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Multidimensional Voice Profiles in Pediatric Professional Voice Users: Objective and Subjective Comparisons between Hifz Students and Normophonic Peers

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Abstract

Objective: Hifz students, who undergo intensive Qur'an memorization training from childhood, are considered "pediatric professional voice users" due to their prolonged daily recitation and high vocal demands. Such training involves repetitive, loud, and melodic voice use, which may predispose them to early voice disorders. This study aimed to compare the multidimensional voice characteristics of Hifz students, who undergo intensive Qur'an memorization training, with age-matched normophonic peers.

Material and Methods: A total of 124 Turkish-speaking children (62 Hifz, 62 controls; aged 11–14 years) were assessed using the Turkish Children's Voice Handicap Index–10 (TR-CVHI-10), GRBAS scale, aerodynamic measure (maximum phonation time, /s/ and /z/ durations, s/z ratio), and acoustic analyses (fundamental frequency, jitter, shimmer, harmonic-to-noise ratio, cepstral peak prominence smoothed).

Results: Hifz students reported significantly higher TR-CVHI-10 scores ($p<0.001$). They exhibited elevated s/z ratios ($p<0.01$), whereas the maximum phonation time did not differ. Acoustically, Hifz students showed lower fundamental frequency ($p<0.05$), higher perturbation (jitter and shimmer; both $p<0.01$), and reduced harmonic-to-noise ratio and cepstral peak prominence ($p<0.01$). GRBAS ratings indicated predominantly mild-to-moderate dysphonia.

Conclusion: Hifz students demonstrated an elevated risk profile for voice disorders, with adverse self-perceptual, acoustic, aerodynamic, and perceptual indicators. Integrating voice hygiene and structured training into Hifz curricula is recommended to support vocal health.

Keywords Hifz students · Pediatric voice · Professional voice use · Acoustic voice analysis · Voice disorders · Child

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INTRODUCTION

Voice is a fundamental component of human communication and a dynamic social tool that is critical to social interaction and self-presentation (1, 2). In childhood, the healthy development of voice is not limited to phonatory adequacy; it is also associated with communicative effectiveness, social development, self-esteem, and broader psychosocial functioning (3-5). Voice production is a complex motor process that requires the coordination of the respiratory, phonatory, resonatory, and articulatory systems (6). Even minor imbalances within these systems can lead to deterioration in voice quality. Early identification of voice disorders during childhood is therefore critical, both in terms of treatment and for supporting academic and social participation (7).

Research has shown that the prevalence of voice disorders in school-aged children ranges from 6.7% to 53.2% (8-11). Most of these disorders are attributed to phonotraumatic causes, such as inappropriate or excessive voice use (10). In children, phonotraumatic vocal behaviors may contribute to pediatric dysphonia and benign vocal fold lesions, particularly vocal fold nodules and, less commonly, vocal fold polyps (12-14).

Among child populations exposed to heavy voice use (15), students enrolled in Qur'an memorization (Hifz) programs represent a distinctive and understudied group. Hifz refers to the memorization of the Qur'an in its entirety (16). Qur'an memorization is widely practiced in the Muslim educational tradition and continues to be implemented in many educational institutions today (17). In Türkiye, Hifz training is offered to children specifically enrolled in these programs, typically beginning in childhood and lasting approximately two to three years (18). Qur'an memorization represents an intensive and prolonged educational process.

Professional voice users are individuals whose occupational or training activities depend on sustained and efficient voice use (19). Children engaged in performance-related voice activities may experience substantial vocal demands from an early age. However, the available literature on pediatric professional voice users remains limited and is predominantly focused on singing and performing contexts (20, 21). Students receiving Qur'an memorization training have been described as "pediatric professional voice users" due to the intensive voice use required in their educational process (15). This definition is linked to the fact that from an early age, these students engage daily in activities that demand prolonged and high-intensity voice production. Such activities include not only memorizing the Qur'an but also melodic recitation (tilawah), loud repetition, and performances in mosque musical forms (22, 23). In Turkish-speaking religious voice users, Arabic vocal performance has been described as involving larynx-oriented voice use patterns that may contribute to vocal difficulties (22). Moreover, the lack of education regarding proper voice use, vocal hygiene, and breathing techniques further increases the risk to vocal health (24). Indeed, Qur'an reciters, who perform exclusively with the human voice without instrumental accompaniment, are highly sensitive to even minor vocal changes and are concerned about the negative impact of dysphonia on their professional performance (25). The literature also notes that Islamic clergy, similar to teachers and preachers as other professional voice users, are exposed to high vocal load and therefore prone to voice disorders (26, 27).

