INVESTIGATING VOICE CHARACTERISTICS OF PEDIATRIC HIFZ PARTICIPANTS

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DEDICATION

This dissertation is dedicated to:

My great teacher and messenger, Prophet Muhammed (peace be upon him), who taught me the meaning of life, My parents and grandparents, who were the reasons for achieving all that I accomplished today, My teachers, who guided and supported me throughout my life, especially My guide and mentor Dr. K. Yeshoda, My beloved siblings, who loved and cared me, and All people, who helped me in different phases of my life.

CERTIFICATE

This is to certify that this dissertation entitled "**Investigating Voice Characteristics of Pediatric Hifz Participants**" is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech-Language Pathology) of the student with Registration Number: P01II21S0023. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru

September, 2023

Prof. M. Pushpavathi

Director

All India Institute of Speech and Hearing

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CERTIFICATE

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DECLARATION

This is to certify that this dissertation entitled "**Investigating Voice Characteristics of Pediatric Hifz Participants**" is the result of my own study under the guidance of Dr. K. Yeshoda, Associate Professor in Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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CHAPTER 1

INTRODUCTION

Voice is defined as the laryngeal modulation of the pulmonary air stream, which is further modified by vocal tract configuration (Michael & Wendahl, 1971). A perceptually normal voice involves the coordination between different subsystems, such as respiratory, phonatory, articulatory, and resonatory systems. The dimensions of voice, such as pitch, loudness, and qualiy, are structurally altered by the size, length, tension, and mass of the vocal folds (Titze, 1995). Functional influences such as lifestyle changes, poor diet, and a lack of concern for voice usage will all contribute to poor voice quality. Any individual who is impacted by these factors whether a professional or non-professional voice user is at risk of having voice problems.

Professional voice users are those who directly depend on vocal communication for their livelihood (Stemple, 1993). As per Koufman & Isaacson (1991), clergymen, priests, imams, teachers, politicians, and telephone operators can be considered as Level II professional voice users, wherein when they experience moderate vocal difficulty, it would hamper their job performances. Imams are professional voice users elected by Muslim communities to lead five daily congregational prayers in mosques. Often most of the Imams are involved in use of loud voice in reciting the Quran and prayers, some are involved in reading the Khutbah (referred to as ‘Khatib) lessons delivered in mosques every ‘Friday’ and on special occasions. Along with these responsibilities, some Imams also overload their vocal mechanism by teaching Madrassa (Islamic studies) and giving other public speeches, Jayakumar et al. (2022).

During the training period, Imam aspirants may enrol in Alim (higher education in Islamic religious science and Imam training) and/ or to the Hafiz programs to qualify as an Imam. Usually, the participants (Imam trainees) of the Hifz program will enrol to

the program at early childhood ages. The Hifz program includes memorization and recitation of the Quran. This program focuses more on melodious reading to convey different feelings and abide by specific rules and regulations of recitation. During this program, the participants are recommended to read the Quran in a loud and clear voice to improve their recitation skills. This program will be held every day of the week, except Friday (Islamic holiday) with an around 8 hours per day of practice period (Maria International School, n.d.). The program duration lasts for 2 to 3 years of training, but the years for training will vary depending upon the memorization power of a student (Mishkah Academy, n.d.). Because of the lengthy training requirements, these programs often limit participants' access to regular schooling.

Studies on Imams' vocal functions have shown to have a 64% of point prevalence of voice problems, and they are associated with various risk factors such as constant use of loud voice, experiencing acid reflux, developing unhealthy vocal habits, and lack of hydration (Yasin, 2018; Jayakumar et al, 2022). Many of the studies have focused on analyzing the vocal functions of Imams with respect to psychosocial factors (Malki & Mesallam, 2012), fasting (Al-Khoufi et al, 2017), and voice training programs (Jayakumar et al, 2022). The Imams may also face a higher vocal load during their training program, being enrolled into the programs at childhood age and this has not been explored in previous literature.

In childhood age range between 2-11 years, voice differs in several ways due to variations in the head and neck, larynx, and vocal fold anatomy compared to adolescence and adulthood, Williams et al. (2012). In addition, many vocal characteristics are underdeveloped until puberty, and the extended use of voice in childhood is vulnerable to developing vocal issues (Barlow & Howard, 2002).In a

cross-sectional study among a large sample (n = 7389) of eight years old children, Carding et al, (2006) identified a 6% prevalence of voice problems.

Interestingly, most of the studies on children who are in practice or training in singing-related programs showed that these training programs positively affected their voice quality (Clarós et al., 2019). Studies have also suggested that singing might complement conventional voice and speech therapy in a positive way (Rinta & Welch, 2008), and chanting, for instance, has been discovered to have a calming impact (Korovin et al, 2003) in children. In contrast, some studies have shown that children with similar practices have experienced neuromuscular issues in laryngeal regions (Trollinger, 2007). Still, it is unclear whether all the singing, reciting, and chanting practices have the same positive impact on vocal functioning in childhood.

Need for the study

Imams considered as Professional Voice Users experience more vocal demands and problems in adulthood (Jayakumar et al, 2022). However, there is no study to examine whether they face any vocal issues during their training in childhood ages.

Reciting being a practicing skill during the Hifz program, demands continuous voice use for long hours during the course of training. There are no studies available that highlight the impact of such extended hours of voice use for training in children. Hence, it appears to be an absolute necessity to investigate the voice characteristics, in terms of quantitative acoustic, qualitative and aerodynamic measures of children's voice who are enrolled in the Hifz program. Further, these voice characteristics have to be compared with children who are not enrolled in the Hifz program to understand the impact of the prolonged voice use during Hifz program training. The results will further improve our understanding of laryngeal anatomy and physiology and voice

characteristics in children who are training to be professional voice users. The results will also become necessary for implementation of appropriate measures for voice use and preventive and corrective measures to reduce voice complaints and issues experienced by children.

