http://e-cacd.org/ eISSN: 2508-5948
Clinical Archives of Communication Disorders / Vol. 11, No. 1: 57-68 / April 2026
https://doi.org/10.21849/cacd.2026.11.1.5

Original Article

Effects of Occupational Vocal Demand on Subjective Vocal Symptoms and Acoustic Indicators of Laryngeal Tension in Speech-Language Pathologists

Received: 1 April, 2026. **Revised:** 28 April, 2026. **Accepted:** 28 April, 2026.

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Purpose Speech-language pathologists (SLPs) are professional voice users whose clinical duties place sustained phonatory demands on the laryngeal system throughout their workdays. However, field-based evidence on the effects of routine clinical work on vocal symptoms and laryngeal tension remains limited. This study examined pre- to post-shift changes in subjective vocal symptoms and acoustic measures associated with laryngeal tension in SLPs.

Methods Twenty-seven female SLPs completed ratings for vocal effort (adapted Borg CR-10 scale), vocal fatigue, and laryngeal discomfort (5-point Likert scale) before and immediately after their work shifts. Smartphone-based voice samples were collected on-site. Fundamental frequency (F0), intensity (I), relative fundamental frequency (RFF; offset 10 and onset 1), cepstral peak prominence (CPP), CPP standard deviation (CPP SD), low-to-high spectral ratio (L/H ratio), and L/H ratio standard deviation (L/H ratio SD) were extracted and compared using paired *t* tests.

Results All three subjective symptom ratings increased significantly after work. Among acoustic measures, F0, I, and L/H ratio increased significantly, whereas RFF offset 10 decreased significantly. No significant pre- to post-shift differences were observed in RFF onset 1, CPP, CPP SD, or L/H ratio SD.

Conclusions Routine clinical work was associated with worsening vocal symptoms and acoustic changes consistent with increased laryngeal tension in SLPs. These findings underscore the importance of preventive voice care, structured recovery periods, and practical self-management strategies for SLPs exposed to high occupational vocal demands.

Keywords speech-language pathologists, vocal demand, vocal effort, relative fundamental frequency, laryngeal tension

INTRODUCTION

Professional voice users are individuals whose occupations require sustained voice use throughout the workday, such as teachers, clergy, counselors, and healthcare providers. Compared with the general working population, professional voice users are more frequently exposed to heavy voice use, elevated background noise, high vocal intensity, and occupational stress—all of which can contribute to vocal fatigue [1,2]. Symptoms commonly reported by these professionals include heightened phonatory effort, throat dryness, laryngeal discomfort, neck and shoulder tension, and a general sense of weakness or reduced control over voice [3,4].

Speech-language pathologists (SLPs) support the communication development and rehabilitation of individuals with communication disorders and are widely recognized as professional voice users with high phonatory

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demands [5]. Their workday typically involves therapy sessions of 30-50 minutes or longer, often followed by parent or caregiver counseling, with sessions frequently scheduled consecutively and with minimal intervening breaks. These demands tend to be particularly pronounced when SLPs work with young children, as effective therapeutic interactions frequently require increased vocal intensity, broad pitch variation, and heightened articulatory precision [6]. Additional environmental factors, including treatment-room noise, dust, humidity, and occupational stress, may further burden the phonatory system [7-9]. Although SLPs share certain characteristics with other professional voice users, their vocal demands are distinctive in several respects. Unlike teachers, who primarily deliver structured content to groups in relatively predictable acoustic environments, SLPs must produce highly varied phonatory models—continuously modifying pitch, rate, articulation, and prosody to serve as therapeutic targets—while simultaneously sustaining extended one-on-one verbal interactions tailored to the specific communicative and cognitive levels of individual clients. This combination of high phonatory precision, sustained interpersonal vocal engagement, and the near-continuous nature of clinical communication, with minimal opportunity for recovery between sessions, renders SLPs a population with a uniquely demanding phonatory profile.