In the literature, studies on the vocal health of religious officials, who are considered professional voice users, have increased in recent years. Most of these investigations have been conducted with adult male participants, such as imams and muezzins (22-24). These studies have mainly focused on voice disorders and their occupational impact on the context of intensive religious voice use. However, research on Hifz students, who can be defined as pediatric professional voice users (15), remains limited. Yet these children are being trained to become professional voice users in the future and are exposed from an early age to prolonged and high-intensity vocal performances.

The primary aim of the present study is therefore to evaluate the objective (acoustic) and subjective (self-report) voice characteristics of children receiving Hifz training in comparison with normophonic peers without voice problems. Specifically, the study addressed the following research questions:

1. Do children receiving Hifz training differ from normophonic peers in self-reported voice-related outcomes?
2. Do children receiving Hifz training differ from normophonic peers in acoustic voice parameters?
3. Do children receiving Hifz training differ from normophonic peers in aerodynamic voice parameters?
4. How are auditory-perceptual voice characteristics distributed among children receiving Hifz training?

MATERIAL AND METHODS

Study design

This study was designed as a cross-sectional comparative study. The sample size was estimated from TR-CVHI-10 values reported in a previous pediatric voice study (22). An a priori power analysis for two independent groups, using a one-tailed hypothesis, α=.10, and 80% power, indicated that approximately 64 participants per group were required.

Participants

The study was conducted with 124 participants, consisting of 62 students receiving Hifz training and 62 students in the normophonic group. The Hifz group comprised 31 girls and 31 boys aged 11–14 years, attending the Şeyhü'l Kurra İbrahim Tanrıkulu Qur'an Courses for girls and boys in the Acıgöl district of Nevşehir, Türkiye. The normophonic group consisted of 31 girls and 31 boys of the same age range, enrolled in middle schools affiliated with the Nevşehir

Provincial Directorate of National Education, Türkiye. Specific inclusion criteria were applied for the selection of participants.

Inclusion Criteria

Hifz group:

- Attending a Qur'an memorization course for at least one month.
- Ability to understand and speak Turkish.
- Aged between 11 and 14 years.
- Participant and family signed the informed consent form.

Normophonic group:

- Ability to understand and speak Turkish.
- Aged between 11 and 14 years.
- A score of "0" (normal) on the "G" (Grade) parameter of the GRBAS scale.
- No signs of voice disorder during the study period.
- Participant and family signed the informed consent form.

Exclusion criteria for both groups:

- Hearing loss,
- Known neurological disorder.
- Upper respiratory tract infection at the time of assessment.
- History of voice therapy.
- History of laryngeal surgery.

Data collection tools

Children's voice handicap index Turkish (TR-CVHI-10)

The Children's Voice Handicap Index is a self-report instrument that enables children aged 8–14 years to subjectively evaluate the difficulties they experience with their voices (28). In this study, the Turkish adaptation (TR-CVHI-10) was used to allow children to express their voice-related difficulties based on their own perceptions (29). It consists of 10 items, each rated on a four-point Likert scale ranging from 0 (never) to 3 (always). The total score reflects the extent to which the child perceives their voice problem; higher scores indicate a more significant and disturbing perception of a voice problem (29).

GRBAS scale

In this study, the GRBAS scale was used for the auditory-perceptual evaluation of voice quality. GRBAS is a widely used clinical scale that assesses five perceptual dimensions of voice: Grade (overall severity of dysphonia), Roughness (irregularity of vocal fold vibration), Breathiness (audible air leakage), Asthenia (weakness or lack of vocal power), and Strain (perceived vocal effort or tension) (30). Each parameter is rated on a 4-point scale from 0 to 3, where 0 indicates normal voice quality and 3 indicates severe impairment. Higher scores reflect greater perceptual deviation in the relevant aspect of voice quality (30).

