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A comparative study of voice characteristics of adults with hearing impairment amplified at different ages and normal hearing

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Abstract
The study aimed to compare the voice characteristics of adults with hearing impairment who were fitted with amplification below 3yrs of age, 4.1 to 6yrs of age, 7.1 to 9yrs of age to normal hearing. Sixty subjects among which forty five were hearing impaired and 15 normal hearing with mean age of 22.2yrs and 20.5yrs participated in the study. Voice samples of sustained phonation of vowel /a/ were collected and analyzed using Visi pitch IV (3950B) for fundamental frequency, jitter, Shimmer and Noise to Harmonic Ratio. The mean F0 was higher in all three hearing impaired group and jitter, Shimmer and noise to harmonic ratio of the hearing impaired group who were amplified below three years of age was more similar to normal hearing group as compared to later amplified groups. All voice parameters were largely deviant in Hearing impaired adults group who were amplified after six years of age.

Keywords: Hearing impaired, F0, jitter, shimmer, noise to harmonic ratio, acoustic analysis.

1. Introduction

Human voice is one of the most important tools in everyday communication. Voice is an integral part of the unique human attribute "speech" (Stemple, 1996) [14]. The voice production is therefore the result of complex interplay of the laryngeal, sublaryngeal and supralaryngeal musculature. Voice reflects the physical development of the child. By the age of 18yrs or so, the voice reaches its mature or adult stage (Stathopoulos, 2000) [13]. The auditory feedback plays an important role in phonatory control as well as vocal fold function by regulating respiratory and phonatory physiological processes (Higgins, Carney & Schulte 1994) [8]. When auditory feedback is disrupted, various changes are observed in vocal motor control (Selleck & Sataloff, 2014) [12]. Speech production in normal hearing children is accompanied by auditory self monitoring of their voice. The acquisition and continuous refinement of speech is naturally achieved by children with normal hearing. However, this comes only with special assistance in severely or profoundly hearing impaired individuals. This is because the hearing impaired communicator doesn't have the sensory capacity to experience the sound auditorily (De Filippo, 1982) [3]. In hearing impaired individuals the difficulty to monitor own voice auditorily even after amplification results in different voice quality and poorly controlled pitch and intonation (Oller *et al*., 1985) [11].

The children with hearing impairment cannot or can only partially rely on their auditory feedback in monitoring their speech and they have to use their visual, tactile or kinesthetic senses to a greater extent than the normal hearing children. However, this feedback provided is less precise than the feedback through hearing. In the literature the abnormalities in voice of the hearing impaired are described using various terms like hoarse, breathy, weak, harsh, husky or strident by many authors (Fairbanks, 1960; Zemlin, 1968; Nickerson, 1975 cited by Wirz, 1991) [17]. Ling (1978) [7] stated deviant voice patterns in hearing impaired are likely to occur when too much emphasis is placed on articulation skills and not enough attention paid to controlling breath and voice production.

Voice problems may be associated with all types and extent of hearing loss. A child with a mild to moderate hearing loss may only have difficulties with oral nasal resonance balance while a child with a more extensive hearing loss may not have resonance problems but other problems involving pitch, loudness, jitter and shimmer (Sussan & Sapienza, 1994) [15]. Higgins, Carney and Schulte (1994) [8] studied the speech and voice production abilities in consistent regular hearing aid users and revealed that the individuals with hearing impairment even after having good speech intelligibility had perceptible abnormal voice quality. The authors have related abnormal voice to increased subglottic pressure rather than an inability to produce or self-monitor the pitch.

Lejska (2004) [5] investigated the voices of hearing impaired. The results indicated reduced pitch and intensity ranges and higher fundamental frequency than the normal hearing. This was regarded to the voice spontaneously made in childhood according to motor phonetic reflex which is centrally fixed and never changed after that. Therefore, deaf people maintain a childlike voice production even in the adulthood thus, resulting in greater effort on voice production in deaf people.

Ubrig *et al* (2011) [16] studied fundamental frequency and its variation in forty postlingually deaf adults pre and post cochlear implantation. The results revealed significant decrease in Fundamental frequency and reduced variation in frequency of sustained vowel production after cochlear implantation as compared to pre cochlear implantation. Hence, the authors

concluded significant difference in phonation of individuals with hearing impairment due to lack of auditory feedback control.

