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How do teachers with self-reported voice problems differ from their peers with self-reported voice health?

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Abstract

Objectives

This randomized case-control study compares teachers with self-reported voice problems, to age, gender and school-matched colleagues with self-reported voice health. The self-assessed voice function is related to factors known to influence the voice: laryngeal findings, voice quality, and personality, psycho social and coping aspects, searching for causative factors of voice problems in teachers.

Methods

Subjects and controls, recruited from a teacher-group in an earlier questionnaire study, underwent examinations of the larynx by High-Speed Imaging and Kymograms; voice recordings; Voice Range Profile; audiometry; self assessment of voice handicap and voice function; teaching and environmental aspects; personality; coping ; burnout, and work-related issues. The laryngeal and voice recordings were assessed by experienced phoniatricians and speech pathologists.

Results

The subjects with self-assessed voice problems differed from their peers with self-assessed voice health by significantly longer recovery-time from voice problems, and scored higher on all subscales of the Voice Handicap Index-T.

Conclusions

The results show that the cause of voice dysfunction in this group of teachers with self-reported voice problems is not found in the vocal apparatus or within the individual. The individual's perception of a voice problem seems to be based on a combination of the number of symptoms and of how often the symptoms occur, along with the time for recovery. The results also underline the importance of using self-assessed reports of voice dysfunction

Background and aim

This paper is a sequel to our epidemiological study of voice problems in Swedish school teachers [1] that examined the influence of working environment on teachers' voices and vocal behavior. Here, we look at etiological factors that may differentiate teachers with self-reported voice problems from teachers without such problems. The self-assessed voice function is related to factors known to influence the voice: laryngeal findings, voice quality, and personality, psycho social and coping aspects, searching for causative factors of voice problems in teachers.

Voice problems are common in teachers and teachers are at high risk of voice disorders compared to other occupations; this has been shown in a number of studies [1-12]. There is a general agreement that vocal load is the major cause of voice problems in the teaching staff. The vocal loading that occurs in the daily-life of teachers has several causes [13]. Long teaching hours, poor room acoustics, and bad air quality are seen as the leading causes of voice problems in teachers. Psychological and emotional aspects may also contribute to voice disorders [14-18]. Teachers commonly work in a stressful environment with high vocal and psychological demands and an increasing number of students along with noticeable cut-downs of resources in Sweden. It is often argued that the physical and psychosocial environment influences voice disorders in teachers, but there are, as far as we know, only a few studies that have investigated this relationship [1, 19, 20].

Several studies [8, 11, 21, 22], have investigated the relationship between self-reported voice problems in teachers and objective findings, primarily laryngeal structures, laryngeal function, and voice quality. They suggest, however, that the relationship is not all that clear. Rantala et al. [23-25] investigated the relationship between subjective complaints and objective acoustic measures in a group of teachers and reported lack of correlation between the subjective complaints and the objective measurements. A recent study by Tavares and Martins [26], did however indicate a connection between laryngeal findings and

reports of hoarseness in a teaching population and Gotaas and Starr [27] found voice quality to correlate to reports of voice fatigue at certain time-points.

Teachers have high occupational voice demands. They need a flexible voice to instruct, discipline, clarify, and for attracting interest and attention. The increased voice load and the voice load's impact on the voice are evident when teachers are compared to occupational groups with lesser occupational voice demands [8, 11, 28]. However, commonly, not all the staff at a work place is affected by voice problems. Thus, the aim of the present study is to compare teachers with self-reported voice problems to age, gender and school-matched colleagues with self-reported voice health. We relate the self-assessed voice function to factors known to influence the voice function: laryngeal findings, voice quality, and personality and psycho social circumstances. In addition, we investigate the teachers' estimation of their voice function and test their hearing, aiming at investigating possible causative factors of voice problems in teachers. The study has a case-control design with the source population being the group of teachers investigated in the earlier study [1].

