Relationship Between Laryngeal Signs and Symptoms, Acoustic Measures, and Quality of Life in Finnish Primary and Kindergarten School Teachers

Munier, Caitriona ; Brockmann-Bauser, Meike ; Laukkanen, Anne-Maria ; Ilomäki, Irma ; Kankare, Elina ; Geneid, Ahmed

Abstract: Objective This study investigated the relationship between the acoustic measure smoothed cepstral peak prominence (CPPS), teacher's quality of life as measured by the voice activity and participation profile (VAPP), laryngeal signs and symptoms, voice related health problems and laryngoscopic findings in Finnish teachers. The relationship between CPPS and sound pressure level (SPL) was also assessed. Methods Vowel and text samples from 183 healthy Finnish teachers (99 kindergarten teachers [KT] and 84 primary school teachers [PST]) were analyzed for CPPS. Text reading was recorded in conversational loudness by PST, and KT were recorded wearing headphones, while listening to a masking noise of children talking to simulate their classroom voice and environment. CPPS values were correlated with the VAPP, self-reported laryngeal signs and symptoms, voice related health variables, and laryngoscopic findings. Results There was a significant difference between the two groups for CPPS text, PST showed significantly lower CPPS values (10.44) than KT (11.52). There was no difference between the two groups for CPPS vowel phonation. There was a significant correlation between SPL text and CPPS text for KT ($P < 0.001$, $r = 0.43$) but not for PST ($P < 0.10$, $r = 0.16$). There was a significant correlation between SPL vowel and CPPS vowel for both PST ($P < 0.001$, $r = 0.47$) and KT ($P < 0.001$, $r = 0.45$). CPPS did not correlate with the VAPP, laryngeal signs and symptoms, health variables or laryngeal findings. Factorial analysis of variance resulted in a significant relationship between the VAPP, laryngeal signs and symptoms, and teacher type. Teacher type and symptoms had a significant effect on VAPP scores. Conclusions In the present work CPPS does not correlate with vocal health indicators of functionally healthy teachers. CPPS was significantly influenced by differences in speaking voice SPL, emphasizing the impact of recording conditions and technique. There was a significant relationship between laryngeal signs and symptoms, teacher type and the VAPP. Laryngeal signs and symptoms and teacher type are important variables and should be included in the clinical evaluation of occupational voice users, and voice problems.

DOI: https://doi.org/10.1016/j.jvoice.2018.12.006

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Summary: Objective. This study investigated the relationship between the acoustic measure smoothed cepstral peak prominence (CPPS), teacher's quality of life as measured by the voice activity and participation profile (VAPP), laryngeal signs and symptoms, voice related health problems and laryngoscopic findings in Finnish teachers. The relationship between CPPS and sound pressure level (SPL) was also assessed.

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Results. There was a significant difference between the two groups for CPPS text, PST showed significantly lower CPPS values (10.44) than KT (11.52). There was no difference between the two groups for CPPS vowel phonation. There was a significant correlation between SPL text and CPPS text for KT ($P < 0.001$, $r = 0.43$) but not for PST ($P < 0.10$, $r = 0.16$). There was a significant correlation between SPL vowel and CPPS vowel for both PST ($P < 0.001$, $r = 0.47$) and KT ($P < 0.001$, $r = 0.45$). CPPS did not correlate with the VAPP, laryngeal signs and symptoms, health variables or laryngeal findings.

Factorial analysis of variance resulted in a significant relationship between the VAPP, laryngeal signs and symptoms, and teacher type. Teacher type and symptoms had a significant effect on VAPP scores.

Conclusions. In the present work CPPS does not correlate with vocal health indicators of functionally healthy teachers. CPPS was significantly influenced by differences in speaking voice SPL, emphasizing the impact of recording conditions and technique. There was a significant relationship between laryngeal signs and symptoms, teacher type and the VAPP. Laryngeal signs and symptoms and teacher type are important variables and should be included in the clinical evaluation of occupational voice users, and voice problems.

Key Words: Smoothed cepstral peak prominence (CPPS)—Voice Activity and Participation Profile (VAPP)—Quality of life—occupational voice users—voice problems—teacher type—laryngeal signs and symptoms—voice related health problems—laryngoscopic findings—voice and emotion—working conditions.

INTRODUCTION

Teachers as voice professionals at risk of voice disorders

Teachers represent the largest group of professionals who use their voice as their primary tool of trade.[1] Voice load is a worldwide problem in the teaching profession.[2] They use their voice with high intensity in noisy classrooms for long periods without suitable breaks[3] and primary school teachers in particular have little opportunity for vocal rest.[4] Studies have reported on the prevalence of voice problems,[1,4,5,6] nature, risk factors,[6] working conditions,[7,8] vocal and physical symptoms, impact on quality of life, performance at work, emotions, communication handicap at work and socially,[9] and their economic impact due to absenteeism from work.[10,11] Due to the fact, that voice problems have a multifactorial etiology and their impact is so wide ranging, evaluation and diagnosis is complex and needs to encompass all dimensions.

In this study, we focus on two large groups of teachers, primary school teachers (PST) and kindergarten teachers (KT). The essential difference between these two groups lies in their working conditions, in particular their working hours, and vocal demands. Kindergarten children are more dependent on the teacher for oral instruction than primary school children as they have not yet learned how to read and write.[4] They therefore need more verbal instruction. This puts greater vocal demands on the teacher's voice, which may reflect in different or more distinct adaptation patterns being used. By contrast, primary school children can work more independently and are less vocally demanding of the teacher's voice,[7] leading to less vocal load during a working day.

Consequently KT have to adapt to a higher vocal demand, which may lead to increased subjective voice

Accepted for publication December 10, 2018.

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Journal of Voice, Vol. ■■, No. ■■, pp. ■■−■■
0892-1997

https://doi.org/10.1016/j.jvoice.2018.12.006

symptoms and also measurable acoustic voice differences after a working day. Several authors have demonstrated that acoustic measurements in vocally healthy teachers show an increased F0 and speaking sound pressure level (SPL), but lower irregularity (perturbation) after a school day. Teachers with more subjective symptoms have been demonstrated to exhibit a less intense increase in F0 and more vocal fatigue.[12,13] Further, dysphonic teachers showed increased jitter and shimmer after vocal load.[14,15]

Cepstral peak prominence and smoothed cepstral peak prominence

"A cepstrum is a log power spectrum of a log power spectrum".[16,17] Based on cepstrum analysis, Hillenbrand et al developed the parameter Cepstral Peak Prominence (CPP), which is a measure of the degree of harmonic organization of the signal.[16,17] The CPP is the relative amplitude of the cepstral peak,[16–18] the level difference (in dB) between the maximum peak in the cepstrum (mainly corresponding to fundamental frequency) and the regression line fitted on the cepstrum.