In occupations with sustained vocal demands, prolonged voice use without adequate rest may increase laryngeal muscular tension, elevate perceived effort, and precipitate vocal fatigue. Such responses may not remain transient; rather, under conditions of repeated and insufficient recovery, temporary hyperfunctional states may consolidate into chronic vocal hyperfunction. Vocal hyperfunction is a functional voice disorder associated with voice misuse or overuse that can impair both work performance and quality of life, regardless of the presence of vocal fold lesions [10]. Therefore, a clearer characterization of vocal symptoms and laryngeal tension-related changes experienced by SLPs in real-world work environments is needed [5,11].

Within the current theoretical framework of vocal hyperfunction described by Hillman et al. [11], transient hyperfunctional responses may arise even in vocally healthy individuals as phonatory demand increases, but these responses typically resolve with adequate rest. However, when provoking factors—such as prolonged voice use, insufficient recovery, and psychological stress—are repeatedly superimposed, individual tissue properties and behavioral phonatory tendencies may interact to promote tissue injury. In a fatigued laryngeal system, speakers often compensate by increasing subglottal pressure and medial compression to maintain habitual loudness and voice quality [12]. Sustained use of such compensatory strategies can accumulate fatigue in both the intrinsic and extrinsic laryngeal musculature and may ultimately contribute to phonotraumatic vocal hyperfunction [3,13-15].

Vocal demand tasks have been widely used to study laryngeal mechanisms under conditions of increased phonatory demand. In laboratory paradigms, participants typically perform extended reading or repeated nonsense-syllable productions to induce vocal fatigue, after which laryngeal changes are assessed [16]. Although this approach affords strict experimental control, it does not adequately reflect the complex, prolonged, and ecologically variable patterns of voice use that characterize professional clinical work [17-19]. Moreover, task duration in laboratory studies is inherently constrained, making it difficult to capture the cumulative vocal demand and restricted recovery experienced across a full workday [20]. Therefore, field-based data collection is necessary to obtain a more ecologically valid characterization of occupational voice use [21].

Practical, field-compatible assessment tools are essential for evaluating vocal demand in working environments. Self-report measures of vocal effort, vocal fatigue, and laryngeal discomfort are closely interrelated outcomes of

phonatory strain [16]. Because they are typically administered on Likert-type scales requiring no specialized equipment, they can be obtained repeatedly in the workplace with minimal burden. For objective acoustic measurement, portable recording devices, such as smartphones, offer an accessible alternative to laboratory-grade instrumentation. Among acoustic parameters that can be reliably derived from smartphone recordings, fundamental frequency (F0)—a time-based measure—has exhibited relatively stable performance across device types and quiet recording environments [19,22,23].

Relative fundamental frequency (RFF) has received growing attention as a sensitive acoustic indicator of laryngeal tension. RFF is a time-based measure that quantifies F0 variation around a voiceless consonant within a vowel-voiceless consonant-vowel (VCV) context, thereby capturing laryngeal tension-related changes during the offset-to-onset transition in vocal fold vibration. Previous studies have demonstrated that RFF is associated with subjectively perceived vocal effort, is sensitive to laryngeal changes induced by vocal demand, and has diagnostic utility for distinguishing hyperfunctional voice disorders from other voice conditions [13,24-26].

Research on RFF among Korean speakers remains limited. An exploratory study involving 10 adult female speakers examined RFF across Korean consonant categories and found offset-onset patterns that were broadly similar to those reported in English [27]. Although this study demonstrated the applicability of RFF to Korean speech, the evidence base remains preliminary, and further normative data across vowels, age groups, and clinical populations are needed. Accordingly, although some normative Korean RFF data are now available, the current evidence does not support routine clinical implementation.

Other acoustic measures—including jitter, shimmer, noise-to-harmonic ratio, and cepstral or spectral indices—have also been applied to characterize voice quality. Jitter, shimmer, and noise-to-harmonic ratio are susceptible to variability introduced by field recording conditions and are therefore less reliable for on-site data collection [16]. F0, being a time-based measure, is comparatively robust to such variability, whereas RFF is considered more sensitive to subtle changes in laryngeal tension through its tracking of F0 fluctuation within a specific phonetic context. Cepstral analysis, while less directly sensitive to laryngeal tension, provides a validated index of overall voice quality disturbance and is now a standard component of clinical voice assessment [28]. Accordingly, laryngeal tension-related changes in field recordings from SLPs are best examined primarily through F0 and RFF, with cepstral measures serving as a complementary index of overall voice quality change.