Acoustic and aerodynamic voice measurements

Objective voice assessment in this study included acoustic and aerodynamic parameters selected to capture complementary aspects of phonatory function. The acoustic measures comprised fundamental frequency (F0), jitter, shimmer, Harmonic-to-Noise Ratio (HNR), and cepstral peak prominence smoothed. F0 reflects the average rate of vocal fold vibration and corresponds to the perceived voice pitch (31). Jitter represents cycle-to-cycle variations in frequency and generally reflects instability in the timing of vocal fold vibration (32). Shimmer represents cycle-to-cycle variations in amplitude and generally reflects instability in the intensity of the acoustic signal (32). Higher jitter and shimmer values are typically associated with reduced stability of phonation (33). HNR reflects the ratio of harmonic energy to noise in the voice signal, with lower values suggesting a noisier and less periodic voice signal (34). CPPS reflects the degree of harmonic organization and periodicity in the acoustic signal; higher values indicate more periodic voice production, whereas lower values are associated with greater dysphonia (35). In pediatric voice assessment, cepstral analysis has also been shown to help differentiate dysphonic from healthy voices in children (36).

For acoustic analysis, the sustained vowels /a/ and /i/ were used because sustained phonation minimizes the effects of intonation and connected-speech variability, allowing a more stable extraction of jitter, shimmer, and HNR measures (37). In addition, F0 and CPPS were examined not only from sustained vowels but also from connected speech, since these measures can also be derived from continuous speech and may better reflect everyday voice use (38, 39).

Aerodynamic assessment included maximum phonation time (MPT), /s/ duration, /z/ duration, and the s/z ratio. MPT reflects the maximum duration for which phonation can be sustained after maximal inspiration and is commonly used as a simple indicator of respiratory-phonatory efficiency (40). The /s/ and /z/ tasks were included because /s/ is a voiceless fricative, whereas /z/ is its voiced counterpart; comparing their durations through the s/z ratio provides clinically relevant information about glottal efficiency and phonatory control, and higher values may suggest glottal inefficiency (41).

Data collection procedure

Voice recordings were conducted in a quiet environment. Participants were seated in an upright and comfortable position, with the microphone placed approximately 10 cm from the mouth at a 45° angle. Voice samples were recorded using a Shure SM58SE microphone and a Roland Rubix 22 audio interface at a sampling rate of 44,100 Hz and saved in .wav format.

Participants were first asked to sustain the vowels /a/ and /i/ for at least 10 seconds. Then, they were instructed to read the sentence *"Serüvenim, resimde gördüğünüz doğa harikası şu dağ köyünde başladı"*, which is part of the *Pinocchio* passage developed

by Köse as a phonetically balanced Turkish text (42, 43). These samples were used for both acoustic analysis and GRBAS evaluation. For the auditory-perceptual evaluation, the voice recordings were independently rated using the GRBAS scale by three speech and language therapists. One rater had 18 months of clinical experience, one had 30 months of clinical experience, and one was a speech and language therapist with 5 years of clinical experience. The third rater also held a doctoral degree in speech and language therapy, had teaching experience in voice disorders, and had relevant clinical expertise in this area. To maintain blinding, the recordings were coded so that the group identity of the participants was not apparent to the raters. When discrepancies occurred among the ratings, the recordings were reviewed together and a consensus score was established. Acoustic analyses were conducted using the Praat software (Version 6.2.23, 2025.06.24, Freeware, Amsterdam, Netherlands).

To calculate the s/z ratio, participants were asked to produce /s/ and /z/ three times for as long as possible, and the longest durations were measured in seconds and ratioed. For maximum phonation time, participants were instructed to sustain the vowel /a/ for as long as possible, and these durations were recorded. Data collection was conducted throughout December 2024 and was completed by the end of the month.

Statistical analysis

The data were analyzed using software jamovi v2.6.17 (The Jamovi Project, Sydney, Australia) and IBM SPSS Statistic, v27.0 (IBM Corp., Armonk, NY, USA). First, the Shapiro–Wilk normality test was applied, and skewness–kurtosis values were examined to determine the distributional properties of the data. Since the assumption of normality was not met, the Mann–Whitney U test, a nonparametric method, was used to evaluate differences between groups. Descriptive analyses included calculations of frequency, percentage, mean, standard deviation, median, minimum, and maximum values. The significance level was set at p<.05. To assess the magnitude of differences between groups, the rank-biserial correlation coefficient (r_{rb}) was used, with values interpreted as follows: <0.10 = "very small," 0.10–0.29 = "small," 0.30–0.49 = "medium," and ≥0.50 = "large effect size" (44). Inter-rater reliability for the GRBAS evaluations was assessed using the intraclass correlation coefficient (ICC). The ICC was calculated in SPSS using a two-way mixed-effects model with absolute agreement, yielding a value of 0.876 (95% CI = 0.849–0.898), indicating a high level of agreement among raters.

