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Acoustic and Aerodynamic Analysis of Voice in Lower Primary, Upper Primary and High School Teachers in Kerala

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Abstract
The present study aimed to compare acoustic and aerodynamic voice characteristics among lower primary, upper primary, and high school teachers in Kerala to identify variations associated with differing occupational vocal demands. A total of 45 teachers participated in the study, with 15 participants recruited from each teaching category. Acoustic parameters, including fundamental frequency (F0), jitter, shimmer, harmonics-to-noise ratio (HNR), and noise-to-harmonics ratio (NHR), as well as aerodynamic measures such as S/Z ratio and maximum phonation duration (MPD), were analyzed. Significant differences were observed in acoustic parameters across the groups. Lower primary teachers demonstrated lower F0 values and higher shimmer and NHR values, whereas high school teachers exhibited lower HNR values, indicating greater vocal compromise. Upper primary teachers showed the most favourable acoustic profile. No statistically significant differences were observed in aerodynamic measures. Overall, the present study revealed that lower primary teachers demonstrated greater vocal compromise compared to upper primary and high school teachers. The findings of the study underscore the role of Speech Language Pathologists (SLPs) in the assessment and intervention of voice disorders in teachers . Thus the current study also highlights need for routine acoustic voice screening, early detection of voice-related changes, and the implementation of tailored vocal hygiene and voice care programs for teachers. Such preventive measures may contribute to minimizing the incidence of occupational voice disorders and enhancing overall vocal health and well-being among teachers in Kerala.

Keywords: acoustic analysis, aerodynamic analysis, teachers, occupational voice disorders, voice, Kerala

Introduction

Voice presents an opening window to a person's personality. Voice is the primary instrument through which most of the people project their personality and influence their environment. The production of human voice includes complex series of events in the peripheral phonatory organs which are controlled by the central nervous system (Sataloff, 2006).

Voice is produced when air from the lungs passes through the vocal folds in the larynx, causing them to vibrate and create sound. This sound is then shaped by the vocal tract—which includes the throat, mouth, and nasal passages—to produce the voice we use for communication. Voice disorders are generally

classified as either organic or functional. Organic voice disorders result from physical problems affecting the respiratory system, larynx, or vocal tract structures. Functional voice disorders, on the other hand, occur when the voice is used inefficiently even though the vocal structures themselves are normal.

An individual who relies on their voice in order to carry out their job is regarded as professional voice users. Professional voice users are singers, teachers, actors, broadcasters, coaches (Lions voice clinic, 2003). The most common vocal symptoms seen in professional voice users are Muscle tension dysphonia, vocal fold lesions (e.g., nodules and polyps), cysts, vocal fold scarring, changes in vocal fold mobility, and age-related users (Franco & Andrus, 2007).

Common symptoms of voice disorders include hoarseness, roughness, breathiness, strained or weak voice, vocal fatigue, and throat pain during speech. These symptoms may arise from factors such as muscle tension, vocal overuse or misuse, vocal nodules, polyps, cysts, laryngeal cancer, vocal fold paralysis, and neurological conditions. According to Aronson and Bless (2009)[cited in American Speech-Language-Hearing Association ,ASHA (1993)] defines a voice disorder as occurring when the quality, pitch, or loudness of a person's voice is inappropriate for their age, gender, cultural background, or geographic location. ASHA emphasizes that a voice disorder exists when an individual perceives their own voice as abnormal and finds it inadequate for daily communication, even if others do not (Colton & Casper, 2011). Aging also affects the vocal folds, just as it impacts other organs of the body.

Assessment of voice include perceptual analysis, acoustic analysis and aerodynamic analysis. Perceptual analysis of voice include Consensus Auditory-Perceptual Evaluation of voice (CAPE-V), Voice handicap index (VHI), Voice related quality of voice (VRQOL), Voice symptom scale (VoiSS) and GRBAS (Grade, Roughness, Breathiness, Asthenia and Strain).