Methods and Materials

Subjects

All participants in the present study were recruited from the population of teachers who participated in our earlier cross-sectional questionnaire survey [1]. The teachers in the cross-sectional study were accessed at regular, pre-scheduled, compulsory collegial meetings at 22, randomly selected schools. All the teachers present at the meetings (n=467) were asked to complete a questionnaire on voice, the interplay of the voice with the classroom-acoustics and on ambient environmental aspects. Planned continuation of the project was explained and the teachers were asked if they were interested in participating, and 220 teachers marked their interest on the questionnaire.

Matching of subjects and controls

In the questionnaire study [1], the grouping of subjects with voice problems and voice healthy subjects was based on the subjects' own ratings of their voice problems. The subjects' rated the statement "I have voice problems" (item 32) on a frequency based scale (0= never; 1=once in a while; 2= sometimes; 3= often; 4= always). For further information

about the questionnaire and the survey, the reader can consult[1]. One group of the subjects for the present study was recruited among the 41 teachers who, in the questionnaire study, rated themselves as suffering from voice problems (2-4 on the rating scale) and who also had agreed to further participation. Since it was important to find pairs of cases and controls working at the same school, we searched for possible controls among the subjects who had assessed themselves as voice healthy (0-1) (n=179) and who worked at the same schools as the voice affected cases.

Among the subjects with self-assessed voice problems, one subject was excluded due to lack of any control at his school. In addition, two smokers were excluded since it was not possible to find a gender- and age matched smoking control at the school. The remaining 38 subjects with self-assessed voice problems were contacted by phone and were informed both orally and in writing about the examination procedures. One was not possible to reach and six subjects declined to participate. Two subjects had changed occupation and no longer worked as teachers. Four declined further participation due to lack of time or interest. A total of 31 teachers with voice problems ended up in the study.

For each subject a control-subject (n=31) was selected from the same school, among those teachers who had estimated no voice problems in the questionnaire study (n=159). The controls were contacted and informed in accordance with the procedure for the case subjects. The pairs were matched for gender and, as closely as possible, for age.

Two paired groups of teachers were thus formed: Group I (N=31, 26F/5M) included teachers with self-assessed voice problems, with a mean age of 48,7 years (Sd=10,7) and a median time in occupation of 15 years (range 1-40); Group II (N=31, 26F/5M) had teachers without voice problems with a mean age of 44,6 years (Sd=9,9) and median time in occupation of 14 years (range 2-39). All the participants had given their written consent to participate in the study. The pairs came from 12 of the 22 schools from the earlier cross-sectional study.

Examination procedure

The teachers were examined at the Department of Logopedics, Phoniatrics and Audiology at Lund University Hospital between May 2009 and February 2010, 6-9 months after the questionnaire study. Written information about the examination procedures was e-mailed to all teachers before the examination and was repeated orally by one of the authors (VLÅ) at the time of the examination. All teachers were subjectively free from upper airway infections and allergies at the time of examination. In most teachers, the examinations were performed during ordinary work weeks and after school-hours; however, three came for the examination at a day off work, two teachers from the case-group and one control. The order of examinations followed the same routine of voice recordings, laryngeal examination and last the phonetogram/voice range profile (VRP). There was no fixed order between answering the questionnaires and the audiometry.

Recordings and analyses

Larynx and the vocal folds

The teachers underwent examination of the larynx and vocal folds with a 70 degree rigid laryngoscope. A digital documentation system was used, HRES Endocam (Wolf, Germany). First, high resolution mode was used for evaluation of organic lesions, adduction and abduction. In high-speed mode 2000 frames/s were recorded for male subjects and 4000 frames/s for female subjects. These recordings were used to evaluate mode and symmetry of vibration at the glottic level. Kymograms were calculated at the mid portion of the membraneous vocal fold. The examinations were performed without local anesthetic in 56/62 subjects, but in six cases: three subjects and three controls Xylocain spray was used (1-3 doses of 10 mg each). These individuals did not differ from their respective groups by the results of the examination. All examinations were performed by one of the authors (RR), who was unaware of the group to which each participant belonged to.