Smoothed Cepstral Peak Prominence (CPPS) is a variant of CPP, and is a spectrum based acoustic measure. It is smoothed in temporal and spectral domains especially to improve the accuracy of cepstral analysis of connected speech.[19] CPPS has been shown to correlate with perceptual dysphonia and specifically breathiness.[20] In recent years cepstral measures of the voice have been used extensively, and are considered to be the most reliable measures of dysphonia.[16,17,19–21] In contrast to traditional time based perturbation measures such as jitter and shimmer, they are applicable to more irregular voice signals with unstable fundamental frequency and sound pressure level (SPL). Healthy periodic voices have a prominent cepstral peak, while dysphonic aperiodic or breathy ones have a reduced cepstral peak.[21] The amplitude of the cepstral peak has been found to correlate with dysphonia severity.[16,17,19–21]

In an Iranian study Hasanvand et al[18] found significant differences between dysphonic and normal subject's CPP and CPPS scores in reading tasks in males and in females, and CPPS sustained vowels in males and females. However, the two male groups showed no differences in CPPS sustained vowel phonation. CPP and CPPS scores were lower in both sustained vowels and reading tasks for dysphonic females compared to the control group and either group of males. They concluded that both CPP and CPPS are reliable in distinguishing between normal and dysphonic voices in connected speech. Hillenbrand and Houde[17] reported that CPP and CPPS were good as measure of breathiness with 92% accuracy for sustained vowels and 85% accuracy for connected speech. In their study, CPPS from sustained vowels correlated better with perceptual analysis than CPPS from continuous speech. Heman-Ackah[20] found that there was a better correlation between perceptual analysis and CPPS in connected speech than in sustained vowels. Lowell and Hylkema[22] reported that speaking context did not significantly impact the CPP measures in normal voices.

Gaskill et al (2017)[21] included intermittently dysphonic subjects in their study and reported that auditory acoustical judgement, and mean CPP are both ineffective for classifying intermittently dysphonic voices. They found that the mean CPP was the strongest single discriminator among three voice types: the normal, intermittent, and the consistently dysphonic groups. The normal and intermittent dysphonic groups voices were not significantly different on CPP distribution skewness, and measures of CPP distribution outliers. Normal and intermittently dysphonic voices differed significantly from consistently dysphonic voices on these variables.

CPPS measures were found to be reliable regardless of acoustic software analysis programme used. Sauder et al[23] investigated the relationship and reliability of CPPS measures from two acoustic software applications Praat[24] and ADVS[24] (Analysis of Dysphonia in Voice and Speech, model 5109 version 3.4.2; Kay Pentax Corporation). They found a strong relationship ($r > 0.88$, $P < 0.001$) between CPP measures derived from both of the softwares. In their study CPPS was very accurate in predicting a voice disorder from connected speech samples with 82% accuracy for PRAAT, and 75% accuracy when using ADSV. Despite slight differences in sensitivity and specificity the authors concluded that CPPS was highly predictive of voice disorders using either programme.

This review of the CPPS literature would indicate that CPPS is a relatively reliable tool in distinguishing between dysphonic and normal voices, and is also a measure of perceptual breathiness. CPPS connected speech has been shown to be a more accurate measure than CPPS vowel phonation. However, CPPS is not a reliable measure of intermittently dysphonic voices. Importantly, CPPS measures were found to be reliable regardless of the acoustic software analysis programme used. To date it is unclear, how subjective voice symptoms correlate with acoustic findings in different teacher groups. Therefore, in the present study CPPS was applied to analyze the voices of kindergarden and primary school teachers during connected speech and vowel phonation.

Evaluating the impact of a voice problem on the individual's daily functions

Historically assessment and diagnosis was often restricted to structural and physiological examination of the larynx and to perceptual analysis of the voice. However, the overall impact of the voice problem was not taken into account. The problem with this approach is that traditional clinical voice evaluation measures did not capture "the impact of the disorder on the limitation of voice activities and restriction in participation." In other words, traditional clinical voice evaluation methods do not capture the

impact of the voice problem on an individual's daily functions in the context of personal, social, and environmental perspectives."[9]

More recently the impact of a voice disorder on the individual's daily communication including social, work, and home environments has been considered. In recognition of this, different assessment tools have been developed[25–27] to capture the overall impact of a voice disorder. In this study, we use the The Voice Activity and Participation Profile (VAPP) developed by Ma and Yiu,[9] a self-assessment questionnaire assessing the impact of a voice disorder on the individual's communication at work, daily communication, social communication, and emotions. It also captures the impact of the voice disorder on the limitation of voice activities, and restriction in participation.

The overall concept of the VAPP is based on the WHO framework emphasizing the effect of a voice disorder on life activities (disability) and participation (handicap).[28] It differentiated itself from previous tools in that it assessed voice activity limitation, and participation restriction separately. It drew on the conceptual framework of the ICIDH Beta 1 (World Health Organization, 1997)[29] in its development. This WHO document was the first to coin the idea of "limitation of activities" and "restriction in participation," these are also affected by environmental and personal factors.

Environmental factors and working conditions

Environmental factors include the individual's work environment, it's working conditions and demands on the individual. The WHO recognizes that work and health interact with one another. When work is fully adapted to human goals, capacities, and limitations and occupational health hazards are under control, work plays a role in promoting both physical and mental health. The work environment and its characteristics can play a role together with other risk factors in the development of disease having a complex and multiple etiology (WHO 1998).[30] This interaction between the environment and the health of the individual is related to the field of Ergonomics, or the adaptation of the individual's environment to promote both physical and mental health. Voice ergonomics relates to adapting jobs, tasks, and environments compatible with the needs, abilities and limitations of people with a voice disorder.[28]

We applied the VAPP, because it takes environmental and personal factors into account, and these factors may affect vocal health. The second reason is that it also measures the impact of a voice problem on the individual's emotions. The relationship between voice and emotions is well known and was first documented by Moses, "The voice is the mirror of our emotions, and as carrier of the emotional message becomes part of the emotion."[31]

Aim of the study

Based on the literature the purpose of this study was to investigate the relationship between CPPS, teacher's quality of life as measured by the VAPP, laryngeal signs and symptoms, teacher type and voice related health problems (asthma, allergies, respiratory infection, and reflux) in KT and PST. In addition, the relationship between CPPS and speaking voice SPL was assessed.

Main hypotheses.

1) Smoothed CPPS correlates with laryngoscopic evidence of vocal fold pathology, teachers' self-perceived laryngeal signs and symptoms, and teachers' voice related quality of life, as measured using the VAPP.
2) CPPS from text reading in habitual loudness correlates better with laryngoscopic evidence of vocal fold pathology, teacher's self-perceived laryngeal signs and symptoms, and teachers' quality of life than CPPS derived from vowel phonation.