Acoustic analysis of voice is the most popular and non-invasive vocal assessment method which is used extensively in dealing with voice of professional voice users and others for voice diagnosis, therapy and research. By analysing vowel sounds, it helps us to understand fundamental frequency (FO), intensity and the filter characteristics (formant frequencies, jitter, shimmer etc). Parameters of voice production includes pitch, MPD, maximum to minimum intensity at various pitches, jitter, noise and resonance. The various acoustic parameters most commonly used in acoustic analysis of voice are fundamental frequency, jitter, shimmer and harmonic to noise ratio (HNR) and noise to harmonic ration (NHR).

Aerodynamic analysis include MPD and S/Z ratio.Different laryngeal and respiratory pathologies affect a person's ability to phonate a sound, which can be quantified using two measures, termed Maximum Phonation Duration (MPD) and S/Z ratio, which allow to assessing the efficiency of the respiratory and phonatory system.

The Maximum phonation duration (MPD) is the longest time that a client can sustain a vowel sound at a comfortable pitch and loudness on a deep breath. Adult females should achieve between 15-25 seconds, whereas adult males exceed this at between 25-35 seconds (Williamson, 2014).

The S/Z ratio is a standard test of vocal function. It is obtained by timing the longest duration that a patient can sustain the individual phonemes S and Z., and then divides the two figures to obtain a numerical ratio. Unlike S, the voiced Z requires phonation (glottis vibration). Under normal circumstances, the ideal S/Z ratio is 1. 95% of people who have problems with their vocal folds have an s/z ratio of greater than 1(Williamson, 2018).

Voice plays a vital role in many professions, particularly for professional voice users such as singers, actors, and teachers. Koufman and Isaacson in 1991 classified teachers as level 2 professional voice

users, as their work heavily depends on effective vocal communication. The teaching profession is particularly demanding on the voice due to continuous speaking, often in noisy classroom environments. Teachers are, therefore, at a higher risk of developing voice disorders because of these occupational demands. Acoustic and aerodynamic analyses provide objective means to evaluate vocal function.

Voice disorders are highly prevalent among school teachers in India, reflecting the significant vocal demands of the profession. Various studies conducted across different regions of the country report a wide range of prevalence rates. For instance, one study reported a prevalence of 18.5% for current voice disorders among secondary school teachers (Bhatt & Vyas, 2019). However, other studies indicate higher rates; Banjara et al. (2017) reported a prevalence of 46.5% among government school teachers, while additional findings suggest that approximately 45.4% of teachers experience current voice problems and up to 70.1% report voice disorders over their teaching career.

Furthermore, lifetime prevalence appears even higher in some studies, with reports indicating that up to 81% of teachers experience voice disorders at some point in their career. Similarly, more than 77% of teachers have reported vocal difficulties during their teaching years (Banjara et al., 2017). These variations highlight that prevalence estimates differ depending on whether current, period, or lifetime measures are considered. Overall, the evidence suggests that voice disorders are a common occupational health issue among Indian school teachers, with prevalence rates ranging from approximately 18% to over 70%.

Speech-language pathologists (SLPs) play a vital role in the prevention, assessment, and management of voice disorders, particularly among high-risk populations such as teachers. Their role begins with comprehensive evaluation, including perceptual assessment, case history, and, when necessary, instrumental analysis to determine the nature and severity of the disorder (Stemple et al., 2014). SLPs are also central to therapeutic intervention, utilizing evidence-based voice therapy techniques to improve vocal efficiency, reduce phonotraumatic behaviors, and restore optimal voice quality. These interventions include vocal hygiene education, respiratory support training, and resonance-based therapy approaches (Stemple et al., 2014). In addition, prevention and vocal health promotion form a significant part of their role, especially for professional voice users such as teachers. SLPs conduct training programs and awareness sessions focusing on healthy voice use, hydration, posture, and strategies to manage vocal demands (Roy et al., 2005).

Furthermore, SLPs work collaboratively with other professionals, including otolaryngologists and educators, to provide a multidisciplinary approach to voice care. This team-based management enhances treatment outcomes and minimizes the long-term impact of voice disorders on occupational performance and quality of life(QoL) (Behrman, 2005).