Given the prolonged voice use and limited recovery opportunities characteristic of clinical practice, SLPs are likely to accumulate heightened vocal effort and fatigue across their workdays. Increased vocal effort may be accompanied by elevated vocal intensity (I), which in turn may promote greater laryngeal tension and corresponding changes in F0 and RFF [3,13,29]. Therefore, the present study examined whether work-related vocal demand during routine clinical practice was reflected in pre- to post-shift differences in subjective vocal symptoms and objective acoustic indices of laryngeal tension in SLPs. Specifically, vocal effort, vocal fatigue, and laryngeal discomfort were assessed before and after work shifts, and acoustic measures—including F0, I, RFF, cepstral peak prominence (CPP), CPP standard deviation (CPP SD), low-to-high spectral ratio (L/H ratio), and L/H ratio standard deviation (L/H ratio SD)—were compared across workdays.

METHODS

Participants

This study was approved by the Institutional Review Board of OOO University (OOO-HR2021024). The re-

Table 1. Participants' characteristics

Characteristics		M (SD or %)
Age (yr)		30.89 (7.15)
Clinical experience (yr)		4.78 (4.04)
Workplace	Private center	7 (26%)
	Community center	3 (11%)
	Hospital	13 (48%)
	Visiting	1 (4%)
Others		3 (11%)

Table 2. Participants' working hours

Characteristics	M (SD)
Total working duration per day (min)	371.04 (95.68)
Working duration per therapy session (min)	40.33 (10.31)
Rest time between therapy sessions (min)	2.70 (3.64)
Maximum rest time during working day (min)	80.93 (72.01)
Number of therapy sessions	7.89 (3.49)

quired sample size was estimated using G*Power (version 3.1.9.7) with paired *t-test* parameters: a medium effect size of 0.5, $\alpha = .05$, and power = .80, yielding a minimum of 27 participants [30]. Accordingly, 27 female SLPs working at speech-language rehabilitation facilities in Seoul and Gyeonggi Province were recruited.

The participants' characteristics are summarized in Table 1. The mean age was 30.89 years, and the mean clinical experience was 4.78 years. Hospitals were the most common work setting (48%), followed by private centers (26%), community welfare centers (11%), home-based therapy (4%), and combined settings (11%).

Work-related time characteristics are presented in Table 2. The mean total working time per day was 371.04 minutes, mean therapy session duration was 40.33 minutes, mean break between sessions was 2.70 minutes, mean longest single break during the workday was 80.93 minutes, and mean number of sessions per day was 7.89.

Data collection

After providing participants with a detailed explanation of the study's purpose and procedures, a written manual outlining the completion of the subjective vocal symptom questionnaire and voice recording protocol was provided.

Symptom ratings and voice recordings were obtained before the start of work and again immediately after work, with all procedures completed in accordance with the manual. To avoid introducing extraneous influences on voice behavior, no vocal hygiene recommendations were provided during the study briefing [19].

Subjective vocal symptoms

Subjective vocal symptoms were assessed using three items rated before and after work: vocal effort, vocal fatigue, and laryngeal discomfort.

Vocal effort was measured using the adapted BORG CR-10 scale [31], a visual rating scale ranging from 0 to 10 with an additional 0.5-point interval between 0 and 1. Participants rated the degree of effort and tension perceived during voice production based on their current laryngeal condition at the time of rating. Higher scores indicated greater vocal effort. Vocal fatigue and laryngeal discomfort were assessed using 5-point Likert scales (1-5), with higher scores indicating greater symptom severity.

Acoustic recording procedures

Voice samples were recorded using the Smart Recorder application on personal Android or iOS smartphones at a sampling rate of 44,100 Hz. Recordings were obtained in a quiet environment both before and after work, with participants instructed to hold the smartphone approximately 10 cm from the mouth. Each participant completed three tasks: (1) sustaining the vowel /a/ twice for 4-5 seconds at a comfortable pitch and loudness; (2) reading the first sentence of the Korean Autumn passage —"Autumn in our country is truly beautiful" [32]— twice; and (3) producing the two-syllable stimulus [ap^{h}a] three times.