Aim

To explore the voice characteristics of Hifz participants using acoustic, aerodynamic, and voice quality measures.

Objectives

- To investigate the acoustic, aerodynamic, and voice quality measures of voice in children attending the Hifz program and children not attending the Hifz program.
- To compare the acoustic, aerodynamic, and voice quality measures of voice between the two groups.

CHAPTER 2

REVIEW OF LITERATURE

The Hifz program includes memorization and recitation of the Holy Quran. Quran recitation focuses more on melodious reading to convey different feelings and abide by specific rules and regulations of recitation. The significance of Hifz in Islamic scholarly education is high, and this highlights the demanding nature of this practice among Muslim children, especially those aspiring to become scholars. Aspirants of Islamic scholarships usually enrol in this program at a younger age, at about 7-9 years of age (Darul Huda Islamic University, n.d.).

Recitation of the Quran is more similar to singing than speaking. With regard to singing training, studies exploring the effects of such training on voice in adult and children populations are available in literature. A systematic review of five major scientific databases on the prevalence of voice disorders on adult singers showed that regardless of singing style both trained and untrained, singers had significantly higher prevalence of voice problems (Pestana et al., 2017). Another study on three hundred and fifteen adult choir singers based on web questionnaire on vocal symptoms, voice knowledge, and risk factors for developing voice problems, showed that the prevalence of voice disorders in adult choir singers are similar to other professional voice users (Ravall & Simberg, 2020). Most of the research on adult singers indicates the risk of developing voice problems in them. In contrast, one study on adult singers documented a positive effect of singing on aging voice wherein, it was reported that the stability of pitch and amplitude did not decline with age in frequent singers (Lortie et al., 2017).

After briefly exploring studies on voice characteristics of adult singers, researchers presently have begun to focus on a crucial aspect of the voice pedagogy:

the voice characteristics of children vocalists. In general, children's voice issues are extremely common compared to adults, and there are undoubtedly a variety of developmental, societal, and environmental factors that contribute to this (McAllister & Sjölander, 2013). Prevalence of voice disorders in the children is documented in the literature. A study on a large group of children (n = 7,389) who were eight years of age, showed that dysphonia was prevalent in children, 6% as per research clinician reports and 11% as per parental reports (Carding et al., 2006). Having elder siblings, being male, and spending long days in large groups were all identified as risk factors for developing voice problems in children (McAllister & Sjölander, 2013). Children have high risk of developing voice problems resulting from tissues reaction to heavy voice usage, researchers suggested that this may be because that under developed vocal folds lack the protecting vocal ligament's three-layered structure (Trollinger, 2007). Children's voice quality has been shown to be impacted by brief group activities like camps based on a study done on ninety-six children (mean age of 11.3 years) who attended summer camp. Hoarseness of children's voice was evaluated using 4-point integral scale. Results showed that hoarseness increased post camp compared to before the summer camp (Casper et al., 1981). Compared to adults, children appear to be more sensitive to environmental factors such as background noise. Various vocal parameters including loudness, subglottal pressure, fundamental frequency, and voice quality, have been observed to be affected by background noise (McAllister & Sjölander, 2013). Szkiełkowska et al. (2020) surveyed 7891 parents who answered 5 survey questions related their children's voice problems and probable causes. Among the participants 35% of children's parents opinioned the important elements causing voice disorder in children were they being noisy and speaking with excessive loudness. Also, the boys

children group reported having more voice problems than girls children group. These studies shows the importance of identifying and treating of voice problems in children.

There are studies available on children vocalists like singers. Most studies documented a positive effect of singing participation on children's voice. In a study on children choir singers aged 8 to 14 years, authors assessed the prevalence of voice disorder by using videostroboscopy. They found that children practicing choir singing lowered the likelihood of voice issues (Clarós et al., 2019). Another study was done on 76 pre-pubertal children using voice recordings, interviews, and a survey. Half of the participants received formal singing instruction, whereas the other half had not. Results showed a noticeable positive impact of formal singing on children's general voice functionality as well as their psychological well-being. Thus, results suggested that singing could be used in educational settings with kids who have voice and speech impairments to help them improve in those areas (Rinta, 2008). A study on 164 normal children and adolescents showed a similar positive impact compared maximum voice intensity, maximum intonation duration, mean fundamental frequency (normal and loud phonation), and frequency and dynamic range of voice and its borders with a voice range profile. The results indicated that children and adolescents who regularly practised singing had improvements in several vocal parameters (Fuchs et al., 2006).

Various measures have been carried out to evaluate the voice characteristics of professional voice users, that includes aerodynamic, acoustics, perceptual and imaging analysis. Such studies conducted on professional voice users examine various acoustic parameters like frequency-related, intensity-related, and noise parameters. Acoustic parameters such as frequency and intensity reflect individual's vocal capability as shown in a study by Siupsinskiene & Lycke (2011). Perturbation measures, jitter indicates the control of vocal fold during vibration, and shimmer indicates the ability

to maintain glottic resistance during phonation, whereas noise parameter, HNR indicates the amount of energy spectrum within voice harmonics (Teixeira et al., 2013). Abdelhamid & Al-Khoufi (2017) used acoustic parameters such as fundamental frequency (F0), relative average perturbation (RAP), shimmer (Shim), noise to harmonic ratio (NHR), and voice turbulence index (VTI) to compare group of 17 Imams (professional voice users) who received voice guidelines and another group of 17 imams who did not receive voice guidelines. The study found positive effect of voice guidelines in group that received the voice guidelines. Another study by Yeshoda et al.(2018) examined voice characteristics of Madrassa teachers (teachers of Islamic schools) by measuring jitter percent (jitter %), relative average perturbation (RAP), and noise-to-harmonic ratio (NHR) from phonation samples. The results showed an increase in all measured parameters compared to the control group indicating the deviancy of voice characteristics in the experimental group.