Speech production is a complex physiological process which requires coordination of neuromuscular, biomechanical and aerodynamic events. Intelligibility of speech may be influenced by the vocal parameters thus many relevant alterations in these parameters may contribute to enhanced speech output in hearing impaired. Hence, it seems reasonable to study the effect of age of amplification on phonation in individuals with hearing impairment.

2. Need of the study: Presently there is ample data describing the acoustic characteristics of the deviant voices of the hearing impaired. However, studies describing adult hearing impaired voice characteristics in relation to their age of amplification are limited. Knowing the fact that there is an immense importance of auditory experience in voice development, a need was felt to study the effect of age of amplification on the voice characteristics of the hearing impaired. Further the information about the voice parameters and contribution of hearing aids to voice production in hearing impaired would enable speech pathologists to devise more effective intervention strategies.

3. Aim of the study

The study was aimed to compare the acoustic voice characteristics of adults with hearing impairment who were fitted amplification below 3yrs of age, 4.1 to 6yrs of age, 7.1 to 9yrs of age to normal hearing individuals.

4. Methodology

4.1. Subjects

A total of 60 subjects participated in the study. Among which forty five subjects were adult male hearing impaired from which three groups were made depending on the age of amplification which are as following: 15 subjects were fitted with amplification below three years of age HI (1), 15 subjects were fitted with amplification in the age of 4.1 to 6yrs HI (2), & 15 subjects were fitted amplification in the age of 7.1 to 9yrs HI (3). A control group of 15 normal hearing (NH) adults with a mean age of 20.5yrs were studied. In the hearing impaired groups i.e. HI (1), HI (2), HI (3) all the participants were in the age range of 21 to 24yrs with mean age of 22.2yrs, having prelingual severe to profound hearing loss, using conventional hearing aids consistently for a minimum duration of 8 hrs per day since fitting, & predominantly were using verbal mode of communication. All subjects were free of upper respiratory tract infection for three weeks minimum before the voice analysis. The normal hearing subjects were perceptually assessed for voice deviance using GRBAS scale (which stands for grade, roughness, breathiness, asthenicity, and strain) only subjects with zero rating were included in the study. All subjects were screened for oral peripheral mechanism abnormalities, history of problems in breathing, neurological or any other associated problems.

4.2. Procedure

The subjects were seated comfortably in a chair in sound treated room and asked to phonate vowel /a/. The voice sample was collected using digital sony voice recorder with microphone placed 6 to 7 cms from the mouth. The samples were uploaded in Visi Pitch IV (3950B), and Multidimensional voice program was used for further analysis. The initial 500 msec was discarded and rest 1000msec was selected from the samples of /a/ to analyze for the following acoustic voice parameters i.e. fundamental frequency (F0), Jitter, Shimmer and Noise to Harmonic Ratio (NHR).

4.3. Statistical analysis of data

The mean and standard deviation values were calculated for F0, Jitter, Shimmer, & NHR for all four groups. The data was subjected to one way ANOVA to find out significant differences and the results revealed that there was a statistical significant difference ($P< 0.05$) between and within the four groups. Hence, the data was further subjected to Post hoc analysis to find out significant differences between the groups.

5. Results

5.1. Fundamental Frequency (F0): The mean overall F0 (Hz) was high in HI (3) (223.47) group who were amplified at 7.1 to 9yrs of age. The mean F0 of normal hearing adults was the lowest (131.70) among all the groups. The mean F0 of HI (1) group who were amplified below three years of age was the lowest within the hearing impaired group. On overall observation of mean F0 there was a statistical significant difference ($P<0.05$) between all three hearing impaired groups compared with normal hearing NH. However, there was no statistical significant difference with in the three Hearing impaired groups. The results are presented in Table 1 and displayed in Graph 1.