In prior Korean research, the tense fricative [s*] demonstrated high sensitivity for RFF measurement, where-

as stop consonants showed comparatively lower variability across repeated productions [27]. Although this study was exploratory and based on a small sample of ten adult female speakers, it indicated that structured VCV stimuli are preferable to sentence-level speech for stable RFF analysis and that lenis consonants should be avoided due to potential intervocalic voicing [27]. English RFF studies have similarly recommended voiceless consonants with low within-speaker variability, particularly /f/ and /ʃ/, for repeated measurement protocols [33,34]. Although Korean [p^h] does not share the same manner of articulation as English /f/, it is a voiceless aspirated stop that can be reliably elicited in a structured VCV context while minimizing the risk of intervocalic voicing. Accordingly, given the repeated-measures design and constraints of field recording, the present study adopted [ap^ha] as the RFF stimulus.

Data analysis

Acoustic analyses were performed in Praat (version 6.3.12; Paul Boersma and David Weenink, University of Amsterdam, the Netherlands) to extract F0, intensity, and RFF. CPP, CPP SD, L/H ratio, and L/H ratio SD were derived using the Analysis of Dysphonia in Speech and Voice software (ADSV™, Model 5109; PENTAX Medical, Montvale, NJ, USA).

F0 was measured from the sustained vowel /a/ to minimize the influence of suprasegmental features such as intonation and speech rate [35]. The mean F0 was calculated from a stable 3-second segment extracted from the mid-portion of the vowel, and the average across two productions was used for analysis. Intensity was measured during sentence reading, which more closely reflects habitual speech in working environments than sustained vowel phonation [36]. The mean intensity across the sentence-reading sample was obtained, and the average of two repetitions served as the final value.

CPP, CPP SD, L/H ratio, and L/H ratio SD, which are representative cepstral and spectral indices of overall voice quality disturbance, were measured from sentence-reading samples to capture voice quality during continuous speech production. The mean values across two repetitions were used for analysis.

RFF was derived from the VCV stimulus [ap^ha] to quantify F0 variation during the final 10 vibratory cycles preceding the voiceless consonant (offset) and the first 10 cycles following it (onset). The normalization protocol described by Stepp et al. [37] was applied, together with a Praat-based framework recently validated for Korean phonetic contexts [27]. Cycle-specific F0 values were converted to semitones (ST) using the equation: $ST = 39.86 \times \log10(F0_i/F0_{ref})$, where $F0_i$ represents the F0 of the *i*-th cycle and $F0_{ref}$ represents the reference F0 (offset 1 or onset 10).

For RFF analysis, each recording was converted to a mono-channel file in Praat, with the pitch range set to 60-300 Hz. The acoustic waveform was magnified to identify the vibratory cycles surrounding the voiceless consonant, enabling the extraction of 10 cycles each for offset and onset. RFF offset 10 (the final cycle before the voiceless consonant) and RFF onset 1 (the first cycle after the consonant) were also calculated (Figure 1). As speakers with laryngeal tension-related voice disorders typically exhibit lower RFF offset 10 and onset 1 values than vocally healthy speakers [37], these two indices were selected as markers of laryngeal tension. The mean across three [ap^ha] productions was used as the final value.

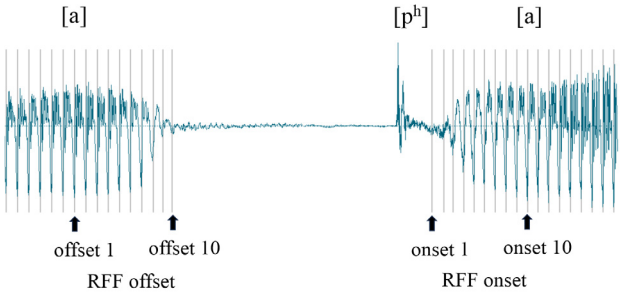


Figure 1. Acoustic waveform of voice offset and onset for the two-syllable stimulus [ap^ha].