Pekkarinen, Himberg, and Pentti (1992) studied noise levels and vocal strain among school teachers. The researchers found that teachers often increased vocal intensity in noisy classrooms, leading to hyperfunctional voice use and vocal fatigue. Acoustic measures showed elevated intensity and altered frequency patterns, while perceptual evaluation indicated hoarseness and vocal roughness. The study established a relationship between classroom acoustics and the development of voice disorders in teachers.

Sapir, Keidar, and Schmidt (1993) focused on aerodynamic analysis among teachers with voice disorders. The study assessed Maximum Phonation Time (MPT), phonation quotient, and airflow rates in teachers experiencing vocal complaints. Teachers with dysphonia demonstrated reduced aerodynamic efficiency and poor breath support during phonation. The findings suggested that aerodynamic measures are important indicators of vocal pathology and can help identify early signs of occupational voice disorders in teachers.

Smith et al. (1997) conducted one of the earliest large-scale studies examining voice disorders among teachers in the United States. The researchers reported that teachers experienced significantly higher rates of hoarseness, vocal fatigue, throat discomfort, and voice loss compared to non-teachers. The study emphasized that continuous classroom speaking places teachers at increased risk for occupational dysphonia. Acoustic measures demonstrated instability in pitch and frequency, while perceptual analysis revealed strained and breathy voice quality among affected teachers.

Rantala and Vilkman (1999**)** examined vocal fatigue among Finnish teachers through acoustic and perceptual evaluation. The study reported that prolonged teaching caused significant vocal strain, reduction in vocal endurance, and deterioration in voice quality. Acoustic parameters such as fundamental frequency and perturbation measures changed significantly after teaching sessions. Perceptual assessment also indicated increased roughness and breathiness. The authors highlighted that inadequate recovery time and poor classroom acoustics contributed to vocal fatigue in teachers.

Sala et al. (2001) investigated the prevalence of voice disorders among Finnish teachers and the influence of vocal loading. The study found that teachers frequently reported hoarseness, throat pain, and vocal fatigue after classroom teaching. Acoustic analysis revealed increased jitter and shimmer after prolonged voice use, while perceptual ratings demonstrated deterioration in vocal clarity and increased strain. The researchers recommended vocal hygiene education and preventive voice training for teachers.

Verdolini and Ramig (2001**)** discussed the physiological basis of vocal fatigue and emphasized the role of excessive vocal loading in occupational voice disorders. The authors explained that continuous phonation causes laryngeal muscle tension, increased collision force of the vocal folds, and reduced phonatory efficiency. Their findings support the importance of aerodynamic and acoustic assessments in identifying early changes in vocal function among professional voice users such as teachers.

Jonckere et al. (2001) introduced the Dysphonia Severity Index (DSI), a multidimensional tool combining acoustic and aerodynamic measures for objective voice assessment. The DSI incorporated parameters such as Maximum Phonation Time, highest phonational frequency, lowest intensity, and jitter. The authors suggested that the index could effectively differentiate normal and pathological voices and could be used in occupational voice assessment among teachers.

Roy et al. (2004) investigated the prevalence of voice disorders in teachers and identified teaching duration, classroom noise, and improper vocal habits as major risk factors. Their findings indicated that female teachers were particularly susceptible to voice problems due to greater vocal load and physiological differences in vocal fold structure. Acoustic analyses showed increased jitter and shimmer values in teachers with dysphonia, while perceptual evaluation revealed mild to moderate hoarseness. The authors concluded that teachers represent a high-risk occupational group for voice disorders.

Houtte et al. (2011) did a systematic review on occupational voice disorders and confirmed that teachers consistently demonstrate higher prevalence of dysphonia than the general population. The review identified acoustic parameters such as jitter, shimmer, and harmonics-to-noise ratio as reliable indicators of vocal dysfunction. Perceptual tools like the GRBAS scale were also found to be effective in assessing voice quality in teachers.

Behlau et al (2012**)** explored the occupational voice disorders in teachers across several countries. Their study highlighted that teachers commonly experience voice symptoms due to heavy vocal demand, poor hydration, stress, and environmental noise. Acoustic analysis revealed abnormal perturbation measures, while perceptual assessment showed breathiness and vocal strain. The authors emphasized that voice disorders negatively affect teachers' professional performance and QoL.