METHODS

Participants

One hundred and eighty three Finnish teachers divided into two groups, of these 99 KT, aged 25–64 years (mean: 43.4 years), and 84 PST aged 26–57 years (mean: 41 years), participated in this study. They volunteered for the study by responding to an internet voice questionnaire. The questionnaires delivered on the internet were divided into four different categories and designed to get information on subject's background including age, teaching experience in years, class size (number of pupils), teaching hours per week, and general voice-related health information (allergies, asthma, reflux, and upper respiratory tract infections). The other categories included were self-assessment of voice quality and subjective voice symptoms. All participants underwent a laryngoscopic evaluation performed by a phoniatrician. The material for this study has been obtained from two previously collected databases at the University of Tampere, which has been described in Ilomäki et al, and Kankare et al.[32,33]

Number of years taught, number of teaching hours and class sizes

For KT in this study, the number of years in teaching varied from 1 to 36 years with the mean number of years in teaching being 17 years. The duration of the working day varied from 1 to 8 hours with a mean of 7.46 hours. On an average, the number of hours teaching was 37 hours per week. The average class size was 19.5 pupils.

For PST the mean number of years teaching was 15.3 years (SD 9.2, range 1–33 years). The mean amount of instruction given per week was 25 hours (SD 1.9, range 20–30). The average class size was 19.4 pupils (SD 7.3, range 6–31), for class teachers the mean was 21.4 pupils (SD 5.7).

Laryngoscopic evaluation

Laryngoscopic examination was carried out on all subjects through videolaryngoscopy. The instruments used were a mobile videolaryngoscopy system (rpSzene-Mobile, Rehder/

Partner GmbH, Germany) composed of a small 1/3" CCD camera rp Cam250, Rehder/Partner mounted with a 28−35 mm focus zoom lens, combined with a 70° laryngeal telescope (model 4450,47, Richard Wolf, Germany) and a cold halogen light source (model rp 150, Rehder/Partner).

Recordings were made in digital format. The subjects were seated leaning forward with the chin up during the examination. Recording was performed during an intermittent and sustained phonation of /i/ before and after throat clearing. The recordings were reviewed by one of the authors A.G. using an endoscopic form. The evaluation scale was 1 = normal larynx, 2 = mild changes, 3 = severe changes, or clear laryngeal findings, such as nodules and polyps.

Subjective laryngeal signs and symptoms

The self-perceived laryngeal signs and symptoms that were investigated by questionnaire were: "aphonia", "vocal fatigue", "hoarse", "irritation or tickle", "mucus or lump", "tired", "tiredness or pain", and "voice breaks". Subjects were asked about the frequency of occurrence of their symptoms which were scored on a Likert scale (scale: 0 = hardly ever, 3 = occasionally, 5 = monthly and 8 = weekly) for the symptoms "aphonia", "hoarse", and "vocal fatigue". These were considered the most serious symptoms. The remaining five symptoms "irritation or tickle", "mucus or lump", "tired", "tiredness or pain" and "voice breaks" were scored on a Likert scale of 0,2,4,7. The sum variables of self-reported laryngeal signs and symptoms were calculated to enable statistical comparison.

VAPP evaluation

Subjective symptoms were assessed using the Finnish version of the VAPP.[34] The Finnish version of the VAPP consists of 28 questions divided into five areas: self-perceived severity of a voice disorder (one question) work section (WS, four questions), daily communication section (DS, 12 questions), social communication section (SS, four questions), and emotion section (ES, seven questions). Ten activity limitation and participation restriction situations are included in the WS, DS, and SS sections. The maximum score of the VAPP total is 280. The questions are answered using a 10 cm long straight line, a visual analogue scale, on which the left end represents "not affected" and the right end "always affected". Respondents place an X on the scale corresponding to the level they were affected by the described voice dysfunction. The distance in millimetres measured from left to where the respondents put an X on the line was used to score each item.

Recording technique and tasks

The PSTs and the KTs were required to read for 1 minute in Finnish from the text "The Human Comedy" by W Saroyan[35] and to maintain phonation of [a:] for 5 seconds at habitual speaking pitch and loudness. The vowel task was repeated three times. The KTs were recorded wearing headphones while listening to a recording of children talking through the headphones. The aim was to simulate the classroom environment and to elicit their classroom voice. All teachers were recorded in an empty classroom. A portable digital recorder (Sony TCD-D8) was used with a headset microphone (AKG B29L) placed at a distance of 6 cm from the corner of subject's mouth at a 45 degree angle.

Calculation of CPPS

CPPS was determined for sustained vowel phonation and continuous speech using PRAAT (version 5.4.05). The analysis window taken from the vowels were the three most stable seconds in the middle, of the second out of the three repetitions. From the speech samples the first two sentences were taken. A sampling rate of 44.1 kHz and the amplitude depth of 16 bits were used. The settings used for analyzing CPPS from text were those published in Watts, Awan, and Maryn.[19]

Statistical methods

A two-sample *t*-test was used to compare the differences between PST and KT. If the data failed tests for skewness and kurtosis, we used the Mann-Whitney *U* test, on condition that it passed the Kolmogov Smirnoff test for equality of distributions.

For correlation of the variables Spearman's rank Correlation Coefficient was applied. For categorical data, we used the Chi-squared test with Fisher's continuity correction. For analysis of the effect of multiple variables on a single variable we used multiple stepwise regression. Included were the covariables age, hours worked per week, voice training, years taught. For analysis of interactions between factors factorial analysis of variance (ANOVA) was applied.

All data was analyzed using NCSS12.[36] The NCSS12 comes with diagnostic tests to test for assumptions Skewness Normality (for each group), Kurtosis Normality (for each group), Omnibus Normality (for each group), Variance Ratio Equal-Variance Test, and Modified Levene Equal Variance Test.

RESULTS

CPPS differences between PST and KT

The Mann-Whitney *U* test was used to compare the results for CPPS in the two speaking tasks with each other for PST and KT (Table 1). There was a significant difference between the two groups in text reading, PST showed significantly lower CPPS values (10.44) than KT (11.52; $P < 0.001$, r 0.414). There was no difference between the two groups for CPPS from sustained vowel phonation KT (13.23), and PST (13.62; $P > 0.05$).