Similar to acoustic analysis, voice quality analysis is another method used in research to understand the voice characteristics of different populations. Voice qualities like harshness, breathiness, and hoarseness can be measured objectively using a few softwares, such as, Dr. Speech. A study done by Asnaashari et al., (2012) measured voice quality parameters (Breathiness, Harshness, and Hoarseness), acoustic parameters (Fundamental frequency, jitter, shimmer, and Normalised noise energy), and an aerodynamic parameter (s/z ratio) to compare voice quality of 34 untreated adults with mild to severe asthma and another 34 healthy adults. Dr. Speech software was used to measure selected voice quality and acoustic parameters. The results revealed a significant difference in all three voice quality parameters, and the authors concluded that lower airway diseases like asthma can impair voice quality.

Aerodynamic analysis is also used in studies of vocal function in various populations. A study reported that aerodynamic measurements reflected voice pathology more clearly than acoustic spectral measurements (Holmberg et al., 2003). Maximum phonation duration (MPD) and s/z ratio are aerodynamic measures which are usually used in routine voice evaluation. MPD gives a rough indication of respiratory and laryngeal functioning. The s/z ratio assesses the amount of time of vocal emission with or without laryngeal vibration and can detect vocal fold lesions or damage (Gelfer & Pazera, 2006). A network meta-analysis study showed that maximum phonation duration was improved post-vocal function exercise training in adults with voice disorders (Latoszek et al., 2023). Asnaashari et al., 2012 also reported significant difference in s/z ratio along with other parameters (normalized noise energy, and voice quality parameters) in 34 untreated adults with mild to severe persistent asthma.

Duan et al. (2011) examined the effectiveness of the voice training program on 31 adult professional voice users suffering from various voice symptoms without any organic pathologies. They used MPD measurement, VHI, and few selected acoustic measures (noise-to-harmonic ratio, jitter, and shimmer) to compare voice quality before and after the voice training. The results revealed significant positive changes in MPD, VHI, and jitter after the training, whereas other measures (noise to harmonic ratio and shimmer) did not differ significantly.

Rosa et al. (2014) explored the voice characteristics of 20 healthy individuals in the age range of 10 to 18 years (children & adolescents) who were regular members of choir singing using a voice evaluation protocol that included MPD, s/z ratio, and other voice-related measures. The MPD values of the participants were divided as “above, adequate, and below” categories based on age-matched norms from the literature. The s/z ratio of the participants were distributed as altered (above 1.2 sec & below 0.8 sec)

and adequate (0.8 sec to 1.2 sec). Results of the study showed that 60% of the participants had increased maximum phonation duration of the vowel /a/ and 80% of the participants had adequate s/z ratio.

A prevalence study on 501 Iranian primary school participants in the age range of 10 to 12 years showed dysphonia subjects with laryngeal pathology had significantly greater s/z ratios (Mohammadzadeh & Sandoughdar, 2017).

Children are more susceptible to voice issues owing to the developing respiratory and laryngeal systems that make them more prone to respiratory related infections. Voice training that involves extensive voice use during childhood years have to be investigated to understand the effects of such voice training. Research reports of incidence and prevalence of voice problems being high in children and also detrimental effects of extensive voice use is high in children. However, some studies explored voice characteristics of singers who were children and indicated the positive impact of singing training on children's voice. According to Rinta & Welch (2008) the positive effect on voice was due to the relaxing or calming nature of singing and singing-related programs.

The review of the literature did not reveal any study that explored and reported vocal characteristics of young Hifz participants. Though some studies report the positive impact of singing on children's voice, it will be interesting to explore the effects of prolonged voice use during specific training that involves regular voice use, such as, the Hifz training. Voice characteristics are in general assessed using quantitative and qualitative measure in terms of acoustic, auditory-perceptual and aerodynamic parameters as these parameters reflect the indirect estimation of the

underlying vocal physiology and laryngeal functioning. Also the required tasks for extracting these parameters are easy and simple to execute.

CHAPTER 3

METHOD

Study design

The present study utilized a standard group comparison research method to examine the voice characteristics of pediatric Hifz participants and pediatric Non-Hifz participants.

Participants

A total of 40 male children aged between 10-11 years participated voluntarily in the study and were divided into two groups. Group I included 20 participants who were enrolled in the Hifz program at the age of 8 years with two years of training and reported of 7-8 hours of voice usage per day. Group II included 20 participants who had not enrolled in the Hifz program but attending a regular local government school for formal education. The participant's age, ethnicity, and socio-cultural background were matched by recruiting from the Malabar region of Kerala (specifically from the Palakkad and Malappuram districts). All the participants had no prior knowledge of vocal hygiene practices. Both groups included participants with Malayalam as their native language and were from similar socio-cultural backgrounds and knew to read and write in Malayalam language.

The participants were selected based on inclusive and exclusive criteria, as mentioned below.

Inclusion criteria

Group 1: Participants of 10-11 years of age who are enrolled in the Hifz program with two years of training and enrolled at the age of 8 years. The participants

had normal age-appropriate speech-language skills based on informal screening and did not have history of ear, nose, and throat infections at the time of the audio recording.

Group 2: Participants of 10-11 years of age who were not enrolled in the Hifz program but attending a regular local government school education.

Exclusion criteria

The study did not include participants with a history of communication skills-related problems such as cognitive, hearing problems, speech and voice disorders, or psychological, neurological, and pulmonary issues.

Ethical clearances

Prior informed consent was obtained from the respective institutions and school authorities as well as the caregivers for including the participants in the study.

Instrumentation

A headset microphone (Logitech H150) connected to Laptop (Lenovo Ideapad Slim 3, core i3 10th Generation) was used for recording the voice samples. The Praat software version *6.0* was used to audio-record the speech samples and extract acoustic parameters after analysis of the speech samples. Dr. Speech software (Tiger Electronics, ltd., USA) was used to analyze the voice samples for voice quality measures of all the participants in both groups.