Mahato et al., (2018) did a study on acoustic analysis of voice in school teachers in Nepal and found out that the fundamental frequency and shimmer value has significantly increased respectively after teaching practice. Unlikely, there was significant decrease in harmonic to noise ratio value and maximum phonation time value after teaching practice where they suggested that vocal abuse, overuse /misuse of voice in teachers for a longer duration can result in in adequate phonatory pattern due to vocal fold tissue damage which will result in vocal nodule or polyp.

Alexander , Shetty and Mathew (2017) did a study of acoustic analysis of voice Indian on 30 primary school teachers (15 male, 15 female) in Mangalore district by using PRAAT software to compare pre- and post-teaching acoustic parameters like mean pitch, jitter, shimmer, voice breaks, and harmonic-to-noise ratio. It found significant increases in voice breaks and mean pitch in males (p=0.03 during slogan repetition), indicating vocal fatigue sensitivity.

Sathyanarayan, Boominathan and Nallamuthu (2019) examined the vocal health practices among school teachers in Chennai using a ~~VH~~ questionnaire was developed to elicit opinions toward one's own voice health and factors that indicated and contributed to impaired/poor ~~VH~~ from 384 school teachers. They found out that 'Flexible voice' (23%), 'enduring voice' (22%), and 'good voice' (22%) were descriptions to indicate good VH by teachers. 'Vocal fatigue' (13%), 'dry throat' (9.4%), 'throat irritation' (4.7%), and 'pain while swallowing/speaking' (3.1%) were frequently reported throat sensations to indicate poor VH. For 30.2% of the teachers, voice mattered for professional needs.

Alexander et al. (2017) using acoustic analysis assessed the teachers' voices before and after teaching sessions. The study evaluated parameters such as jitter, shimmer, and fundamental frequency among Indian teachers exposed to prolonged vocal loading. The findings revealed significant variations in acoustic parameters after teaching activities, indicating vocal fatigue caused by continuous voice use. The authors emphasized that teachers are at high risk for developing occupational voice disorders because of excessive vocal demand.

Majeed and Haneefa (2017) carried out a prospective study among school teachers in South India to evaluate dysphonia using perceptual, acoustic, and aerodynamic analyses. Their study included perceptual evaluation through the GRBAS scale, acoustic assessment using jitter and shimmer measures, and aerodynamic measures such as Maximum Phonation Time (MPT) and S/Z ratio. The study reported statistically significant differences between teachers with voice complaints and those without vocal symptoms. Teachers with dysphonia demonstrated reduced MPT, abnormal jitter and shimmer values, and altered perceptual voice quality.

Deborah (2021) investigated the effects of vocal loading on teachers' voices using acoustic, aerodynamic, and self-perceptual measures. The study included teachers who engaged in prolonged classroom teaching for more than four hours daily. Acoustic analysis showed deterioration in voice quality after teaching, especially in shimmer and frequency variation. Aerodynamic analysis revealed reduced phonatory efficiency, while perceptual measures indicated increased vocal fatigue. The study highlighted that prolonged speaking without adequate voice care can negatively affect vocal performance in teachers.

Boominathan et al. (2010) explored voice characteristics and recovery patterns in Indian adults after vocal loading. Although the study was not exclusively conducted among teachers, it provided valuable insights into occupational voice use. The authors found that prolonged phonation caused temporary deterioration in vocal quality, especially in professional voice users. These findings are relevant to teachers, who continuously use their voices in classroom settings and may experience similar vocal strain.

Rantala, Vilkman, and Bloigu (2002) examined subjective and objective voice changes among primary and secondary school teachers. The study demonstrated that teachers often experience hoarseness, vocal fatigue, and throat discomfort after prolonged teaching sessions. Objective acoustic measurements showed increased perturbation measures and reduced vocal stability after work. The researchers concluded that occupational voice demands significantly affect teachers' vocal health.

Devadas (2023) studied the perception of primary school teachers regarding voice problems and the impact of voice hygiene education. The research reported that many teachers were unaware of proper vocal hygiene practices. After voice training and awareness programs, improvements were observed in acoustic and perceptual voice parameters. The study emphasized the importance of preventive voice care strategies for school teachers.