TABLE 1.
Differences in CPPS Values for Primary and Kindergarten Teachers

	Teachers	Mean	SD	Range	Significance (*P*)
CPPS vowel	Kindergarten	13.32	1.93	8.63	ns $P > 0.05$
	Primary	13.62	2.08	9.42	
CPPS text	Kindergarten	11.52	1.13	5.32	$P < 0.001$, r 0.414
	Primary	10.44	1.54	7.38	

Correlations between CPPS and SPL in vowels and text

It has been reported in the literature that an increase in SPL may result in an increase in CPPS scores.[37] KT wore headphones while listening to a recording of children's voices during voice recordings (masking effect), so there were anticipated differences in SPL values between PST and KT. The Spearman correlations were carried out for each teacher type individually. The Scatter plots 1 and 2 are a good example of how elicitation of the classroom voice through wearing headphones with masking noise influenced SPL text in KT. The Scatter plots show the distribution of SPL text and vowel for the two teacher types.

There was a significant correlation between SPL text and CPPS text for KT ($P < 0.000009$, r = 0.43) but not for PST ($P < 0.102862$, r = 0.165). Figure 1 shows that KT had a higher mean SPL (86.9 dB SD 3.1 dB) for text than PST (76.2 dB SD 3.5 dB).

There was a significant correlation between SPL vowel and CPPS vowel for both KT ($P < 0.000006$, r = 0.452) and PST ($P < 0.000006$, r = 0.471). The mean SPL vowel for KT was 91 dB (SD 3.7 dB), and for PST, 82 dB (SD 6.1 dB) (Figure 2).

Correlation between CPPS and indicators of vocal health

CPPS from text and vowel did not correlate with the self-reported laryngeal signs and symptoms, voice related health problems (asthma, reflux etc) or with any VAPP parameters.

Correlation between CPPS and laryngoscopic examination

There was no significant effect of laryngoscopic exam results on CPPS (CPPS vowel $P < 0.05$, $P = 0.06614$ and CPPS text $P < 0.043192$). We analyzed the relationship between the laryngoscopic examination and CPPS using the randomized block ANOVA and the nonparametric equivalent, the Kruskal-Wallis test. There was a trend for a high score on the Phoniatric exam to affect CPPS, but this was not significant as there was huge variability.

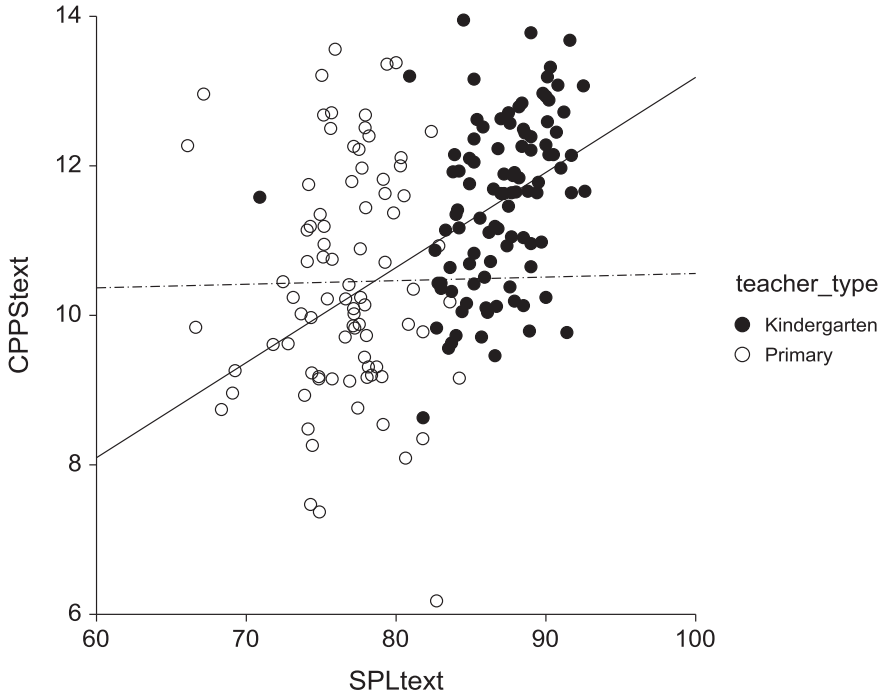

FIGURE 1. Correlations between CPPS and SPL derived from text for primary and kindergarten teachers.

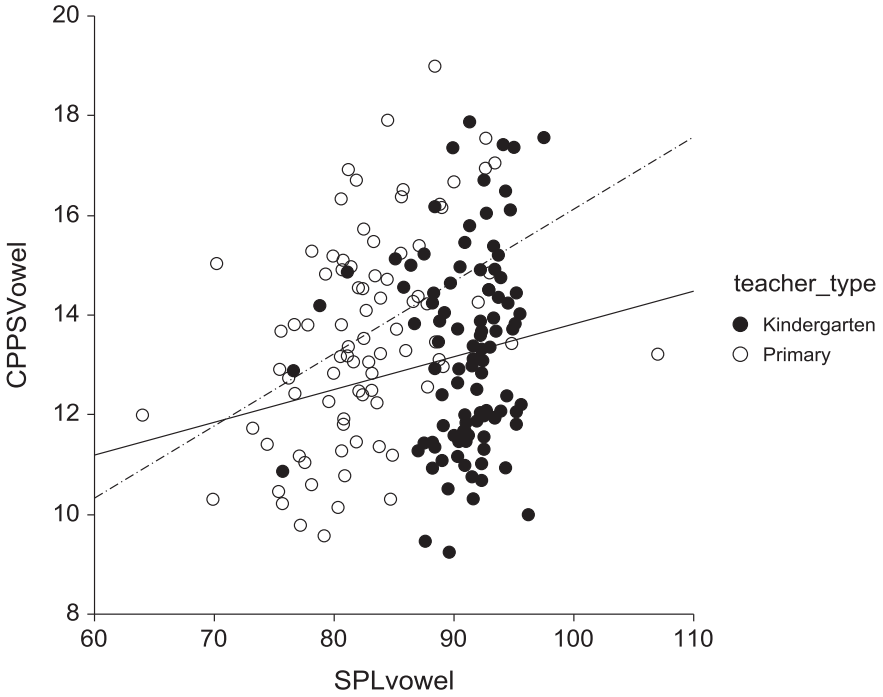

FIGURE 2. Correlations between CPPS and SPL derived from vowel for primary and kindergarten teachers.

Differences in VAPP sums for PST and KT

There were significant differences between PT and KT for all VAPP sums and for activity limitation. PST scored significantly higher for all VAPP sum parameters with the exception of VAPP social sum, where KT scored significantly higher (Table 2).

Interactions between the parameters from the VAPP, laryngeal signs and symptoms and teacher type

We carried out a factorial ANOVA to examine the response of a range of parameters to eight different laryngeal signs and symptoms and teacher type. KT and PST are differentiated by their working conditions, therefore, teacher type was used as a proxy for working conditions. The parameters from the VAPP were: activity limitation, communication sum, emotion sum, job sum, severity sum, social sum, and total VAPP. The acoustic parameters included in the factorial ANOVA were CPPS text, CPPS vowel, SPL text, and SPL vowel. The Laryngeal signs and symptoms included were: aphonia, voice breaks, fatigue, hoarse, irritation or tickle, mucus or lump, tired, and tiredness or pain.