Statistical analysis

Pre- to post-shift differences across all variables were evaluated using paired *t* tests. All analyses were conducted using IBM SPSS Statistics (version 26.0; IBM Corp., Armonk, NY, USA), with the significance level set at .05.

Intra-rater reliability was assessed by re-analyzing data from 6 participants (20% of the sample) one month after the initial analysis. Spearman rank-order correlation coefficients indicated high reliability for all parameters at $p < .01$: F0 ($r = 1.00$), intensity ($r = .993$), RFF offset 10 and onset 1 ($r = .957$), CPP ($r = .980$), and L/H ratio ($r = .976$).

RESULTS

Subjective vocal symptoms

All three subjective vocal symptom ratings increased significantly after work (Table 3). Post-shift scores were significantly higher than pre-shift scores for vocal effort ($t = -5.623$, $p < .001$), vocal fatigue ($t = -6.476$, $p < .001$), and laryngeal discomfort ($t = -5.499$, $p < .001$).

Acoustic characteristics

Significant pre- to post-shift differences were observed for F0 ($t = -2.262$, $p = .033$), intensity ($t = -2.356$, $p = .027$), RFF offset 10 ($t = 2.806$, $p = .001$), and L/H ratio ($t = -2.857$, $p = .007$). No significant differences were observed for RFF onset 1, CPP, CPP SD, or L/H ratio SD (Table 4). Specifically, F0, intensity, and L/H ratio

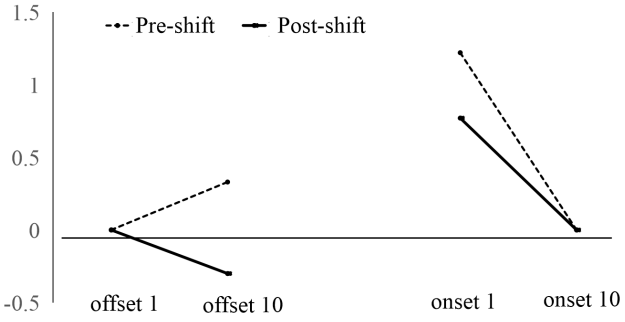


Figure 2. Mean values of relative fundamental frequency (RFF) before and after work.

Table 3. Subjective vocal symptom ratings before and after work

Subjective voice symptoms (minimum-maximum)	Pre-shift M (SD)	Post-shift M (SD)	t	p
Vocal effort (0-10)	1.41 (1.94)	3.20 (2.33)	-5.623	< .001
Vocal fatigue (1-5)	2.22 (1.29)	3.33 (0.98)	-6.476	< .001
Laryngeal discomfort (1-5)	1.63 (0.82)	2.67 (1.05)	-5.499	< .001

Table 4. Acoustic parameters before and after work

Acoustic features	Pre-shift M (SD)	Post-shift M (SD)	*t*	*p*
F0 (Hz)	192.52 (15.31)	197.26 (14.55)	-2.262	.033
I (dB)	70.69 (11.10)	71.81 (10.14)	-2.356	.027
RFF offset 10	0.33 (0.67)	-0.30 (0.76)	2.806	.001
RFF onset 1	1.22 (1.27)	0.77 (1.39)	1.558	.132
CPP (dB)	6.41 (.95)	6.26 (1.26)	.799	.429
CPP SD (dB)	3.30 (.58)	3.20 (.59)	1.222	.229
L/H ratio (dB)	26.01 (6.11)	27.94 (6.49)	-2.857	.007
L/H ratio SD (dB)	8.70 (.95)	8.55 (1.40)	.774	.443

Note. F0, fundamental frequency; I, intensity; RFF, relative fundamental frequency; ST, semitones; CPP, cepstral peak prominence; CPP SD, CPP standard deviation; L/H ratio, low-to-high spectral ratio; L/H ratio SD, L/H ratio standard deviation.

increased after work, whereas RFF offset 10 decreased. Pre- to post-shift RFF traces are illustrated in Figure 2.