Stimuli and Tasks

1. **Maximum Phonation Duration (MPD):** Participants were asked to take a deep breath and to sustain phonation of the vowel and fricative sounds [a], [s], and [z] individually at their comfortable pitch and loudness for as long as possible

in a single breath. Each participant performed three trials of the maximum phonation task with an interval of one minute between each trial.

2. **Reading:** Participants were instructed to read the Malayalam 300-word passage (Savithri & Jayaram, 2005) fluently without errors.

The stimuli and the tasks were common for both groups of participants. In order to elicit appropriate responses, a small demonstration of each task was shown by the investigator, and the participants were asked to follow the same.

Data Recording Procedure

Participants were made to sit comfortably on a chair in a noise-free room and instructed to complete the tasks. Speech samples (vowel phonation, maximum phonation duration, and the reading task) of each participant were audio-recorded individually using *Praat* Software version *6.00* through a headset microphone, maintaining a 10 cm microphone to mouth distance. The recording was carried out in 44100Hz sampling frequency and 16 bits of quantization.

Data Analysis

Aerodynamic Analysis: Each participant's longest of three MPD trials of sustained phonations of [a], [s], and [z] were noted for the final aerodynamic analysis. The s/z ratio was estimated as the ratio of longest duration of /s/ to the ratio of longest duration of /z/. The s/z ratio was classified as adequate if within 0.8 to 1.2 and altered if above or below the range (Rosa et al., 2014).

Acoustic Analysis: Three seconds of a stable portion of phonation [a] sample and the middle two sentences from the read sample were considered for acoustic analysis using

Praat software. From the phonation sample, Mean pitch (MF0), Mean intensity (MI), Mean noise to harmonics ratio (MNHR), jitter% (local), and shimmer% (local) values were extracted. From the reading sample, Mean pitch (MF0), and Mean intensity (MI) values were extracted.

Voice Quality Analysis: The same three-second phonation sample [a] that was used for extraction of the acoustic parameters was used for voice quality analysis using Dr. Speech. The severity of the voice quality, in terms of hoarseness, harshness and breathiness were noted.

Statistical Analysis

The aerodynamic, acoustic, and voice quality measurements obtained from the speech samples of both groups of participants were tabulated and subjected to statistical analysis using the IBM Statistical Package tool for the Social Sciences (SPSS) software. The research variables of the present study were as follows:

Dependent variables: Acoustic Parameters, Aerodynamic Parameters, and Voice Quality Parameters

Independent variables: Participants of Group I and II.

CHAPTER 4

RESULTS

The present study aimed to investigate the voice characteristics of Hifz participants using acoustic, aerodynamic, and voice quality measures. The study included two groups of participants (Group I: Hifz participants and Group II: Non-Hifz participants). Phonation and reading samples were recorded and analyzed to obtain acoustic, perceptual, and aerodynamic parameters in both groups. Praat and Dr. Speech software were used to extract acoustic and voice quality parameters, respectively. MPD and s/z ratio was estimated by using Praat software.

The statistical analysis which was carried out in the study are:

1. Normality testing for acoustic and aerodynamic data in order to decide on appropriate inferential statistic tests for each parameter.
2. Descriptive statistics for acoustic, voice quality, and aerodynamic parameters.
3. Comparison of Hifz and Non-Hifz participants on acoustic, voice quality, and aerodynamic parameters using SPSS software version 26.0.

For the normality testing, Shapiro – Wilks test was carried out. Results showed that certain acoustic and aerodynamic parameters were within normal distribution, whereas other parameters were non-normally distributed. Accordingly, an appropriate inferential statistic test was carried out for each parameter.

Comparison of acoustic parameters between the groups

Phonation samples and reading samples were subjected to acoustical analysis by using Praat software, and the raw data were uploaded into SPSS software.

Normality test revealed, parameters, MF0, MI, and MHNR of phonation sample and MF0, and MI of reading were normally distributed ($p > 0.05$). Whereas, jitter, and shimmer of phonation samples were non-normally distributed.

Descriptive statistics were done to calculate the mean, median, and standard deviation of both groups, and the values are displayed in Table 1. Considering the acoustic parameters from the phonation sample, the mean and median value of MF0 [*M* = 267.2, *Mdn* = 261.1] and MI [*M* = 74.96, *Mdn* = 75.61] are higher for the Hifz s participant group compared to Non-Hifz participants [MF0: *M* = 248.7, *Mdn* = 247.3; MI: *M* = 69.11, *Mdn* = 69.33]. Similarly the mean and median values of shimmer [*M* = 5.789, *Mdn* = 5.708] and MHNR [*M* = 13.90, *Mdn* = 13.96] were higher in Hifz participants compared to Non-Hifz participants [shimmer: *M* = 5.789, *Mdn* = 5.708; MHNR: *M* = 12.80, *Mdn* = 12.72]. Whereas the jitter mean and median was lower in Hifz participants [*M* = 0.452, *Mdn* = 0.359] in comparison to Non-Hifz participants [*M* = 0.518, *Mdn* = 0.449].

The acoustic parameters under the reading sample showed that the mean and median of MF0 were lower for Hifz participants [*M* = 243.4, *Mdn* = 235.9] compared to Non-Hifz participants [*M* = 248.6, *Mdn* = 248.1]. But the mean and median of MI were higher for Hifz participants [*M* = 67.10, *Mdn* = 68.35] in comparison to Non-Hifz participants [*M* = 65.93, *Mdn* = 65.29].

Both in phonation and reading samples, the standard deviation values of all parameters were lower for the Hifz participants group, but the standard deviation in MF0(P) [*SD* = 47.54] and shimmer [*SD* = 3.023] of the phonation sample were higher in Hifz participants compared to Non-Hifz participants [MF0: *SD* = 39.69, shimmer: *SD* = 2.607].

