in order to control the pain. Since vaccination was not provided to the preterm low birth weight babies, alternate pain evoking method was used as tapping on the nose of the infant. The researcher carried out cry recording while the nursing staff performed the immunization procedure for wellborn nursery babies. The audio recorder Olympus LS-100 Multi track linear PCM recorder (48kS/s) was positioned in front of the newborns with an external microphone situated 10 cm away from infant's mouth. The recorded infant cries in MP3 format were transferred to a PC and converted into .wav files for acoustic analyses. Demographic details of the infants were also obtained.

Acoustic Analyses

PRAAT software version 5.4.01 was used for the acoustic analysis. Analysis for the initial 15 seconds of each cry sample, which was selected and segmented from the total cry samples were carried out to extract the acoustics parameters. Frequency, Intensity and Formant parameters were extracted from those samples from the wide band spectrographic displays as shown in Figure 1, 2 and 3.

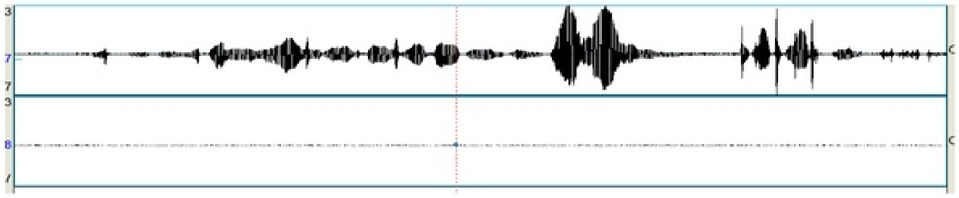

Figure 1: wave form representation of total cry sample

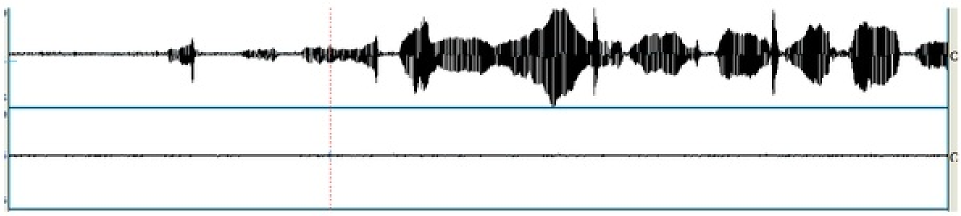

Figure 2: Wave form representation of selected 15 sec cry duration from the onset

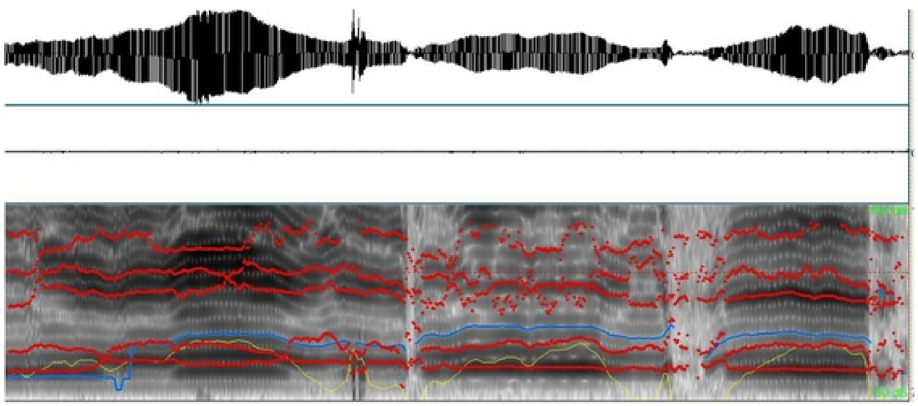

Figure 3: Spectrogram representation of the cry. Formants (Red lines), Intensity (Yellow) and Pitch contour (Blue lines) are shown.

Mean and standard deviation (SD) values for each parameter in preterm LBW and well born nursery babies were tabulated in Statistical Package for Social Sciences (SPSS) version 17.00 for statistical analysis. Differences were considered statistically significant, if p-value was below

0.05. As the data did not achieve normality, Mann- Whitney U-test was used to check the differences between preterm LBW infants and wellborn nurseries.