Khateeb et al. (2022) examined vocal habits, Dysphonia Severity Index (DSI), and voice-related QoL among teachers. Their findings suggested that poor hydration, improper vocal habits, and increased workload significantly contributed to vocal problems. Teachers with abnormal DSI scores also showed poorer perceptual voice quality and reduced aerodynamic efficiency.

METHOD

Aim of the Study

To analyse and compare the acoustic and aerodynamic characteristics of voice among lower primary, upper primary, and high school teachers in Kerala and to compare the vocal parameters across different teaching levels.

Participants

A total number of 45 participants were selected. The individuals were further divided into three groups and each group consisted of 15 individuals

1. Group 1- 15 Lower Primary school teachers
2. Group 2- 15 Upper primary school teachers
3. Group 3 - 15 High school teachers

The study was carried out in 2 phases

Phase 1

Acoustic analysis were carried out in a quiet room using microphone and laptop. Each participant was instructed to phonate a sustained vowel /a/ at a comfortable pitch and loudness for analysis of F0, jitter, shimmer, HNR, and NHR using PRAAT SOFTWARE.

Phase 2

For aerodynamic assessment, participants were asked to sustain the consonants /s/ and /z/ for as long as possible in a single breath to derive the S/Z ratio, and to sustain the vowels /a/, /i/, and /u/ for maximum phonation duration (MPD), each measured using a stopwatch or digital timer across 3 trials, with the longest duration recorded for analysis.

STATISTICAL ANALYSIS

Data were analyzed using Jamovi 2.4.8. Descriptive statistics (means and standard deviations) were computed for each acoustic and aerodynamic parameter across the three groups. One-way analysis of variance (ANOVA) was used to compare group means, and Tukey's Honestly Significant Difference (HSD) post hoc test was applied to findings for identifying pairwise group differences. Statistical significance was set at $p < .05$.

Results and Discussion

The present study aimed to compare acoustic (fundamental frequency, jitter, shimmer, harmonics-to-noise ratio [HNR], and noise-to-harmonics ratio [NHR]) and aerodynamic (S/Z ratio and maximum phonation duration [MPD] for the vowels /a/, /i/, and /u/) voice parameters across three groups of school teachers — lower primary, upper primary, and high school teachers

Table 1shows the *Acoustic analysis of voice in the* lower primary, upper primary, and high school teachers

Parameters of acoustic analysis	**Group**	**n**	**M**	**SD**	**F(2, 42)**	**P**	**SIG**
Fundamental Frequency, F0 (Hz)	Lower Primary Teachers	15	166.49	15.60	32.70	< .001*	HS
	Upper Primary Teachers	15	205.53	16.88			
	High School Teachers	15	205.26	11.89			
Jitter (%)	Lower Primary Teachers	15	0.66	0.14	1.53	.236	
	Upper Primary Teachers	15	0.63	0.07			NS
	High School Teachers	15	0.58	0.13			
Shimmer (%)	Lower Primary Teachers	15	8.83	1.84	11.56	< .001*	
	Upper Primary Teachers	15	6.08	1.17			HS
	High School Teachers	15	6.84	0.46			
HNR (dB)	Lower Primary Teachers	15	18.06	3.34	74.82	< .001*	
	Upper Primary Teachers	15	22.18	1.12			HS
	High School Teachers	15	14.82	2.07			
NHR	Lower Primary Teachers	15	0.064	0.011	127.94	< .001*	

	Upper Primary Teachers	15	0.015	0.004			HS
	High School Teachers	15	0.031	0.013			

Hs- High Significance ,*NS-No Significance*

Table 1 revealed the mean fundamental frequency (F0) of lower primary teachers was markedly lower than that of upper primary teachers and high school teachers , and this difference was statistically significant, Jitter values were comparable across the three groups . Hence no statistical differences were noticed. Shimmer was significantly higher in lower primary teachers than in upper primary and high school teachers.

HNR differed significantly across the three groups with upper primary teachers showing the highest mean HNR followed by lower primary teachers and high school teachers , the lowest of the three groups. NHR showed the inverse pattern and likewise differed significantly across groups with lower primary teachers showing the highest noise component and upper primary teachers the lowest with high school teachers intermediate.