Table 1: Mean Fundamental frequency F0 in Hz and Standard Deviation across four groups

Groups	Age of amplification	Mean	Standard deviation	n	Minimum	Maximum	F	P
HI (1)	Below 3yrs	200.28	54.62	15	141.44	332.71	6.676	0.001
HI (2)	4.1 to 6yrs	203.89	48.29	15	140.92	287.69		
HI (3)	7.1 to 9yrs	223.47	93.10	15	167.06	441.88		
NH	-	131.70	21.13	15	97.63	157.41		

95% Confidence Interval for Mean		
Groups	Lower Bound	Upper Bound
HI (1)	170.0312	230.5368
HI(2)	177.1445	230.6355
HI(3)	171.9117	275.0323
NH	119.9936	143.4073

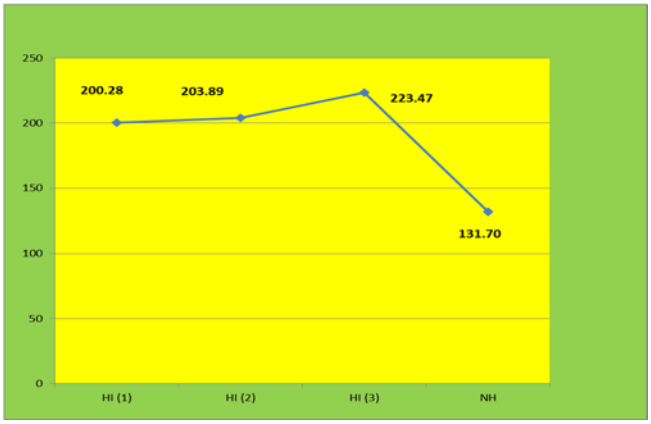

Fig 1: Mean Fundamental Frequency (Hz) across four groups

5.2. Jitter %: The overall mean jitter value was the highest in hearing impaired group HI (3) (2.366) who were amplified at 7.1 to 9yrs of age followed by HI (2) (2.251) who were amplified at 4.1 to 6yrs of age. The mean jitter value was lowest in normal hearing group (0.32). Among the three hearing impaired groups HI (1) who were amplified below three years of age had lowest mean jitter value (1.253). On overall observation of mean jitter value there was a statistical significant difference (P<0.05) between all three HI groups compared to normal hearing group. However, there were statistically significant differences in hearing impaired groups only between HI (1) to HI (2) & HI (3) i.e. Jitter values of HI (1) who were fitted below three years of age were more similar to normal hearing group. The jitter % across all the four groups is presented in Table 2 and displayed in Graph 2.

Table 2: Mean Jitter in % and Standard Deviation across four groups

Groups	Age of amplification	Mean	Standard deviation	n	Minimum	Maximum	F	P
HI (1)	Below 3 years of age	1.253	0.849	15	0.36	3.47	9.477	0.000
HI (2)	4.1 to 6yrs	2.251	1.603	15	0.26	6.28		
HI (3)	7.1 to 9yrs	2.366	1.585	15	0.26	6.28		
NH	-	0.321	0.114	15	0.18	0.59		

95% Confidence Interval for Mean		
Groups	Lower Bound	Upper Bound
HI (1)	0.7830	1.7240
HI(2)	1.3640	3.1396
HI(3)	1.4888	3.2446
NH	0.2581	0.3846