Results

The present study was aimed to investigate the acoustic parameters of cries in wellborn nursery babies and in babies with preterm low birth weight (LBW). The results are compared and discussed separately under fundamental frequency, formants, number of pulses and degree of voice breaks. Table 1 shows the mean, standard deviation and range of cry variables obtained for both preterm LBW and wellborn nursery babies. The present study revealed a number of significant differences in the cry characteristics in both the groups.

Table 1

The mean, SD and range of cry variables obtained in preterm LBW and wellborn babies

Acoustic Parameters	Normal infants		Low birth weight infants		p- value
	Mean (SD)	Range	Mean (SD)	Range	
Average F0	491 (44)	409 - 553	461 (67)	355 - 562	0.206
Minimum F0	185 (77)	76 - 350	175 (84)	77 - 348	0.760
Maximum F0	1151 (89)	959 - 1255	870 (267)	492 - 119	0.008*
Median F0	486 (40)	404 -546	449 (59)	353 - 542	0.089
Mean intensity	63 (4)	58 - 72	62 (4)	56 - 70	0.337
No. of pulses	4045 (755)	2748 - 5767	3373 (869)	2962 - 2068	0.050*
No. Voice breaks	24 (6)	2 - 35	26 (8)	16 - 41	0.336
Degree of voice break	37 (12)	17 - 56	49 (11)	34-63	0.050*
F1	1155 (94)	1000 - 1291	1076 (73)	938 – 1192	0.029*

F2	2182 (172)	1980 - 2601	1921 (133)	1596 – 2111	0.000*
F3	3274 (102)	3087 - 3458	3189 (110)	3328 -3189	0.089
F4	4192 (212)	779 - 3887	4202 (89)	4046 -4357	0.116

*significant at 0.05 level

a) Fundamental frequency (F0)

Table 1 displays the mean and standard deviation of average, minimum, maximum and median fundamental frequency of all the 30 infants. As observed, the results indicated slightly lower values of average, minimum and maximum fundamental frequencies in preterm LBW babies compared to well born babies. However, Mann- Whitney U-test yielded statistically significant difference (p=0.008) between preterm LBW and well born babies, only for maximum frequency.

b) Formants

Analysis on formants indicated lower F1, F2 and F3 and higher F4 values for preterm LBW infants compared to the control group. Statistical analysis showed significant difference in both F1 (p=0.029) and F2 (p=0.00). No significant difference was noticed in the F3 (p=0.089) and F4 (p=0.116) values.

c) No of pulses and Degree of voice breaks

Preterm LBW infants showed decrease in (p=0.05) number of pulses and increase in degree of voice breaks (p=0.05) significantly compared to well born infants. Number of pulses in the signal represents the voiced component of the cry signal. Lower number of pulses in the cry signal of preterm LBW infants indicates less voiced sounds in the cry compared to the control group.

Similarly, higher degree of voice breaks in preterm LBW infants cry indicates more of silence and unvoiced component in the signal compared to wellborn nursery infants. No significant difference was seen in intensity and number of voice breaks in the infants cry sample analysis.

Discussion

The present study investigated the acoustic analyses of infant cry in preterm LBW and wellborn nursery infants. The results of the present study revealed significant difference in maximum F0, number of pulses, degree of voice breaks, formant (F1 & F2). The average maximum F0 is 870 ±267 Hz for preterm LBW infants which are much lower than that of wellborn nursery infants. Average, minimum and median F0 values also showed lower values in preterm LBW infants but did not show any significant from the control group. Similarly, F1 and F2 values were also lower in preterm LBW babies compared to wellborn nursery infants. However, these results are not in agreement with the earlier studies. Studies on acoustic cry analysis of infants indicated higher minimum fundamental frequency in preterm LBW infants and higher formant values than normal infants (Rautava, Ojala, Parkkola, Rikalainen, Haataja & Lehtonen, 2007). Studies on LTAS measurement in preterm infants demonstrated a high overall first spectral peak across an entire cry sample than their controlled match, which indicates higher vocal F0 in the preterm group (Goberman & Robb 1999). Similar findings of higher F0 in preterm newborns were also reported by Johnston, Stevens, Craig and Grunau (1992). The findings of the earlier studies were attributed to two possibilities. Higher F0 in the cries of preterm infants may simply be related to smaller vocal folds, resulting from physical size differences at birth. Another possibility for the high F0 in preterm infants could be due to the elicitation of additional stress response for the pain stimuli. During the stress of pain, the laryngeal musculature is tightened, which might have effects of raising F0 (Wasz- Hockert, Lind, Vuorenkoski, Partanen, & Valenne, 1968; Zeskind, 1983; Johnston et al., 1992).