Table 1: Mean, Median, and Standard deviation of acoustic parameters for all participants.

Parameters	Hifz Participants			Non-Hifz participants		
	Mean	Standard deviation	Median	Mean	Standard deviation	Median
MF0 (P)	267.2	47.54	261.1	248.7	39.69	247.3
MI (P)	74.96	4.442	75.61	69.11	5.186	69.33
Jitter	0.452	0.223	0.359	0.518	0.228	0.449
Shimmer	5.789	3.023	5.708	5.788	2.607	5.495
MHNR	13.90	3.568	13.96	12.80	4.401	12.72
MF0 (R)	243.4	28.43	235.9	248.6	33.87	248.1
MI (R)	67.10	3.682	68.35	65.93	4.556	65.29

(Abbreviations: P-Phonation; R-Reading; MF0-Mean Fundamental Frequency; MI-Mean Intensity; MHNR-Mean Harmonic to Noise Ratio).

Inferential statistics were done to compare acoustic parameters between the groups. Depending upon the nature of the data distribution (normal or non-normal) appropriate parametric or non-parametric test was decided. All parameters except jitter and shimmer were normally distributed ($p > 0.05$). So mean values of these parameters were subjected to the Independent-sampled t-test. As the jitter and shimmer data were not normally distributed ($p < 0.05$), the mean values of these two parameters were subjected to the Man-Whitney U test. The obtained t value from Independent sampled t-test and |Z| value from the Man-Whitney U test, along with mean and standard deviation, are displayed in Tables 2 and 3, respectively.

Table 2: t value and P value of comparison of Hifz and Non-Hifz participants.

Parameters	M(SD) of Hifz participants	M(SD) of Non-Hifz participants	t value	P value
MF0 (P)	267.2(47.54)	248.78(39.69)	1.330	0.191
MI (P)	74.96(4.442)	69.12(5.186)	3.826	0.000*
MHNR	13.90(3.568)	12.80(4.402)	0.865	0.393
MF0 (R)	243.4(28.43)	248.6(33.87)	-0.522	0.605
MI (R)	67.10(3.682)	65.93(4.556)	0.893	0.378

*(Abbreviations: P-phonation; R-reading; MF0-Mean Fundamental Frequency; MI-Mean Intensity; MHNR-Mean Harmonic to Noise Ratio *significance $p < 0.05$ level)*

Table 3: Z value and P value of comparison of Hifz and Non-Hifz participants on phonation

Parameters	M(SD) of Hifz participants	M(SD) of Non-Hifz participants	Z value	P value
Jitter	0.452(0.223)	0.518(0.229)	-1.299	0.194
Shimmer	5.789(3.023)	5.788(2.607)	-0.054	0.957

Among the parameters considered for the parametric test (Independent-sampled t-test), only the MI (P) [$t(38) = 3.82$, $p = 0.00$] showed a significant difference between the groups. Although the mean scores of MF0(P), MHNR, MI(R) in Hifz participants and MF0(R) in non-Hifz participants were higher, no significant difference was observed. The statistical mean scores of Jitter [$|z| = 1.29$, $p = 0.19$] and shimmer [$|z| = 0.05$, $p = 0.95$] revealed that there was no significant difference between the groups on phonation.

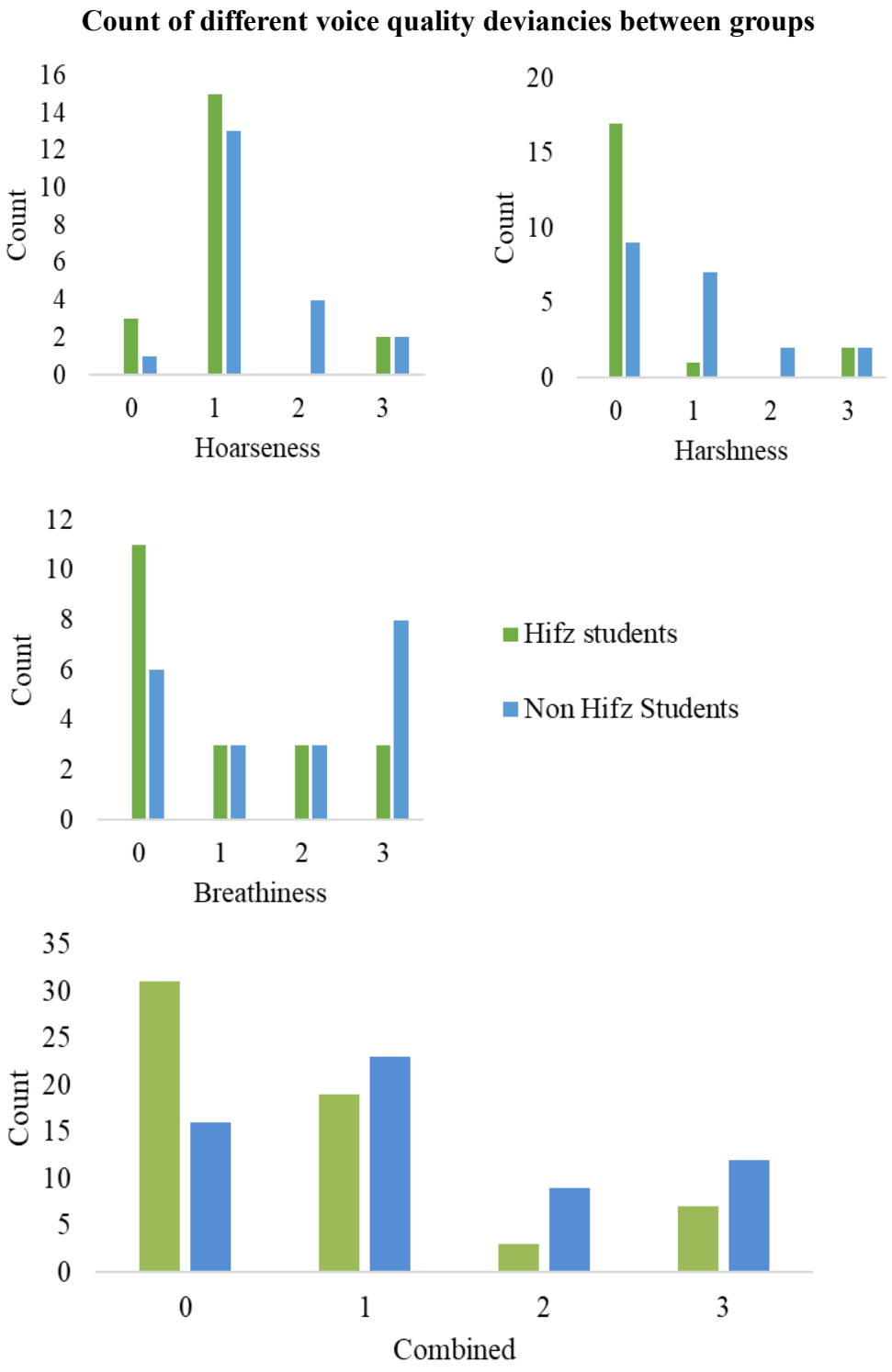
Comparison of voice quality parameters between groups