Ethical considerations

Ethical approval was obtained from the Non-Interventional Clinical Research Ethics Committee of Cappadocia University (Date: 03.10.2024, No: 24.17). Official permissions were obtained from the Nevşehir Provincial Directorate of Religious Affairs and the Nevşehir Provincial Directorate of National Education. Children provided assent after receiving age-appropriate information, and written informed consent was obtained from their parents/legal guardians. All procedures complied with relevant ethical standards and the Helsinki Declaration (1975, revised 2024).

RESULTS

The demographic characteristics of Hifz students and normophonic children are presented in Table 1. Daily voice use duration was significantly higher in Hifz students than in normophonic children (U=0, p<.001, r_{rb}=–1.00). Within the Hifz group, girls reported significantly longer daily Qur'an reading time (U=281, p=.003, r_{rb}=–0.42) and daily voice use duration than boys (U=175, p<.001, r_{rb}=–0.64).

Table 1. Comparison of demographic information between Hifz students and normophonic children

Variables	Group	Gender	N	Mean	SD	Median	Min	Max	*U*	p	Effect Size (r_{rb})
Age	Hifz students	Girls	31	13.23	0.96	14.00	11.00	14.00	1611	0.104	−0.16
		Boys	31	12.48	0.96	12.00	11.00	14.00			
		Total	62	12.85	1.02	13.00	11.00	14.00			
	Normophonic children	Girls	31	12.58	1.23	12.00	11.00	14.00			
		Boys	31	12.48	1.09	12.00	11.00	14.00			
		Total	62	12.53	1.16	12.00	11.00	14.00			
Duration of education (months)	Hifz students	Girls	31	31.10	9.28	30.00	12.00	48.00	384	0.108	−0.20
		Boys	31	26.39	12.64	30.00	6.00	48.00			
		Total	62	28.74	11.25	30.00	6.00	48.00			
Daily Qur'an reading time (hours)	Hifz students	Girls	31	10.81	1.60	10.00	9.00	15.00	281	**0.003***	−0.42
		Boys	31	9.74	0.81	10.00	9.00	12.00			
		Total	62	10.30	1.37	10.00	9.00	15.00			
Daily voice use duration (hours) – Between groups	Hifz students	Total	62	13.71	1.29	14.00	11.00	17.00	0	**<0.001***	−1.00
	Normophonic children	Total	62	4.47	0.80	4.50	3.00	6.00			
Daily voice use duration (hours) – Hifz group	Hifz students	Girls	31	14.42	0.99	14.00	13.00	17.00	175	**<0.001***	−0.64
	Hifz students	Boys	31	13.00	1.16	13.00	11.00	16.00			
Daily voice use duration (hours) – Normophonic group	Normophonic children	Girls	31	4.58	0.85	5.00	3.00	6.00	393	0.188	−0.18
	Normophonic children	Boys	31	4.35	0.75	4.00	3.00	6.00			

Duration of education and daily Qur'an reading time were calculated only for Hifz students. *p<.05 indicates statistical significance. SD: Standard deviation, U: Mann–Whitney U test statistic, r_{rb}: Rank-biserial correlation coefficient (effect size).

Table 2 presents the distribution of GRBAS ratings among Hifz students. Overall, ratings were predominantly in the mild-to-moderate range across all GRBAS parameters, with severe ratings observed only rarely.

As shown in Table 3, Hifz students had higher TR-CVHI-10 scores (U=1060, p<.001, r_{rb}=−0.45), longer /s/ duration (U=1186, p<.001, r_{rb}=−0.38), shorter /z/ duration (U=1345, p=.004, r_{rb}=0.30), and higher s/z ratios (U=177, p<.001, r_{rb}=−0.91) than normophonic children, whereas maximum phonation time did not differ significantly.