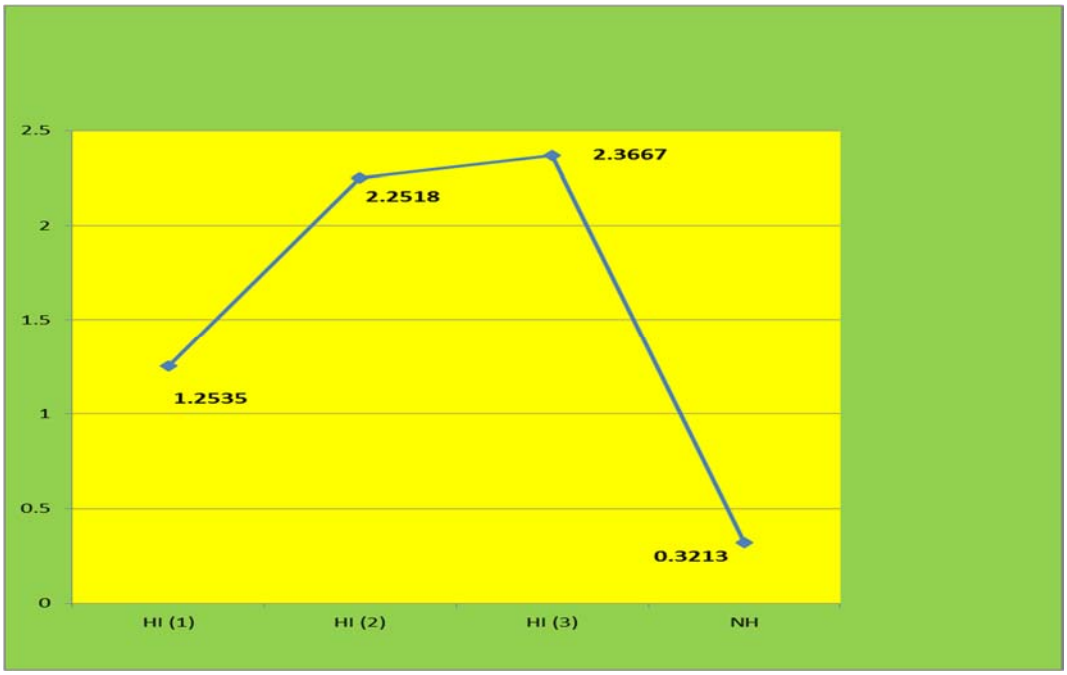

Fig 2: Mean Jitter in % across four groups

5.3. Noise to Harmonic Ratio (NHR): The overall mean NHR value was the highest in hearing impaired group HI (3) (0.305) who were amplified at 7.1 to 9yrs of age followed by HI (2) (0. 281) who were amplified at 4.1 to 6yrs of age. The mean NHR value was lowest in normal hearing group (0.142). Among the three hearing impaired groups HI (1) who were amplified below three years of age had the lowest mean NHR value (0.270). On overall observation of mean NHR value there was a statistical significant difference (P<0.05) between all three HI groups compared to normal hearing group. However, there were significant differences in hearing impaired groups only between HI (3) to HI (1) & HI (2) i.e. NHR values of HI (3) who were fitted at 7.1 to 9 yrs of age were more deviant to all other groups. The NHR across all the four groups is presented in Table 3 and displayed in graph 3.

Table 4: Mean Noise to Harmonic Ratio (NHR) and Standard Deviation across four groups

Groups	Age of amplification	Mean	Standard deviation	n	Minimum	Maximum	F	P
HI (1)	Below 3 years of age	0.270	0.130	15	0.12	0.65	5.589	0.002
HI (2)	4.1 to 6yrs	0.281	0.136	15	0.12	0.58		
HI (3)	7.1 to 9yrs	0.305	0.145	15	0.12	0.58		
NH	-	0.142	1.711E-02	15	0.10	0.17		

95% Confidence Interval for Mean		
Groups	Lower Bound	Upper Bound
HI (1)	0.1986	0.3432
HI(2)	0.2054	0.3567
HI(3)	0.2243	0.3857
NH	0.1330	0.1519

Fig 3: Mean Noise to Harmonic Ratio across four groups

5.4. Shimmer %: The mean overall shimmer (%) was high in HI (2) (9.68) group who were amplified at 4.1 to 6yrs of age followed by HI (3) group (7.89) who were amplified between 7.1 to 9yrs of age. The mean shimmer of normal hearing adults was the lowest (3.78) among all the groups. The mean shimmer of HI (1) group who were amplified below three years of age was the lowest (7.48) within the hearing impaired group. On overall observation of mean shimmer there was a statistical significant difference ($P<0.05$) between all three hearing impaired groups compared with normal hearing. The results are presented in Table 4 and displayed in Graph 4.

Table 3: Mean Shimmer in % and Standard Deviation across four groups

Groups	Age of amplification	Mean	Standard deviation	n	Minimum	Maximum	F	P
HI (1)	Below3 years	7.4851	2.1235	15	5.49	12.65	16.792	0.00
HI (2)	4.1 to 6yrs	9.6843	3.2642	15	5.23	15.31		
HI (3)	7.1 to 9yrs	7.8927	2.4508	15	5.23	13.37		
NH	-	3.7820	0.8732	15	2.69	5.66		

95% Confidence Interval for Mean		
Groups	Lower Bound	Upper Bound
HI (1)	6.1279	8.8423
HI(2)	7.8766	11.4919
HI(3)	6.7167	9.0686
NH	3.2984	4.2656