Across all four parameters, the pairwise pattern was broadly consistent: lower primary teachers differed significantly from both upper primary and high school teachers, whereas upper primary and high school teachers differed significantly from each other only on HNR and NHR, and not on F0 or shimmer.

Table 2 shows the *Aerodynamic analysis of voice in the* lower primary, upper primary, and high school teachers

Parameter	**Group**	**n**	**M**	**SD**	**F(2, 42)**	**p**	**SIG**
S/Z Ratio	Lower Primary Teachers	15	1.01	0.23	2.63	.091	NS
	Upper Primary Teachers	15	1.08	0.15			
	High School Teachers	15	1.24	0.30			
MPD /a/ (s)	Lower Primary Teachers	15	10.70	3.37	1.50	.243	NS
	Upper Primary Teachers	15	10.96	1.68			
	High School Teachers	15	12.68	3.67			
MPD /i/ (s)	Lower Primary Teachers	15	10.61	2.90	2.26	.127	

Parameter	Group	n	M	SD	F(2, 42)	p	SIG
	Upper Primary Teachers	15	10.46	1.32			NS
	High School Teachers	15	12.81	4.02			
MPD /u/ (s)	Lower Primary Teachers	15	9.85	2.51	3.14	.063	NS
	Upper Primary Teachers	15	9.81	0.98			
	High School Teachers	15	12.91	4.64			

Hs- High Significance ,*NS-No Significance*

Table 2 showed that unlike the acoustic parameters, none of the aerodynamic measures differed significantly across the three groups. The S/Z ratio was numerically highest in high school teachers) and lowest in lower primary teachers , but this difference was not significant. Similarly, MPD for /a/, /i/, and /u/ was descriptively longest in high school teachers and shortest in lower and upper primary teachers, but none of these differences reached significance. The /u/ comparison approached, but did not reach, conventional significance, and was accompanied by the largest standard deviation in the high school group, suggesting greater individual variability in that group.

Discussion

The present study compared the voice of lower primary, upper primary, and high school teachers in Kerala using acoustic and aerodynamic analysis to determine which group demonstrated the greatest vocal compromise. The results revealed a differentiated pattern: acoustic analysis of voice reliably distinguished the three groups, whereas aerodynamic analysis did not reach statistical significance despite descriptive trends favoring greater compromise among high school teachers.

The significantly lower F0 observed in lower primary teachers relative to upper primary and high school teachers is noteworthy. While a lower F0 is not inherently pathological, when considered alongside the concurrently elevated shimmer and NHR in the same group, it may reflect increased vocal fold mass or stiffness consistent with mild edema secondary to vocal overuse . Lower primary teachers frequently engage in animated, pitch-variable speech directed at young children, including singing and exaggerated prosody, which may impose cumulative mechanical loading on the vocal folds despite shorter individual class durations.

High school teachers demonstrated the lowest HNR among the three groups, indicating a comparatively higher proportion of aperiodic noise in the acoustic signal. This finding aligns with the demands of sustained, lecture-style phonation typical of higher-grade instruction, which may produce cumulative vocal fatigue across longer, less vocally varied speaking episodes . The concurrently higher, albeit non-significant, aerodynamic values and variability among high school teachers further suggest heterogeneous respiratory-laryngeal compensation strategies within this group, possibly reflecting a wider range of vocal

loading histories or compensatory behaviours developed over years of teaching experience.

In contrast, upper primary teachers exhibited the most favourable acoustic profile across nearly every parameter, including the highest HNR and lowest NHR and shimmer. This intermediate position between lower primary and high school teaching levels may correspond to a more balanced vocal demand: sufficient vocal variability to avoid the loading patterns seen in lower primary teachers, yet without the prolonged sustained phonation characteristic of high school instruction. This pattern tentatively suggests that vocal risk in teachers may not increase linearly with grade level taught, but instead follows a non-linear relationship shaped by distinct pedagogical and vocal-use demands at each level.