Table 2. GRBAS ratings of Hifz students (N=62)

Parameter	Gender	Normal (0) n (%)	Mild (1) n (%)	Moderate (2) n (%)	Severe (3) n (%)
G	Girls	1 (3.20)	17 (54.80)	13 (41.90)	-
	Boys	-	9 (29.00)	21 (67.70)	1 (3.20)
	Total	1 (1.60)	26 (41.90)	34 (54.80)	1 (1.60)
R	Girls	10 (32.30)	15 (48.40)	6 (19.40)	-
	Boys	2 (6.50)	14 (45.20)	12 (38.70)	3 (9.70)
	Total	12 (19.40)	29 (46.80)	18 (29.00)	3 (4.80)
B	Girls	10 (32.30)	19 (61.30)	2 (6.50)	-
	Boys	7 (22.60)	13 (41.90)	11 (35.50)	-
	Total	17 (27.40)	32 (51.60)	13 (21.00)	-
A	Girls	1 (3.20)	22 (71.00)	8 (25.80)	-
	Boys	1 (3.20)	13 (41.90)	16 (51.60)	1 (3.20)
	Total	2 (3.20)	35 (56.50)	24 (38.70)	1 (1.60)
S	Girls	4 (12.90)	20 (64.50)	7 (22.60)	-
	Boys	1 (3.20)	11 (35.50)	18 (58.10)	1 (3.20)
	Total	5 (8.10)	31 (50.00)	25 (40.30)	1 (1.60)

GRBAS: Grade (overall severity), Roughness, Breathiness, Asthenia, Strain. Percentages are shown in parentheses.

Table 3. Comparison of voice handicap and aerodynamic measures between Hifz students and normophonic children

Variables	Group	N	Mean	SD	Median	Min	Max	*U*	p	Effect Size (r_{rb})
TR-CVHI-10	Hifz students	62	2.03	1.98	1.00	0.00	6.00	1060	**<0.001***	−0.45
	Normophonic children	62	0.42	0.62	0.00	0.00	2.00			
Maximum phonation time (s)	Hifz students	62	13.50	4.63	13.00	6.00	34.00	1915	0.974	0.003
	Normophonic children	62	13.50	4.37	13.00	6.00	32.00			
/s/ duration (s)	Hifz students	62	14.68	3.63	14.00	7.00	25.00	1186	**<0.001***	−0.38
	Normophonic children	62	12.36	4.17	12.00	5.00	30.00			
/z/ duration (s)	Hifz students	62	11.47	3.38	10.50	5.00	23.00	1345	**0.004***	0.30
	Normophonic children	62	13.65	4.90	13.00	8.00	35.00			
s/z ratio	Hifz students	62	1.30	0.18	1.28	0.94	1.89	177	**<0.001***	−0.91
	Normophonic children	62	0.93	0.19	0.93	0.48	1.19			

TR-CVHI-10: Turkish version of the Children's Voice Handicap Index–10; SD: Standard deviation, U: Mann–Whitney U test statistic, r_{rb}: Rank-biserial correlation coefficient (effect size). *p<.05 indicates statistical significance.

As shown in Table 4, normophonic children had significantly higher F0 values than Hifz students for /a/ (U=1371, p=.006, r_{rb}=0.29), /i/ (U=1426, p=.013, r_{rb}=0.26), and connected speech (U=937, p<.001, r_{rb}=0.51). Hifz students showed higher jitter for /a/ (U=916, p<.001, r_{rb}=−0.52) and /i/ (U=1222, p<.001, r_{rb}=−0.36), as well as higher shimmer for /a/ (U=653, p<.001, r_{rb}=−0.66) and /i/ (U=1306, p=.002, r_{rb}=−0.32). Normophonic children also had higher HNR for /a/ (U=1385, p=.007, r_{rb}=0.28) and higher CPPS for /a/ (U=1289, p=.002, r_{rb}=0.33), whereas no significant group differences were found for HNR /i/, CPPS /i/, or connected-speech CPPS.

Table 4. Comparison of acoustic measures between Hifz students and normophonic children