The effects on all parameters were similar for all laryngeal signs and symptoms and teacher type. For conciseness, only data for the symptom "Hoarse" is shown.

TABLE 2.
Averages for VAPP Sums for Primary and Kindergarten Teachers

Parameter	Type	Count	Mean	Standard Deviation	*P*
VAPPseveritysum	Primary	84	25.80952	22.54285	0.000000
	Kindergarten	99	7.606061	13.79501	
VAPPjobsum	Primary	84	78.40476	74.11894	0.000001
	Kindergarten	96	28.73958	23.66932	
VAPPcomsum	Primary	84	186.9643	170.9537	0.000000
	Kindergarten	99	69.06061	63.51953	
VAPPsocialsum	Primary	84	42.86905	58.83892	0.000000
	Kindergarten	99	176.3434	169.4405	
VAPPemotionsum	Primary	84	122.0119	126.8456	0.000000
	Kindergarten	99	33.55556	49.12442	
VAPPtotalscore	Primary	84	459.1429	396.201	0.000000
	Kindergarten	99	72.66666	85.08963	
ActivityLimitation	Primary	84	172.0952	147.5663	0.000000
	Kindergarten	99	379.495	333.6037	

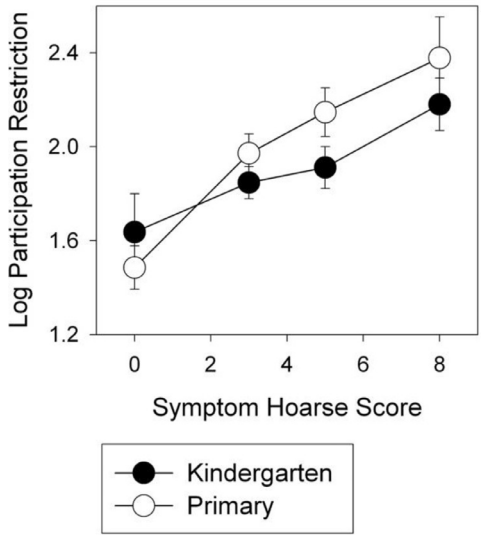

FIGURE 3. Effect of symptom hoarse on participation restriction.

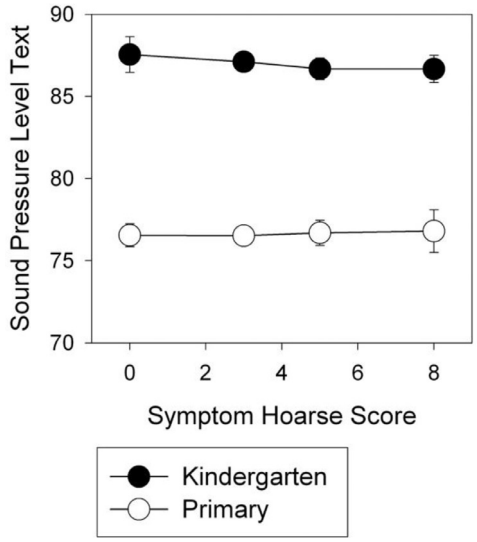

FIGURE 4. Effect of teacher type only on SPL.

In this study, there were very highly significant effects of teacher type on symptoms and the interaction between them. These findings are illustrated in Figures 3–7, indicated values are the mean for KT (closed circles) and primary teachers (open circles) and are shown with the standard error of the mean. The figures illustrate different types of results. Figure 3 shows the effect of symptoms only, Figure 4 the effect of teacher type only on SPL text. Kindergarten teachers consistently scored higher for SPL than primary teachers. Figures 5 and 6 show the effect of both teacher type and symptom. Figure 7 shows the interaction effect between teacher type and symptom, and the effect of interaction. Here, as the symptom level goes up, there is a diverging interaction between the two teacher types.

There was a significant effect of the symptom hoarse score on participation restriction and no effect of teacher type ($P = 0.001$) (Figure 3).

CPPStext, SPLtext, SPLvowel, and VAPPemotion sum all showed a very similar type of response to Symptom Hoarse with no increase in average score with increasing Symptom Hoarse Score. Only data for SPL text are shown here. There was a significant effect of teacher type on SPL text ($P < 0.001$). The teacher type only effect gives two parallel lines (Figure 4).

For VAPP social sum KT scored higher than PST, and the score increased with increasing Symptom Hoarse Score. There was a significant effect of both symptom hoarse ($P = 0.0278$) and teacher type ($P < 0.001$) (Figure 5).

ActivityLimitation, VAPPtotal, VAPPcommsum, VAPPjobsum, VAPPsocialsum, and VAPPseveritysum all showed a very similar type of response, there was an effect of both teacher type and Symptom Hoarse Score. Only data for VAPP total score is shown here. There was a significant effect of both symptom hoarse and teacher type (both

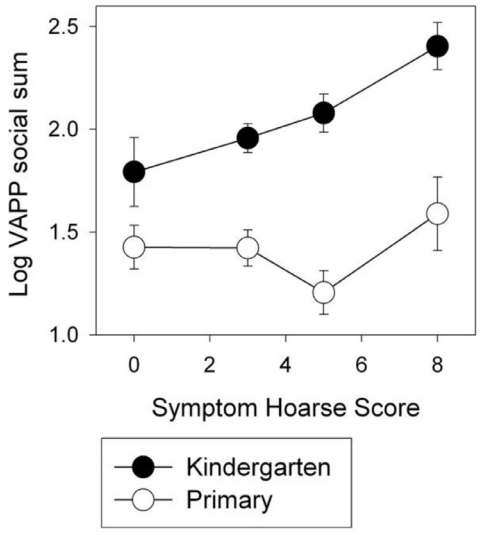

FIGURE 5. Effect of teacher type and symptom hoarse combined on VAPP social sum.

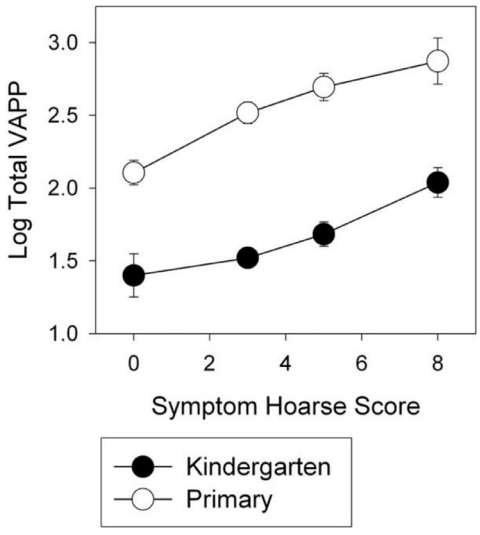

FIGURE 6. Effect both teacher type and of symptom hoarseness on VAPP total score.