In contradiction to these justifications, Shinya, Kawai, Niwa &Yamakoshi (2014) suggest that increased F0 of spontaneous cries in preterm babies were not caused by their smaller body size, but instead might be caused by more complicated neurophysiological states owing to their different intrauterine and extra uterine experiences. However, the lower maximum F0 in our study could be attributed other reasons as fatigue and exhaustion of the babies due to their continuous crying in the NICU as the preterm LBW infants were recipients of intensive care during the recording. Few of the preterm LBW infants were crying even before the nose tapping stimulation and hence their baseline arousal level could not be controlled in the present study. This continuous cry of the preterm LBW infants might lead to fatigue and also the intensity of the cry signal was observed to be reduced in the preterm LBW infants which could possibly result in lower fundamental frequencies. Chen et. al's (2014) study on preterm infants using LTAS is in support with the current study results. They obtained lower fundamental frequency in preterm babies compared to the full term babies and results were justified based on the external factors which are presence of back ground noise during recording, interaction between the infant and caretaker.

The present study also revealed decrease in number of pulses in preterm LBW infants indicating the presence of less voiced sounds in their cry bouts compared to the wellborn nursery infants. The outcome of the analysis also indicated that preterm LBW infants had lesser amount of voicing and or phonation in their total cry duration. This is in consonance with the earlier studies, which indicated lesser amount of phonation and duration of cries produced by preterm infants

(Michelsson et al., 1982; Thoden et al., 1985; Cacace et al., 1995). Goberman and Robb (1999) had measured the percent phonation value i.e. the amount of phonation that remained after the removal of non-voiced portions of the crying episode. The result indicated lower percent phonation in preterm babies in the cry signal (Goberman and Robb, 1999). Even, the present study also revealed similar results with reduced number of pulses or lesser amount of phonation in preterm LBW compared to wellborn nursery infants. Preterm LBW infants were frequently exposed to intravenous injection as a part of their routine care in NICU. Associated Pain, discomfort or distress could have made the infant fatigued, and which would have caused reduced subglottal pressure resulting in cessation of vocal fold vibrations. This could have attributed to the reduced voiced component in cry represented as decreased number of pulses in them.

Degree of voice breaks (DVB) was another parameter, which showed significant difference indicating higher value for preterm LBW infants than wellborn nursery infants. DVB is the ratio of the total length of the areas representing voice breaks in the time of the complete voice sample. Higher degree of voice breaks indicates more of silence and distribution of unvoiced component in the infant cry. Analysis in the present study indicated higher degree of voice break in preterm LBW infants. Various authors also supported the findings of the current study indicating higher degree of voice break in high-risk babies (Sangeetha, 1999; Kheddache and Tadj, 2013). Sangeetha's (1999) study of acoustic parameters using MDVP on normal and high-risk babies showed higher mean value (44.7) of DVB for premature babies compared to normal (30.16) infants. Kheddache and Tadj (2013) reported higher average percentage of no-voice segments for healthy premature cries compared to full-term healthy cries. The authors concluded that the percentage of no-voice segments is not dependent on gestational age, but on the pathology itself and the difference in voice breaks were attributed to the immature innervations of the larynx in preterm newborns.

Conclusions

In precise, the present study indicated deviancies of acoustic variables in preterm LBW infants compared to full term normal babies in terms of fundamental frequency, formants, voiced components and the degree of voice breaks. The collective results suggested the acoustic parameters that could differentiate the specific high-risk population at an early stage for effective management of such infants and it does offer an acoustic profile of the crying behaviour of preterm LBW infants.

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