Variables	Group	N	Mean	SD	Median	Min	Max	*U*	p	Effect Size (r_{rb})
Fundamental frequency /a/	Hifz students	62	216.36	24.43	216.29	118.48	287.17	1371	**0.006***	0.29
	Normophonic children	62	220.68	45.74	232.00	101.90	297.20			
Fundamental frequency /i/	Hifz students	62	219.01	29.49	217.86	121.58	280.53	1426	**0.013***	0.26
	Normophonic children	62	225.87	45.31	234.82	100.94	303.69			
Fundamental frequency (Connected speech)	Hifz students	62	226.88	25.29	231.46	140.48	276.34	937	**<0.001***	0.51
	Normophonic children	62	250.53	52.50	258.33	113.22	344.17			
Jitter (local) /a/	Hifz students	62	0.49	0.18	0.49	0.15	1.21	916	**<0.001***	−0.52
	Normophonic children	62	0.36	0.16	0.33	0.17	1.32			
Jitter (local) /i/	Hifz students	62	0.44	0.18	0.42	0.17	1.39	1222	**<0.001***	−0.36
	Normophonic children	62	0.34	0.13	0.31	0.13	0.62			
Shimmer (local) /a/	Hifz students	62	3.16	1.50	2.91	1.24	7.59	653	**<0.001***	−0.66
	Normophonic children	62	1.91	0.44	1.94	0.76	2.85			
Shimmer (local) /i/	Hifz students	62	2.16	0.86	2.05	0.74	5.18	1306	**0.002***	−0.32
	Normophonic children	62	1.72	0.55	1.60	0.72	3.09			
Harmonic-to-noise ratio /a/	Hifz students	62	20.28	3.25	19.82	14.19	30.78	1385	**0.007***	0.28
	Normophonic children	62	21.43	2.38	21.61	16.52	29.43			
Harmonic-to-noise ratio /i/	Hifz students	62	22.46	2.83	21.86	17.52	29.94	1653	0.179	0.14
	Normophonic children	62	23.12	3.13	22.93	17.89	33.25			
CPPS /a/	Hifz students	62	21.16	2.62	20.71	13.14	28.42	1289	**0.002***	0.33
	Normophonic children	62	22.58	2.50	22.06	18.23	30.26			
CPPS /i/	Hifz students	62	22.15	2.81	22.54	16.05	28.70	1715	0.302	0.11
	Normophonic children	62	22.85	2.49	22.78	18.26	30.45			
CPPS (Connected speech)	Hifz students	62	15.72	1.10	15.57	13.71	18.64	1852	0.728	0.04
	Normophonic children	62	15.84	1.15	15.65	14.22	20.06			

SD: Standard deviation, U: Mann–Whitney U test statistic, r_{rb}: Rank-biserial correlation coefficient (effect size), CPPS: Cepstral Peak Prominence Smoothed. *p<.05 indicates statistical significance

DISCUSSION

This study showed that children receiving Hifz training exhibited a less favorable multidimensional voice profile than their normophonic peers. Overall, the Hifz group reported greater voice-related difficulty, showed less favorable aerodynamic and acoustic findings, and demonstrated predominantly mild-to-moderate perceptual deviations on GRBAS ratings. Taken together, these findings suggest that the intensive and repeated vocal demands of Hifz training may adversely affect vocal function even during childhood.

This pattern suggests that the intensive and often high-intensity voice use required by Islamic rituals and Qur'an recitation can negatively affect voice quality even during childhood. Direct pediatric evidence on this type of voice use remains limited. However, the available literature on pediatric professional voice users indicates that children engaged in sustained performance-related voice activities may face substantial vocal demands and may require careful clinical evaluation and vocal training. Carroll et al. emphasized the complexity of voice demands in pediatric performers (20), while Crossley et al. highlighted the scarcity of literature in this area and the need for adequate vocal training and multidisciplinary management (21). In religious officials and other professional voice users, the nature of the work entails prolonged, high-intensity vocal tasks with variable pitch demands, which place a heavy vocal load (45). When training and vocal hygiene support are insufficient, this load predisposes individuals to phonotrauma. These unique occupational demands have been extensively described for adult religious officials, with emphasis on the fact that the human voice serves as the sole "instrument" during daily worship and educational practices (22).

An additional observation concerns the gender-related pattern within the Hifz group. Although girls had longer daily Qur'an reading time and daily voice use duration, boys appeared to show less favorable perceptual voice distributions on several GRBAS parameters. Because detailed sex-based acoustic and aerodynamic comparisons were not a primary focus of this study, these findings should be interpreted cautiously as descriptive observations.