The results of the current study on three group of teachers in terms of acoustic analysis of voice is in accordance with the previous study done in Nepal on school teachers by Mahato et.al(2018) , where they suggested that vocal abuse, overuse /misuse of voice in teachers for a longer duration can result in in adequate phonatory pattern due to vocal fold tissue damage which will result in vocal nodule or polyp. The absence of significant group differences in aerodynamic measures (S/Z ratio and MPD) contrasts with the robust acoustic findings and warrants careful interpretation. Aerodynamic measures such as MPD are influenced substantially by respiratory capacity, motivation, and instructional set, and may be less sensitive to subtle, early-stage laryngeal changes than acoustic perturbation measures . These findings carry clinical implications for voice care programs targeting teachers in Kerala. Given that acoustic indices appear more sensitive than aerodynamic indices in this population, voice screening protocols for teachers may benefit from prioritizing acoustic analysis as a first-line, non-invasive screening tool. Furthermore, the differentiated risk profile across teaching levels suggests that vocal hygiene education should be tailored: lower primary teachers may benefit from strategies addressing pitch and loudness variability (e.g., amplification devices, resonant voice therapy techniques), whereas high school teachers may benefit from strategies addressing sustained phonation fatigue (e.g., structured vocal rest periods, breath-support training)

Conclusions

The present study aimed to compare acoustic and aerodynamic analysis of voice among lower primary, upper primary, and high school teachers in Kerala to determine variations in vocal characteristics associated with different teaching demands. A total of 45 teachers participated in the study, with 15 participants each from lower primary, upper primary, and high school teaching groups. Acoustic parameters, including fundamental frequency (F0), harmonic-to-noise ratio (HNR), noise-to-harmonic ratio (NHR), and shimmer, along with aerodynamic measures such as S/Z ratio and maximum phonation duration (MPD), were analyzed and compared across the three groups.

The results revealed significant differences in acoustic parameters among the teaching groups, indicating variations in vocal fold vibratory characteristics and voice quality. Lower primary teachers demonstrated reduced F0 along with increased shimmer and NHR, suggesting greater vocal perturbation that may be associated with frequent pitch variations, increased loudness, and expressive voice use required during early childhood instruction. High school teachers exhibited reduced HNR values, reflecting increased acoustic noise and possible effects of prolonged lecture-based voice use and vocal fatigue. In contrast, upper primary teachers showed a comparatively better acoustic profile with higher HNR and lower perturbation measures, suggesting more efficient vocal functioning.

Aerodynamic parameters, including S/Z ratio and MPD, did not demonstrate statistically significant differences among the groups, although descriptive trends indicated greater variability among high school

teachers. This suggests that aerodynamic measures may be less sensitive than acoustic parameters in identifying subtle occupational voice-related changes.

The findings of the present study suggest that lower primary teachers experienced the greatest degree of vocal compromise among the three teaching groups. This was evidenced by significantly lower fundamental frequency (F0) values and higher shimmer and noise-to-harmonic ratio (NHR) values, indicating greater vocal perturbation and reduced vocal efficiency. High school teachers demonstrated the lowest harmonics-to-noise ratio (HNR), suggesting increased acoustic noise and possible vocal fatigue associated with prolonged lecture-based teaching. In contrast, upper primary teachers exhibited the most favourable acoustic profile, indicating comparatively efficient vocal functioning and lower occupational vocal risk.

The findings indicate that vocal demands differ across teaching levels and that the risk of voice-related difficulties may depend on specific teaching behaviours rather than grade level alone. The study emphasizes the importance of regular acoustic voice screening, early identification of vocal changes, and implementation of targeted vocal hygiene and voice conservation programs for teachers. These preventive strategies may help reduce the risk of occupational voice disorders and promote better vocal health among teachers in Kerala.

Limitations

- Limited small sample size
- Regarding control of confounding variables such as years of teaching experience, daily teaching hours, classroom size, and self-reported vocal symptoms was not specified

Future Directions

- Sample size can be increased.
- Perceptual voice quality ratings and self-report measures in the study
- Years of teaching experience, daily teaching hours, classroom size, and self-reported vocal symptoms can be taken to consideration
- Follow- up studies can be done in the same group with the mentioned future drections.

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