Voice quality was assessed using Dr. Speech software and parameters from the phonation sample /a/ were extracted, and the raw data were uploaded into SPSS software. Descriptive statistics were done to calculate the percentage and frequency of each voice quality parameter's deviancy levels. Fisher's Exact test was carried out to see the association between groups 1 and 2 with respect to voice quality parameters.

Figure 1 explains the percentage count of each voice quality parameter's deviancy levels. Results showed that the majority (highest count) of the participants in both groups (Hifz participants and Non-Hifz participants) were in the 'mildly deviated' category for hoarseness and the 'no deviance' category for harshness. While the majority of Non-Hifz participants were in the 'severely deviated' category, and the Hifz participants were in the 'no deviance' category, respectively, for their breathiness voice quality. When examining the distribution of deviancy levels (Combined graph which showed the total count of deviancy levels of all three voice quality parameters in Figure 1), it was evident that there were more Hifz participants in the 'no deviance' category than Non-Hifz participants. Whereas all other higher deviation categories ('mildly deviated', 'moderately deviated', & 'severely deviated') had a greater proportion of Non-Hifz participants than Hifz participants.

Figure 1

The number of counts for voice quality parameters' deviancy levels in both Hifz and Non-Hifz participants.



Fisher's Exact test showed significant association between the groups and the levels of deviancy in Harshness quality (p = [.012]). Whereas in other voice quality parameters (Hoarseness (p = [.236]) & Breathiness (p = [.297]) did not show significant association between the groups and the levels of deviancy. The percentage values, along with Fisher's test values, are displayed in Table 4.

Table 4: Percentage of each voice quality parameter and Fisher's Exact test results (p-value) for Hifz and Non-Hifz participants.

Parameters	Groups	Percentage(Count) of Deviancy level				Fisher's Exact test
		No deviancy (0)	Mild deviancy (1)	Moderate deviancy (2)	Severe deviancy (3)	
Hoarseness	Hifz participants	15%(03)	75%(15)	00%(00)	10%(02)	.236
	Non-Hifz participants	05%(01)	65%(13)	20%(04)	10%(02)	
Harshness	Hifz participants	85%(17)	05%(01)	00%(00)	10%(02)	.012*
	Non-Hifz participants	45%(09)	35%(07)	10%(02)	10%(02)	
Breathiness	Hifz participants	55%(11)	15%(03)	15%(03)	15%(03)	.297
	Non-Hifz participants	30%(06)	15%(03)	15%(03)	40%(08)	
Combined	Hifz participants	52%(31)	31%(19)	05%(03)	12%(07)	
	Non-Hifz participants	27%(16)	38%(23)	15%(09)	20%(12)	

*(Abbreviations: Count-Number of times each deviancy level (No deviancy (0), Mild deviancy (1), Moderate deviancy (2) & Severe deviancy (3)) occurred; Combined-Total of all the three voice quality parameters' count *$p < 0.05$)*

Comparison of aerodynamic parameters between groups

The scores of MPD and s/z ratio data were uploaded in SPSS software, and the test of normality was carried out. Results revealed that, the scores of MPD were normally distributed ($P > 0.05$), and the scores of s/z ratio were non-normally distributed.

Descriptive statistics were done to calculate the mean, median, and standard deviation of both groups, and the values are shown in Table 5. The mean, median, and standard deviation of MPD were higher for the Hifz participants, and the values of s/z ratio were higher for the Non-Hifz participants group.

Table 5: Mean, Median, and Standard deviation of Aerodynamic parameters for Hifz and Non-Hifz participants.

Parameters	**Hifz Participants**			**Non-Hifz participants**		
	Mean	Standard deviation	Median	Mean	Standard deviation	Median
MPD	9.790	2.811	9.670	9.289	2.764	9.180
s/z	0.930	0.384	0.796	0.957	0.480	0.849

(Abbreviations: MPD-Maximum phonation duration; s/z-Ratio of sustained /s/ and /z/)

Inferential statistics were done to compare aerodynamic parameters between the groups. Depending upon the nature of the data distribution (normal or non-normal) appropriate parametric or non-parametric test was decided. As the MPD was normally distributed ($p > 0.05$), mean values of the MPD were subjected to the Independent-

samples t-test. Whereas, s/z ratio values were non-normally distributed ($p < 0.05$), and its mean values were subjected to Man-Whitney U test. The |Z| value from the Man-Whitney U test and t value from the Independent-samples t-test, along with mean and standard deviation, are displayed in Table 6.