DISCUSSION

This study examined whether routine clinical work produces measurable changes in vocal symptoms and acoustic indicators of laryngeal tension in female SLPs by comparing self-reported symptoms and voice measures obtained before and after a typical workday. Post-shift ratings of vocal effort, vocal fatigue, and laryngeal discomfort were each significantly elevated, as were F0, intensity, and L/H ratio. Conversely, RFF offset 10 declined significantly after work. These findings collectively indicate that an ordinary clinical workday leaves a discernible imprint on both the subjective and acoustic dimensions of voice in SLPs.

The significant post-shift increases in all three subjective vocal symptom ratings attest to the phonatory burden inherent in clinical practice. Vocal effort rose from a relatively low pre-shift level to a moderate post-shift level, suggesting that maintaining continuous, high-quality communication across successive therapy sessions requires progressively greater phonatory resources. Excessive voice use disrupts vocal fold vibratory behavior and erodes muscular endurance, prompting speakers to exert additional effort to preserve habitual loudness and voice quality [10]. The parallel post-shift increase in intensity observed in this study is consistent with this compensatory mechanism.

During therapy sessions, SLPs are routinely required to produce highly intelligible verbal models, sustain extended therapeutic interactions, and frequently repeat or emphasize target utterances. Under such conditions, elevated vocal effort is not merely a subjective sensation; it reflects physiological adaptations that include increased vocal fold contact force and elevated subglottal pressure [13,38]. The accompanying post-shift increase in vocal fatigue and laryngeal discomfort, therefore, suggests that the daily communicative demands of clinical practice can accumulate a transient laryngeal burden and may elicit a hyperfunctional phonatory response pattern.

The significant post-shift increases in F0 and intensity reflect a predictable physiological relationship between laryngeal tension and subglottal pressure. Greater speech intensity typically requires elevated subglottal pressure, which tends to raise F0 [39,40]. SLPs routinely modulate their speech to deliver clear verbal models and sustain effective therapeutic interaction, and the present data suggest that both vocal intensity and pitch increased because of these demands. The post-shift elevation in F0 may also reflect heightened tension in the intrinsic and extrinsic laryngeal musculature—including the suprahyoid region—along with upward displacement of the laryngeal framework [13,14].

The significant post-shift decline in RFF offset 10, accompanied by a non-significant downward trend in RFF onset 1, aligns with previous evidence identifying RFF as a sensitive marker of laryngeal tension induced by vocal demand [13,41,42]. In a VCV phonetic context, the offset segment captures the transition from voiced to voiceless production, during which vocal fold abduction begins. As vocal fold contact diminishes and transglottal pressure dynamics shift, the vibratory period lengthens and F0 falls toward the end of the offset segment [43]. In speakers with healthy voices, longitudinal vocal tension remains relatively stable during this transition, yielding minimal F0 reduction at offset [37]. By contrast, in hyperfunctional phonatory states, the regulation of longitudinal tension becomes less efficient, and RFF declines more steeply during the voiceless transition [11,25,37,44]. The reduction in RFF offset 10 observed after work, therefore, suggests that sustained clinical voice use leaves the larynx in a state of temporary hypertonicity. The post-shift increase in vocal intensity observed in the present study should not be regarded

as a simple confounding variable in the interpretation of RFF changes. Elevated vocal intensity is fundamentally a behavioral and physiological reflection of increased vocal demand: producing louder voice necessitates higher subglottal pressure, greater vocal fold adduction force, and increased medial compression—all of which promote laryngeal tension [13,39,40]. From this perspective, the concurrent post-shift increases in intensity and decreases in RFF offset 10 are not independent or competing observations; rather, they represent converging indicators of the same underlying hyperfunctional phonatory state driven by occupational vocal demand. Indeed, one aim of the present study was to document this integrated pattern of change across multiple acoustic dimensions simultaneously. Nevertheless, we acknowledge that the relative contributions of intensity-related phonatory adjustment and intrinsic laryngeal tension to the observed RFF decline cannot be experimentally partitioned within the present field-based design. Future studies that systematically control for or equate vocal intensity across pre- and post-shift conditions would allow a more precise characterization of the independent contribution of laryngeal tension to RFF change.