$P < 0.001$). PST scored higher than KT at all levels of Symptom Hoarse Score, and scores increased for both groups of teachers with increasing Symptom Hoarse Score (Figure 6).

For VAPP communication score, there was an interaction between teacher type and Symptom Hoarse Score. There was a significant effect of symptom hoarse ($P = 0.036$), teacher type ($P < 0.001$) and of the interaction between them ($P = 0.012$). PST kept a consistently high score, and this did not increase with symptom Hoarse Score whereas KT had a low VAPP communication score at low symptom Hoarse Score and this increased with an increase in symptom Hoarse Score. Here as the symptom goes up, there is diverging interaction between the two teacher types (Figure 7).

Table 3 shows the effect of symptom and teacher type on emotion sum. There is a commonality of response for every symptom and teacher type. This gives an indication of how different symptoms responded. In Table 3, all symptoms are responding in a similar way.

It shows the statistical values for the effect of both symptom and teacher type on emotion sum and the effect of the interaction. Emotion sum is significantly affected by teacher type/working conditions but not by symptom. Therefore, working conditions have an important effect on VAPP emotion sum. Similar effects of symptom and teacher type can be found for all VAPP sums. There was a highly significant relationship between laryngeal signs and symptoms in this study and all VAPP sums.

This effect and similar effects of all symptoms and teacher type on the job indicate that the individual's job is negatively impacted by these variables. This is also true for all VAPP sums.

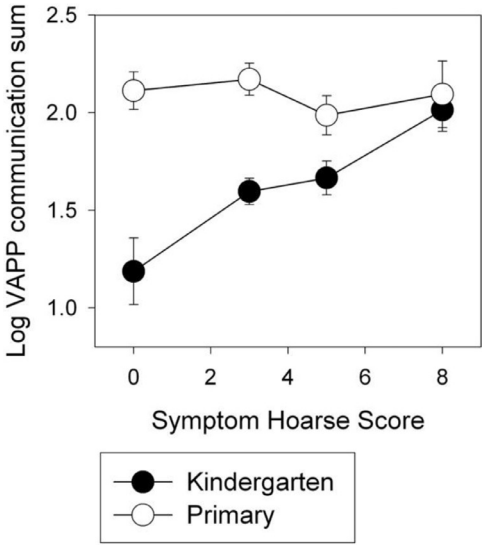

FIGURE 7. Interaction of teacher type with symptom hoarse on VAPP communication sum score.

Relationship between health problems and VAPP

There was a significant relationship between VAPP emotion sum and asthma ($r = 0.046$). Likewise there was a significant relationship between respiratory infection and VAPP job sum ($r = 0.011$), and social sum ($r = 0.031$). There was no association between the health problems, allergies and reflux and CPPS, VAPP, or SPL (Table 4).

Differences in health indicators and VAPP sums for PST and KT

The results of this study allow us to reject hypotheses 1 and 2. CPPS did not correlate with the VAPP, laryngeal signs and

TABLE 3.
Effect of Laryngeal Signs and Symptoms and Teacher Type on VAPP Emotion Sum

Symptom	VAPP	Symptom Effect	Teacher Type Effect	Interaction
Aphonia	Emotion sum	0.163886	0.000008	0.286207
Voice breaks		0.372451	0	0.339864
Fatigue		0.103365	0.00001	0.845643
Hoarse		0.1426	0	0.603455
Irritation tickle		0.178919	0.000007	0.508206
Mucous lump		0.42446	0	0.879025
Tired		0.122696	0.000354	0.94194
Tiredness or pain		0.162911	0	0.698215

TABLE 4.
Relationship Between Health Problems and VAPP Emotion Sum, Job Sum and Social Sum

Health Problems	VAPP Emotion Sum	VAPP Job Sum	VAPP Social Sum
Asthma	$r = 0.046$ $P < 0.05$		
Respiratory infection		$r = 0.011$ $P < 0.05$	$r = 0.031$ $P < 0.05$

symptoms or laryngoscopic evidence of vocal fold pathology. We, therefore, consider CPPS to be an independent variable.

Likewise our results allow us to reject hypothesis 2, CPPS text read in habitual loudness did not correlate better with laryngeal signs and symptoms, with quality of life as measured using the vocal activity and participation profile, or with laryngoscopic evidence of vocal fold pathology than CPPS derived from vowel phonation.

There was however a clear correlation between CPPS and SPL. This correlation was evident between CPPS vowel and SPL vowel in both PST and KT. It was also evident between CPPS text and SPL text for KT but not for PSTs. This difference was influenced by the recording conditions used.

DISCUSSION

There were significant differences in CPPS text scores between the two teacher types. PST had lower CPPS text scores than KT, but there was no difference between the two groups for CPPS vowel phonation. There was a significant correlation between CPPS vowel and SPL vowel for both KT and PST. correlation between SPL text and CPPS text for KT, but not for PST. However, there was no relationship between CPPS, laryngeal signs and symptoms, the VAPP or laryngoscopic exam results.

Teacher type and laryngeal signs and symptoms had a significant effect on all VAPP sum scores. PST scored higher than KT for all VAPP sum scores with the exception of VAPP social sum where KT scored higher. There were significant relationships between the health problems; asthma and VAPP emotion sum, and between respiratory infection and VAPP job sum and VAPP social sum. There was no relationship between the health problems allergies and reflux and the VAPP.

The implications of these results would indicate that CPPS is an independent variable and does not correlate with subjective measures and laryngeal findings. The significant correlation between CPPS and SPL means that attention needs to be paid to the recording conditions and that the variables SPL, and mouth to microphone distance need to be controlled in order to obtain representative CPPS values. More attention also needs to be paid to the importance of including laryngeal signs and symptoms and teacher type in the voice evaluation and in treatment. Working conditions (teacher type = working conditions) and laryngeal symptoms are important variables to be included in voice evaluation.