Table 6: t value/Z value and P value for Hifz and Non-Hifz participants.

Parameters	M(SD) of Hifz participants	M(SD) of Non-Hifz participants	t value/ Z value	P value
MPD	9.790(2.811)	9.289(2.764)	0.569 (t)	0.573
s/z ratio	0.930(0.384)	0.957(0.480)	-0.162(Z)	0.871

*(Abbreviations: MPD-Maximum phonation duration; s/z-Ratio of sustained /s/ and /z; t-t value; Z-Z value *significance $p < 0.05$ level)*

Results showed that the mean scores of MPD of Hifz participants ($M = 9.79$) were higher compared to Non-Hifz participants ($M = 9.28$). Whereas in s/z ratio, the mean scores were higher for Non-Hifz participants ($M = 0.95$) compared to Hifz participants ($M = 0.93$). But the differences were not statistically significant for both MPD [$t(38) = 0.56$, $p = 0.57$] and s/z ratio [$|z| = 0.16$, $p = 0.871$].

Further, the counts of s/z ratios of both Hifz participants and Non-Hifz participants were distributed across two categories (Adequate & Altered) (Table 7). Results showed that almost an equal number (14-15) of participants in both groups came under the 'altered' category.

Table 7; Distribution of s/z ratio across altered and adequate category

Parameter	Groups	Altered	Adequate (0.8 to 1.2)
s/z ratio	Hifz participants	15	5
	Non-Hifz participants	14	6

CHAPTER 5

DISCUSSION

The study aimed to investigate the voice characteristics of Hifz participants by comparing acoustic, aerodynamic, and voice quality measures between the Hifz and the Non-Hifz group of children. The results of this study suggested that comparably voice quality is less deviant in children who are enrolled in vocal training (Hifz participants) than children who did not enrol in vocal training (Non-Hifz participants). Literature have also reported similar findings in children who are enrolled in singing-related programs (Clarós et al., 2019; Fuchs et al., 2006; Rinta, 2008). Even though the effect of the singing program on children's voice was evident but it is unclear whether all types of voice use singing, chanting, and recitation have a similar effect on children's vocal functioning because of the different natures and styles of these programs. In adults, the professional voice users are classified as elite and non-elite professional voice users depending on the vocal demands and voice expectations (Koufman & Isaacson, 1991).

Acoustic Analysis

Acoustic analysis of phonation and reading of Hifz participants and Non-Hifz participants were compared. The acoustic analysis results of the phonation showed a significantly high MI in Hifz group. Even though the mean values of all other acoustic parameters were increased except MF0 (R), jitter in the Hifz group compared to Non-Hifz group participants, statistical significance was absent (Tables 1-5). The significant increase in Mean Intensity (MI) in Hifz participants can be the result of use of loud voice (loud recitation) that they practiced regularly. This result aligns with the results

of Siupsinskiene & Lycke (2011), suggesting that vocal training, especially in children, can contribute to positive vocal capabilities in voice intensity and frequency. The mean MF0 in Hifz participants was higher than Non-Hifz participants and did not reach significance. Even though we were unable to find a similar supporting study in the singing children population, we drew parallels with an existing study in the adult singing population for this exact outcome, that is, a significant difference only in MI but not in MF0. (Prakup, 2012) explored acoustic characteristics of voice in older adult singers and nonsingers and reported significant difference in MI and non-significant difference in MF0 between singers and nonsingers. These findings suggest that MI is a more robust parameter reflecting the effect of vocal programs on voice loudness than MF0.

When results of the acoustic analysis of reading were scrutinized, the mean MI of Hifz participants were higher compared to Non-Hifz participants. This could indicate the generalization and practice effect of regular loud recitation to reading task. Whereas MF0 was higher in Non-Hifz participants. These results find support from Rothman et al. (2001) study, wherein, they reported the Mean F0 extracted from reading sample did not show any role in distinguishing singers from non-singers

Voice perturbation measures in frequency and amplitude, jitter and shimmer showed mixed findings. The confounding effect of voice SPL on jitter and shimmer was larger even after the treatment and jitter and shimmer were reported as least meaningful if voice loudness level was not controlled adequately (Brockmann-Bauser et al., 2014). The median scores of Jitter were higher in Non-Hifz group than in Hifz group but it was not significant. This indicates that the Hifz participants were able to maintain the controlled voice production during phonation and affirms with the findings of (Pribuisiene et al., 2011) that highlighted lower Jitter in singing group of children

compared to non-singing group children. The median scores of shimmer were almost similar in both groups and was in consonance to Pribuisiene et al. (2011), who reported almost similar Shimmer values in both singing and nonsinging groups of children. MHNR was higher in Hifz participants compared to Non-Hifz indicating better harmonics energy spectrum in voice of Hifz participants. Higher HNR values correlate with controlled and better voice production. Hence, Group 1 participants (Hifz) may be thought to possess better voice production than the participants in Group 2 (Non-Hifz).

Voice Quality Analysis

The results of the voice quality of the phonation showed harshness to be significantly different between the groups. 85% of Hifz participants had no deviancy, 5% had mild deviancy, and 10% had severe deviancy on harshness as against 45% with no deviancy, 35% mild deviancy, 10% moderate deviancy, and 10% severe deviancy on harshness in Non-Hifz participants. These difference were significant across participants of groups 1 and 2 (Table 4). Other voice quality parameters, namely hoarseness and breathiness were not significantly different between the groups. Maximum number of participants in groups 1 and 2, (75% Hifz and 65% Non-Hifz) were showed mild deviancy for “hoarseness”. For “breathiness”, most participants in group 1 (Hifz) had no deviancy whereas 40% of group 2 participants showed “severe deviancy”.