The onset segment, by contrast, reflects the resumption of voicing following the voiceless consonant—a phase involving renewed vocal fold adduction, restoration of transglottal pressure, and interaction with longitudinal vocal tension [25]. In hyperfunctional voice disorders, impaired regulation of longitudinal tension also depresses onset RFF, with reduced onset 1 being a characteristic finding [37]. The present study observed a post-shift decrease in RFF onset 1 that did not reach statistical significance. This non-significant trend should be interpreted with caution and cannot be taken as evidence of onset-related laryngeal change in the present sample. Rather, onset measures are inherently more susceptible than offset measures to variability introduced by speech rate, vocal intensity, and speaking style [25,45]. Therefore, the non-significant change in onset 1 is more plausibly attributed to the greater intrinsic variability of the onset segment, compounded by real-world field recording conditions. Any inference regarding onset-related hypertonicity in this context would require replication with stricter recording controls and a larger sample.

The significant post-shift increase in L/H ratio warrants brief consideration. The L/H ratio reflects the distribution of spectral energy between low- and high-frequency bands (typically with a cutoff at 4 kHz) and is routinely interpreted alongside CPP in clinical voice assessment. It is important to note that L/H ratio may reflect both laryngeal tension and vocal effort, as both constructs can influence the distribution of spectral energy. Laryngeal tension, in a narrower biomechanical sense, refers to altered vocal fold stiffness and impaired longitudinal tension regulation, primarily indexed by F0 and RFF; vocal effort, by contrast, is a broader perceptual and physiological construct reflecting the phonatory resources required to produce voice, more directly indexed by intensity and subjective ratings. Because these constructs are not orthogonal and some acoustic measures overlap across both, interpretation of the L/H ratio requires caution. The absence of significant changes in CPP, CPP SD, and L/H ratio SD, alongside the significant increase in L/H ratio, suggests that work-related alterations in phonatory behavior influenced spectral energy distribution without producing a generalized deterioration in overall voice quality. As intensity also increased after work, the rise in L/H ratio may, in part, reflect the redistribution of spectral energy associated with louder speech. Accordingly, the observed increase in L/H ratio should not be interpreted as an independent index of laryngeal tension per se; it may, at least in part, reflect the redistribution of spectral energy secondary to increased vocal intensity rather than a direct consequence of altered vocal fold biomechanics. Recent evidence has linked increased vocal intensity to higher L/H ratios in vocally healthy individuals, and both mean

sound pressure level and L/H ratio have been identified as robust acoustic correlates of vocal effort [13,46]. The present finding, therefore, indirectly reflects compounded changes in intensity, vocal effort, and spectral balance rather than an isolated index of laryngeal tension.

The work schedules reported by participants help contextualize these findings. On average, participants worked approximately 6 hours per day, with therapy sessions lasting about 40 minutes, and breaks between sessions averaging less than three minutes. Such brief inter-session recovery periods are unlikely to permit adequate physiological restoration of the phonatory system. As transient vocal fatigue accumulates without sufficient rest, laryngeal tension may persist and compound across sessions, ultimately producing the measurable changes observed at the end of the workday.

Recovery from vocal demand is a multifactorial process influenced by the proportion of voiced to voiceless speech, pausing behavior, habitual intensity, pitch, and individual physiology [47,48]. Prior research in teachers demonstrated that full recovery of subjective vocal effort following a two-hour sustained reading task required 4-6 hours in half of participants and up to 12-18 hours in 90% [49]. Although these values cannot be directly extrapolated to SLPs, the underlying principle remains applicable: extensive occupational voice use demands meaningful recovery time. When structured rest periods are not incorporated into the workday, the likelihood that transient hyperfunctional patterns will become habitual increases substantially [50].