Fig. 4: Mean Shimmer in % across four groups

6. Discussion: The overall study findings indicate higher F0 similar to findings of Lee (2012) [6]. Higher jitter, shimmer, noise to harmonic ration in adults with hearing impairment compared to normal hearing. These findings are similar to study conducted by Dehqan & Scherer, (2010) [2]. The values of F0 when observed individually were slightly varying within all the three hearing impaired groups irrespective of their age of amplification however these were not statistically significant. The possible reason for this might be that the conventional hearing aids used i.e. body level or analog BTE's by the hearing impaired have lesser bandwidth which may affect the auditory feedback and make them rely more on Kinesthetic feedback for controlling voice parameters (Ferrand 2006) [4]. On the evaluation of jitter%, Shimmer % and NHR values the hearing impaired group who were amplified below three years of age were found to be more similar to normal hearing group as compared to later amplified groups. As Jiitter, shimmer and noise to harmonic ratio are acoustic dimensions which reflect the stability of vocal fold vibration these findings indicate that the hearing impaired have considerable difficulty in maintaining phonatory stability as compared to normal hearing when amplified at a later age Monsen (1979) & Horii (1980) [10, 9]. On overall vocal parameters observation in the present study are largely deviant in hearing impaired individuals who were amplified at much later ages thus clearly emphasizing the role of audition in voice development.

7. Conclusion: With the study findings it can be concluded that in deaf adults who are amplified after six years of age had higher phonatory instability and spectral noise in their voice indicating lack of auditory experience and possible inference of reduced laryngeal control during phonation. The voice parameters of deaf adults who were amplified below three years of age were largely similar to normal hearing adults hence, reflecting the importance of early amplification and auditory feed back in voice development. Therefore, voice rehabilitation strategies used in hearing impaired should focus not only on auditory training but also on other aspects which help improving the vocal fold vibration stability.

References

1. Calvert DR, Silverman SR. Speech and deafness. Revised Ed. Washington DC: Alexander Graham Bell association for the Deaf, 1983.
2. Dehqan A, Scherer RC. Objective Voice Analysis of Boys With Profound Hearing Loss. Journal of Voice. 2010; 25(2):e61-e65.
3. De Filippo. Tactile perception. In D.G sims, G.G Walter and R. L Whitehead (Eds), Deafness and communication Assessment and training. Baltimore: Williams & Wilkins, 1982, 40-52.
4. Ferrand CT. Relationship between masking levels and phonatory stability in normal-speaking women. Journal of voice. 2006; 20(2):223-228.
5. Lejska M. Voice field measurements - a new method of examination: the influence of hearing on the human voice. Journal of voice. 2004; 18(2):209-215.
6. Lee GS. Variability in Voice Fundamental Frequency of Sustained Vowels in Speakers with Sensorineural Hearing Loss. Journal of Voice, 2012; 26(1):24-29.
7. Ling D. speech development in hearing impaired. Journal of communication disorders.1978; 11(2-3):119-124.
8. Higgins MB, Carney AE, Schulte L. Physiological assessment of speech and voice production of adults with hearing loss. Journal of Speech and Hearing Research. 1994; 37:510-521.
9. Horii Y. Some voice fundamental frequency in tree groups of hearing-impaired individuals. Journal of Communication Disorders 1980; 13:195-205.
10. Monsen RB. Acoustic qualities of phonation in young hearing-impaired children. Journal of Speech and Hearing Resarch. 1979; 22:270-288.
11. Oller Dk, Eilers RE, Bull DH, Carney AE. Prespeech vocalizations of a deaf infant: a comparison with normal metaphonological development. Journal of Speech and Hearing Research. 1985; 28(1):47-63.
12. Selleck MA, Sataloff RT. The impact of auditory system on phonation: A review. Journal of voice. 2014; 28(6):688-693.
13. Stathopoulos DN. A review of the development of the child voice: an anatomical and functional perspective. In P.White (Ed), *Child voice*. Stockholm, Sweden: KTH Voice Research Centre, Department of Speech, Music & Hearing (KTH). 2000, 1-12.
14. Stemple JC. Voice disorders: an introduction. Language, Speech and Hearing Services in Schools 1996; 27(1):239.
15. Sussan JE, Sapienza C. Articulatory development and gender effects on measures of fundamental frequency and jitter. Journal of Voice. 1994; 8(2):145-156.
16. Ubrig MT, Goffi-Gomez MV, Weber R, Menezes MH, Nemr NK, Tsuji RK. voice analysis of postlingually deaf adults pre & post cochlear implantation. Journal of voice. 2011; 25:692-699.
17. Wirz S. The Voice of the deaf. In M. Fawcus (Ed), Voice Disorders and Their Management. London: Croom Helm. 1986, 240-259.