In general the voice quality measures were better for the Hifz participants and may be inferred that the Hifz training program had a beneficial effect on the voice of the participants in group 1. Support may be drawn from the findings of Rinta & Welch (2008), who reported that children participating in certain singing programs had

improved voice quality. Further support may be drawn from improved acoustic measures in participants of Hifz group compared to Non-Hifz group. Increased Jitter median and decreased MHNR median in Non-Hifz participants correlated with higher deviancy in hoarseness, harshness and breathiness. Lower mean MHNR correlated with more deviancy of Harshness (Roughness) (Eskenazi et al., 1990) in Non-Hifz participants. However, these correlations must be interpreted cautiously since the Jitter & MNHR differences were not significant between the two groups.

These results of acoustic and voice quality measures, in general, indicated that the Non-Hifz participants might have indulged in vocal abusive behaviours at homes and schools as is commonly noticed in most children. Whereas, children enrolled in regular voice practice and training similar to the participants in Hifz program might refrain from indulging loud talking and vocally abusive behaviors because of their training. Also, the Hifz participants are in residential set-ups and hence follow disciplined life style and may have less exposure to outside world and lesser interactions with peer age group interactions that might have reduced the chances of vocal abuse behaviours.

Aerodynamic Analysis

Aerodynamic parameters, MPD and s/z ratio did not show a significant difference between the groups even though the mean value of MPD was slightly higher in Hifz participants than in Non-Hifz participants, which is in accordance with Rosa et al. (2014) findings. They studied healthy children and adolescents practicing choir and reported that 60% of them had increased MPD on phonation. Extended vocal practice involving various breathing adjustments and vocal modulation may even the result in

untrained singing population achieving better control over the respiratory and phonatory systems compared to the nonsinging population (Ravi et al., 2019). Similar findings of MPD and s/z ratio in both groups of participants may signify similarly maturing respiratory and laryngeal systems. When s/z ratio was checked for adequate and altered categories (Table 7) nearly equal number of participants (5-6) both in Hifz and Non-Hifz groups were within the adequate category (0.8 to 1.2). Whereas, the median of s/z ratio was less in Hifz participants compared to Non-Hifz participants. This could be due to the fact that Non-Hifz children were less exposed to /z/ sound that is present in Arabic language and hence more familiar to Hifz participants. This might have led to the reduced value of /z/ duration, consequently increasing the Median value of s/z ratio in the Non-Hifz group.

Thus, the current study showed that children enrolled in the Hifz program were at advantage as they had comparatively better voice acoustics than Non-Hifz children. And also less likely chances of encountering voice problems compared to other children who were not enrolled in any vocal training program. It may be inferred that the Hifz program (loud recitation of the Holy Quarn) would help in strengthening voice, especially the loudness, pitch control and voice quality maintenance and also help them refrain from indulging in the commonly prevalent childhood vocal abuse behaviours.

CHAPTER 6

SUMMARY AND CONCLUSION

The current study aimed to investigate vocal characteristics of Hifz participants. A total of 40 participants (20 Hifz participants & 20 Non-Hifz participants) were recruited for this comparative study. A selected set of acoustic, aerodynamic, and voice quality measures were extracted from phonation and reading samples to examine the voice characteristics of Hifz and Non-Hifz participants.

Praat and Dr. Speech softwares were used to extract the acoustic and voice quality measures respectively. s/z ratio and MPD were estimated by using Praat software. The results of the acoustic analysis showed significant increase only in the average MI for Hifz participants. All other parameters except shimmer were less deviant in Hifz participants than Non-Hifz participants. Voice quality analysis result revealed that the combined (overall) graph for all voice quality measures showed most Hifz participants to be under “no deviancy” or “mild deviancy” categories. Harshness was significantly deviant in the Non-Hifz group compared to the Hifz group. Among the aerodynamic parameters, mean MPD values were higher in Hifz participants than Non-Hifz participants. A nearly equal number of participants in both Hifz and Non-Hifz participants had s/z ratio within the adequate range.

The overall acoustic and voice quality measures were better for the Hifz participants indicating beneficial effect of the Hifz training program on the voice of group 1 participants. These results further indicates that the Non-Hifz participants could have had the prevalence of indulging in vocal abusive behaviours at homes and schools. In contrast, children enrolled in Hifz program might have refrained from indulging in

loud talking and other vocally abusive behaviors due to their regular training and practice.

The current study results indicate probable positive vocal benefits in children who were enrolled in the Hifz program as proved from better voice acoustics measures than Non-Hifz children. It may also be considered that the Hifz program (loud recitation of the Holy Quran) strengthened voice, especially its loudness and children achieve better pitch control and voice quality maintenance cautioning them to refrain from indulging in the commonly prevalent childhood vocal abuse behaviours. However, strengthening of these preliminary findings by replicating such studies on larger sample and including more tasks and acoustic, aerodynamic and invasive measures will be needed before generalizing the findings of the present study.

Implications of the study

- The findings could initiate newer research perspectives in the area of paediatric vocal pedagogy. Current research evidence highlight the detrimental effects of regular voice practice in children owing to the differences in vocal anatomy and physiology compared to the adults.
- The results are encouraging evidence for the beneficial effects of structured regular voice training programs in children. This indicates that incorporating activities, such as, singing and recitation would reduce the voice deviancies in children. But it is equally important to control other vocally abusive and misuse behaviors in such programs.

- Children's voice is are more sensitive and adopting carefully individualized vocal behaviors and habits should be advocated because of their still-developing laryngeal structures and requires regular monitoring.

Limitations of the study

The sample size of this study was relatively less and therefore limited the statistical power to detect differences in many parameters. Also, the current study only focused only on a few quantitative measures (acoustic, voice quality & aerodynamic parameters) but were not correlated with subjective measures. Future studies can incorporate a more comprehensive approach by incorporating perceptual and self-reported measures.

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