CLINICAL IMPLICATIONS

CPPS differences between PST and KT

One would have expected to find lower CPPS values in KT in this study than in PST, because of differences in their working conditions. KT in this study worked 37-hour a week, as opposed to a 25-hour week for primary teachers.[32,33] In a Finnish study[33] the working conditions of KT were found to have a negative impact on their voice. It reported that KT have special demands for the voice, they regularly work in the open air and speaking and giving instruction in the open air is demanding for the voice. There are extra demands on the voice in the cold winter climate due to central heating and low air humidity. Kindergarten teaching demands a wide variation of voice in speaking, singing, and in the noisy activities of the kindergarten school.[33] The results of this study did not support the findings of Munier et al[4] who reported that teachers teaching the two youngest classes (aged 4−6) in primary school, had a higher incidence of voice problems than those teaching to older classes (aged 7−12). They attributed this difference to the fact that kindergarten children put greater vocal demands on the teacher as they have not yet learned how to read and write, whereas primary school children can work more independently and put less vocal demands on the teacher.

In this study, however, the differences in CPPS scores between KT and PST were mainly due to the differences in the recording conditions between the two teacher types. KT used a higher SPL, mean 91 dB than PST, mean 83 dB, which resulted in a higher CPPS score.[37,38] Awan et al[37] reported significant increases in CPPS with increase in loudness or SPL. This has implications for clinical recordings: mouth to microphone distance, and amplitude levels, should be controlled and standardized in order to obtain true CPPS values.[38] It has also been reported that slight variations in loudness/intensity of voicing can have a significant influence on the acoustic correlates of voice quality such as jitter and shimmer and harmonics-to-noise ratio.[39] These authors reported a significant decrease in jitter and shimmer with an increase in loudness and intensity. They also found a significant rise in Fo from medium to loud phonation. This effect should be taken into account in CPPS analysis, and the necessary control of vocal intensity in recording should be made.[39]

The finding that PST in this study scored higher than KT for all VAPP sum scores with the exception of VAPP emotion sum indicates that they have a higher incidence of voice problems than KT. This may be due to their working conditions and a different voice load from KT. The primary school curriculum plays an important role here. Leao et al reported that in primary schools in New Zealand the curriculum is very vocally demanding of the teacher, requiring them to teach a variety of subjects.[40] They attributed the higher incidence of voice problems in PST to the teaching curriculum which calls for a significant amount of interaction with students. In an Iranian study, hoarseness was attributed to the learning process and pupil/teacher verbal interaction.[41] Munier et al[7] attributed the overloaded curriculum in Ireland to being an important risk factor in the development of voice problems. The curriculum and the teacher/pupil interaction are important variables to be considered in the etiology of voice problems. In this study, we believe that the higher VAPP sum scores among PST are probably due to this occupational effect.

CPPS text and CPPS vowel

The recorded loudness difference between KT and PST influenced the CPPS text SPL text correlations. In this study, there was a significant correlation between SPL text and CPPS text for KT but not for PST. This may mean that the habitual loudness level used by teachers in the classroom may be related to their laryngeal signs and symptoms. Longtitudinal studies controlling the loudness level, SPL text, would be needed in order to prove this. Therefore, measures of CPPS should be interpreted taking into account SPL effects independently from symptoms and the VAPP. There was no difference between the two teaching groups for CPPS vowel values, despite the fact that recordings were made under the same conditions as for CPPS text. One reason for this may be that CPPS text is more representative of normal of speech than CPPS vowel. Continuous speech has the same prosody as normal speech whereas in CPPS vowel phonation, it is easier to control/manipulate the acoustic output including the SPL and this will be reflected in the CPPS vowel values. In the relationship between CPPS and SPL, CPPS vowel correlated very highly with SPL vowel for both KT and PST. It may be that CPPS vowel in combination with SPL vowel is a more reliable measure than CPPS vowel on its own.

Hasanvand et al (2017)[18] found significant differences between male and female dysphonic and normal subject's CPPS vowel and text scores. However, the dysphonic and normal male groups showed no differences for CPPS vowel phonation. They concluded that CPPS is reliable in distinguishing between normal and dysphonic voices in connected speech. Halberstam et al[42] reported that CPP text is a more valid objective measure of hoarseness than CPP for sustained vowels. On the other hand, Hillenbrand and Houde reported that CPPS sustained vowel phonation is a good measure of breathiness.[17] Further studies in dysphonic voices applying CPPS under adequate control of voice SPL are warranted to determine how this parameter is best and most usefully applied.

Effect of teacher type and laryngeal signs and symptoms on the VAPP

Laryngeal signs and symptoms are a correlate of daily voice function and are an important variable in voice evaluation. We found a significant consistent effect of laryngeal signs and symptoms on the VAPP sum scores for PST and KT. The laryngeal signs and symptoms were: "aphonia", "vocal fatigue", "hoarse", "irritation or tickle", "mucus or lump", "tired", "tiredness or pain", and "voice breaks". PST scored higher than KT for all VAPP sums with the exception of VAPP social sum where KT scored higher. They also scored higher than KT on all symptoms. Likewise teacher type (working conditions) also had a significant effect on all VAPP sum scores. We equate in the present work working conditions with teacher type. Working conditions define and differentiate KT and PST. They differ in the number of working hours per week, age group taught, in vocal load, and in the teaching curriculum, so working conditions are also an important variable in voice evaluation. Our results would indicate that there is an important relationship between VAPP and laryngeal signs and symptoms and teacher type, and that the VAPP is also a very robust tool in the evaluation of professional voice users.

Many studies have reported on the prevalence of vocal symptoms among teachers. Ohlsson et al (1997)[43] in a study of student teachers reported that students with vocal symptoms are at risk of developing voice disorders during their professional careers. Devadas et al (2017)[44] in a survey of 1082 teachers in India, reported that out of 14 symptoms exhibited by teachers 52% reported a tired voice, significant at the <0.001 level. Other studies have reported on tiredness or vocal fatigue as a highly significant symptom. Munier et al[4] found vocal fatigue to be significant symptom in PST. In their study, the symptom "vocal fatigue" was reported more frequently in the junior classes of the primary school. The most frequently symptoms reported by PST were "voice fatigue" 18%, "dry throat" 19%, and "inability sing high notes" 20%. Leao et al[40] reported vocal fatigue to be one of the most frequently reported symptoms and also to be one of the most severe symptoms. Teachers rated throat discomfort, voice quality alterations, singing difficulties and vocal fatigue to be the four most frequent and severe symptoms in descending order out of 11 symptoms. Simberg[45] reported a clear association between the number of potential vocal risk factors and the number of voice symptoms.[45] In a Finnish study, a significant correlation ($P < 0.01$) was found between voice symptoms and the negative impact of working conditions.[33] In this study, we report a clear association between laryngeal signs and symptoms and their impact on the individual's communication in daily life as elicited by the VAPP.

Laryngeal signs and symptoms among teachers were very common in this study and may be the early signs of developing voice problems. Therefore, symptoms should be included in questionnaires evaluating vocal health. Teachers and occupational voice users should be trained to identify them, and should seek help when they first become aware of them. Intervention in the workplace by a voice specialist at this stage may help to prevent the development of a voice disorder. Primary care doctors and laryngologists should also be aware of laryngeal signs and symptoms.