The higher TR-CVHI-10 scores observed in the Hifz group may indicate a greater subjective burden of voice-related difficulties among children exposed to intensive daily recitation without structured voice training. This interpretation is also consistent with pediatric literature suggesting that voice training and regular specialist follow-

up may play a protective role in children with high voice demands. For example, Clarós et al. reported lower rates of voice disorders in choir singers than in nonsinging children, possibly because of voice training and the habit of regular otorhinolaryngologic examination (46). Our self-reported voice findings are also consistent with the higher VHI-10 scores observed in adult Islamic religious officials, who report a greater voice handicap than other groups of professional voice users (22). Such differences have been suggested to be related to the heavy vocal load imposed by the profession and the heightened awareness stemming from the central importance of voice for occupational success (22). In addition, studies have shown that Muslim religious officials in Türkiye are disadvantaged in terms of training and vocal hygiene because systematic voice–music education is not included in their professional curricula, which may contribute to their higher prevalence of voice problems (47). Because relevant pediatric literature on Qur'an recitation and similar religious voice-use contexts remains limited, comparisons with adult Islamic religious officials should be interpreted cautiously. These adult groups may still provide useful contextual support. They share several vocal demands with Hifz students, including prolonged recitation, repeated loud voice use, and heavy dependence on the human voice for performance.

When acoustic and aerodynamic indicators are considered together, a consistent pattern emerges in the Hifz group, characterized by increased perturbation (jitter/shimmer) and elevated noise components. Specifically, jitter and shimmer values were higher for both vowels, while reduced HNR was significant only for /a/, and CPPS was also lower for /a/. This pattern suggests increased cycle-to-cycle irregularity and noise in phonation. In addition, the absence of significant CPPS differences for the /i/ vowel and connected speech may reflect stimulus-dependent variability. Previous literature has shown that diagnostic performance for cepstral measures may be lower for close vowels, such as /i/ and /u/, as well as for connected speech, than for open vowels, such as /a/ (48). Similarly, on the aerodynamic side, prolonged /s/ duration, shortened /z/ duration, and the marked increase in the s/z ratio suggest differences in glottal efficiency and phonatory control among Hifz students. The mean s/z ratio in the Hifz group was 1.30, whereas it was 0.93 in the normophonic group. In normative pediatric data, the s/z ratio is reported to be close to 1.0 in most healthy children, while values ≥ 1.2 have been described as potentially indicating impaired vocal fold closure, abnormal vibratory behavior, or possible laryngeal pathology (49). Therefore, the elevated s/z ratio observed in the Hifz group may have clinical relevance as an indicator of glottal inefficiency. By contrast, the maximum phonation time (MPT) did not significantly differ between the groups. This may suggest that the overall respiratory-phonatory capacity reflected by this global measure was similar in Hifz students and normophonic children. The mean MPT values observed in both groups (13.5 s) were also close to previously reported school-age normative data (50).

Taken together, these objective indicators and the higher TR-CVHI-10 scores in the Hifz group suggest a greater subjective burden of voice problems in these children. The predominance of mild-to-moderate impairments in GRBAS ratings further supports this pattern at the perceptual level. Our findings highlight the need to integrate structured voice training and vocal hygiene modules into the Hifz education curriculum. The benefits of such training, which have been demonstrated among adult religious officials, may be even more protective and preventive during childhood (45). Existing pediatric professional voice-user literature also emphasizes the importance of adequate vocal training, early recognition of voice problems, and multidisciplinary management in children with intensive voice demands (21, 46). Moreover, national recommendations for mandating voice–music education in professional training are consistent with the existing literature (47). At a practical level, routine voice assessments, dosage management (balancing daily vocal load), acoustic modifications, hydration, and behavioral hygiene should be implemented in combination with teaching techniques adapted to pediatric populations.

Limitations and future directions

This study has several limitations. Its cross-sectional design prevents causal interpretation, and the single-province sample limits generalizability. Although the achieved sample size was close to the a priori target, it remained slightly below the required number per group. Laryngoscopic examination was not included, which limits conclusions regarding possible vocal fold pathology. In addition, other intensive voice-related activities, vocal hygiene behaviors, hydration, dietary habits, and pubertal voice changes were not systematically controlled, and these factors may have influenced the acoustic and perceptual findings.

Future research should include larger multicenter samples and longitudinal designs following Hifz students across different stages of training. Studies incorporating laryngoscopic assessment, standardized voice training programs, and telepractice-based screening or counseling may provide stronger evidence for prevention and intervention in this population.

CONCLUSION

In summary, Hifz students exhibited higher subjective voice handicap, more adverse acoustic indicators, and a widespread pattern of perceptual impairments compared to their normophonic peers. This profile reflects the effects of early exposure to voice use of similar intensity and nature as professional vocal demands and strongly supports the need for early, structured voice training and systematic monitoring.

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