From a clinical standpoint, these findings support the importance of preventive voice care for SLPs. When high voice demands recur daily without adequate recovery, temporary hyperfunctional states may consolidate and compromise professional communication, clinical effectiveness, occupational satisfaction, and quality of life [11,51]. Since SLPs face elevated phonatory demand while often having limited opportunities for recovery, practical self-management strategies warrant implementation [52]. Brief vocal exercises during inter-session breaks—such as straw phonation or resonant voice techniques—may help reduce laryngeal hypertonicity and support tissue recovery [52-54]. Direct evidence for the effectiveness of such approaches during clinical workdays is emerging. A recent crossover study demonstrated that semi-occluded vocal tract exercises (SOVTE)—specifically voiced high-frequency oscillation (VHFO)—performed during short breaks between therapy sessions resulted in improvements or maintenance of acoustic parameters (including CPP, jitter, and noise-to-harmonic ratio) compared with voice rest alone, suggesting that active vocal recovery exercises during inter-session breaks may more effectively mitigate the accumulation of vocal loading than passive rest [55]. These findings are directly relevant to the present study, as both lines of evidence indicate that routine clinical voice use induces measurable vocal loading within a single workday and that targeted brief interventions during the workday may help attenuate these effects. Outside working hours, limiting unnecessary voice use and maintaining vocal hygiene practices, including adequate hydration and sleep, can further facilitate recovery.

This study has several limitations. First, the degree of vocal demand likely varied across participants as a function of clinical experience, work setting, and client characteristics; these variables were not controlled [56]. Differences in session intensity, client age and severity, treatment approach, and environmental characteristics (e.g., background noise level, room acoustics) were not controlled and may have differentially affected both subjective ratings and acoustic measures across participants. Future studies should consider stratifying participants by work setting or client population to reduce this source of confound. Second, the cross-sectional, single-day design precludes conclusions regarding longer-term patterns of occupational voice use and recovery; future longitudinal studies spanning weeks or months are warranted. Third, the use of personal smartphones maximized data

collection feasibility but introduced device-related variability that could not be fully controlled. Cepstral and spectral measures such as CPP and L/H ratio are particularly sensitive to recording conditions, including device microphone quality, background noise, and distance from the mouth, and it is possible that some portion of the observed variation in these parameters reflects recording artifacts rather than true physiological change. Although steps were taken to standardize recording conditions (quiet environment, fixed recording distance), the use of personally owned devices of varying types and microphone characteristics constitutes an inherent limitation that should be considered when interpreting the cepstral and spectral findings. Fourth, although [ap^{h}a] was selected based on available Korean RFF evidence and the requirements of field-based repeated measurement, optimal RFF stimuli for Korean speakers require further validation with larger and more diverse samples [27,34]. Fifth, because RFF is sensitive to prosodic factors, speech rate, and intensity, future field-based studies should incorporate stricter recording controls to reduce variability [45]. Sixth, the actual degree of vocal loading experienced during each participant's work shift was not objectively quantified. Factors such as total speaking time, vocal intensity during sessions, and the distribution of voiced and voiceless phonation varied across participants but were not measured. The absence of objective ambulatory vocal monitoring (e.g., accelerometry-based measures of vocal dose) means that the extent to which the observed pre-to-post-shift changes can be causally attributed to vocal demand remains limited. Future studies should incorporate objective ambulatory measures to better characterize occupational vocal load and its relationship to acoustic and subjective outcomes.

In summary, this study demonstrates that routine clinical work in SLPs produces measurable changes in both subjective vocal symptoms and objective acoustic measures—including F0, intensity, RFF offset 10, and L/H ratio—within a single workday. The concurrence of increased vocal effort, fatigue, and laryngeal discomfort with a significant decline in RFF offset 10 indicates that repeated phonatory demands without sufficient recovery can precipitate transient laryngeal hypertonicity. To safeguard the vocal health of SLPs, workplace policies ensuring adequate rest periods, together with voice care education and accessible self-management programs, appear warranted.

ACKNOWLEDGMENTS

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2024S1A5A2A03034643), as well as a Kangnam University Research Grant (2024). Portions of this study were presented at the 2023 Joint Conference of the Korean Academy of Speech-Language Pathology and Audiology and the Korean Association of Speech-Language Therapy.

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