The VAPP and Emotion

In this study, there was a significant relationship between teacher type and emotion sum. Teacher type/working conditions in this study had a significant effect on VAPP Emotion sum. Therefore, working conditions affect VAPP emotion sum. The relationship between voice and emotion is well-documented in the literature Scherer (2003).[46] Scherer was the first to carry out empirical research investigating the link between voice and emotion. In his research fundamental frequency Fo was proven to be a good indicator of emotion.[47] Other research has focused on voice in the

communication of emotion[48] and the effects of emotions on voice quality.[49] This relationship was illustrated by Moses (1960).[31] "The voice is the mirror of our emotions and the voice as carrier of the emotional message becomes part of the emotion." The emotions bring about changes in muscle tension in respiration and phonation which result in changes in voice quality.[50] It has been reported that acoustical analysis of the voices of subjects undergoing the same stressful situation revealed individual differences in fundamental frequency.[51]

Correlation between laryngoscopic examination and CPPS

There was no significant effect of laryngoscopic exam results on CPPS. This would be expected as one can suffer from a voice disorder with having any visible lesions on the vocal folds and in turn visible lesions do not always lead to significant alterations of the acoustic spectrum. However, we would have expected that for those with substantial laryngeal changes there would have been an effect on their CPPS values. In principle, structural alterations to the vocal folds would affect their vibratory pattern, and thus cause changes in the acoustic voice signal and in turn lower CPPS values. Due to the fact that there was no significant relationship between laryngoscopic exam results and CPPS text and vowel, we assume that both CPPS and Laryngoscopic exam are independent variables which should be interpreted separately. It should be noted that the subjects in this study were functionally healthy, and were working in a vocally demanding profession. They were not patients and had not consulted a phoniatric clinic or laryngologist for help.

Health problems

Health problems (allergies, asthma, upper respiratory tract infection, and reflux) can lead to a modification of the laryngeal mucosa and in turn may have led to a voice problem. In this study, Asthma had a significant effect on emotion sum. Respiratory infection had a significant effect on job sum, social sum and communication sum. There was no association between Allergies, Reflux and CPPS, SLP, or VAPP.

Health problems in PST are well-documented in the literature. In an Iranian study, health problems are referred to as "Job Disease" or "Job Ill Health" teachers have developed after they became teachers.[41] They found that high systolic blood pressure, allergies, and voice hoarseness to be the most common health problems. The main risk factor for blood pressure besides age and job experience was emotional stress. The use of allergic tools, unfavorable air condition, and a closed classroom environment were the risk factors for developing allergies. Hoarseness was attributed to the learning process and the pupil/teacher verbal interaction. The authors found that voice problems were very common in PST and that the most frequently affected taught the younger classes.[41] Munier et al also found that there was a higher incidence of voice problems in teachers teaching the younger classes of the primary school.[4]

One reason for the high incidence of health problems in PST may be due to their reluctance to seek medical help early when the first symptoms appear. They tend to continue teaching with a voice problem and only seek help when the problem is chronic.[10] It may be that PSTs are reluctant to take time off from work to visit a physician due to overloaded work and family schedules.[10,52] This behavior is a barrier to care and may lead to development of a chronic voice problem. Da Costa et al[10] reported that there are multiple barriers to care for the dysphonic teacher, including the lack of awareness of the availability of professional help. Leao et al[40] found that teachers hesitate to seek assistance for a voice problem. This practice of being reluctant to visit a physician for a voice problem may also apply to other health problems in teachers. Some of the reasons for this behavior may be lack of awareness about their health problem, lack of awareness of services available, fear of the risk of chronicity or worsening of the problem.[40]

SUMMARY

1. The individual difference in CPPS scores between KT and PST was impacted by the fact that KT were recorded in an empty classroom, wearing headphones through which they heard a background noise of children's voices. This variable caused them to use a louder voice (Lombard effect) which is confirmed by their high sound pressure level scores. PSTs were recorded under normal conditions in their classroom and were not wearing headphones.
2. The finding of a significant positive correlation between CPPS text and SPL text for KT and not for PST has important pragmatic implications. It shows that this acoustic measure picked up on differences in recording conditions between KT and PST indirectly. From the results of this study, it could be ascertained that CPPS text and vowel, and SPL text and vowel, used in combination are more accurate than using CPPS on its own.
3. The significant and consistent effect of laryngeal signs and symptoms and teacher type on the VAPP in this study is unexpected and exciting. One of our main findings was that, as the values for symptoms increased, the values for VAPP sums also increased. Another important finding is that working conditions had a significant effect on VAPP emotion sum. The VAPP is a good measure of the impact of a voice problem on the individual's daily communication activities and through this seems to be indirectly related to laryngeal signs and symptoms. This study confirms that laryngeal signs and symptoms reported by the individual, and teacher type are very important variables to be applied in the clinical examination of voice problems. From this study we can say that laryngeal signs and symptoms may be the early signs of a developing voice problem and should not be ignored.

4. The significant correlation between asthma, upper respiratory tract infection and the VAPP may mean that these health problems impact the normal vibratory cycle of the vocal folds because of changes to the laryngeal mucosa brought about by them. The present results emphasize, that asthma or upper respiratory tract infections increase subjective voice dysfunction.

CONCLUSION

In this study, there was a significant difference in SPL between the two groups, KT and PST while reading, and this difference may have caused the differences in CPPS values. It also confirms that there is a significant positive correlation between CPPS and voice SPL when applied to connected speech. This means that as SPL values increase CPPS values also increase. This indicates that the voice task and recording conditions, such as background noise affect how voice is produced and thereby influence the instrumental acoustical measurement results.

The effect of laryngeal signs and symptoms and teacher type on the VAPP was significant. This finding was unexpected and implies that laryngeal signs and symptoms and teacher type (working conditions) are very important variables and should be included in the clinical evaluation of occupational voice users and voice patients. The health problems asthma and respiratory infection were significantly related to subjective voice symptoms as indicated by VAPP job sum, communication sum, social sum, and emotion sum. These health problems may impact negatively the normal vibratory cycle of the vocal folds, because of changes to the laryngeal mucosa.

ACKNOWLEDGMENTS

This work was presented at the Voice Foundation's 47th symposium on Care of the Professional Voice June 2018 in Philadelphia.

We would like to thank Professor Michael Parkinson, Bio statistician, (Dublin City University, Ireland) for statistical analysis, Professor Jan Svec, Bio Physicist, (Palacky University, Czech Republic) for advising on instrumental acoustical analysis and Professor Erkki Vilkman (University of Helsinki) who was the inspiration for carrying out this project.

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