Analyses of larynx and vocal folds

The recordings were coded and randomized. The final evaluation of the recordings was made in consensus by two experienced phoniatricians (with 29/20 years experience, and also well trained and experienced (11/7 yrs) in using High Speed Imaging in daily clinic) unaware of the grouping of the subjects. Following clinical practice, the guidelines by the Committee on Phoniatrics of the European Laryngological Society (ELS)[29], and suggestions

by Kendall [30] for high-speed imaging, a protocol was constructed to assess the following (brackets refer to the presentation of results):

- The morphological structure of the vocal folds (Table 1)
- Asymmetry of posterior larynx: The position of the corniculate tubercles during phonation and rest [31]. (Tables 1 and 2)
- The symmetry of abduction and adduction of the vocal folds (Table 1)
- The activity of the false vocal folds (Table 1)
- The degree and type of glottal opening at maximal closure (Tables 3 and 4)
- The propagation and amplitude of the mucosal wave of the right and left vocal fold separately. (Table 1)
- The symmetry and periodicity of vocal fold vibration of the right and left vocal fold separately. (Table 1)
- The phase difference/periodicity: variations in the vibratory cycle, possibly causing asymmetrical closure. (Table 1)
- The Open Quotient in percent of the glottal cycle (time of open phase/time of vibratory cycle). (Fig.1)

The glottic open phase and phase difference were assessed from kymograms. All parameters were judged on a four-point scale (0, no deviance; 3, severe deviance) except for the degree of glottal closure which was judged on a six point rating scale according to Södersten and Lindestad [32] and the pattern of glottal closure which was also categorized according Södersten and Lindestad [32]:

- A: spindle shaped incomplete closure, with closure at the vocal processes.
- B: spindle-shaped incomplete closure at the posterior third of the folds, with closure at the vocal processes.
- C: Spindle-shaped incomplete closure at the anterior third of the folds, with closure at the vocal processes.
- D: Incomplete closure at the posterior and the anterior thirds of the folds, closure at the vocal processes and at the middle of the membranous portion (“hourglass”).

To assess intra-rater reliability, eight randomly selected recordings were analyzed twice.

Voice

The voice signal was digitized at 16 kHz with 16 bit resolution in a sound-proof booth during the reading of a standard text (the Northwind and the Sun) using Soundswell Core 4.0 + Soundswell Voice 4.0, (Hitech Development AB, Täby, Sweden) and a head-worn microphone (MkE2 Sennheiser, www.sennheiser.com), placed 30 cm from the mouth. Due to a change of computer equipment, five of the voices were recorded on MiniDisc (Sony MDS-101), with the same microphone. All recordings were made by one of the authors (VLÅ).

Perceptual rating of voice quality

The voice recordings with a total duration of about 45 s each were organized in three differently randomized "lists" so that all 62 voices were presented in a different order on each list. A panel of three experienced voice-pathologists (who had worked for 32, 30 and 16 years with voice and voice judgments) rated all voices in consensus on a Visual Analogue Scale (VAS) which was presented through the Spruce listening test: Judge 2.0 (Hitech Medical, Täby Sweden). The voices were judged for five parameters, defined according to Hammarberg: hyperfunction, breathiness, vocal fry, hard glottal onsets, and instability [33]. In addition, Grade of Voice Disorder was estimated in analogy with the GRBAS scale [34]. The choice of parameters was limited by the number of parameters possible to present in the Judge application. The judges were given written information with instructions to listen to each voice at a maximum of three times. They were also instructed not to return to a voice that already had been rated. The judges were further instructed to comment on other aspects than those presented through the Judge application, and in such cases add the comments to a protocol. The results were then calculated for overall differences and intra class correlations.

Voice Range Profile

A maximum phonetogram (Voice Range Profile, VRP) was performed with the teacher standing in front of a laptop computer and recorded on a real-time phonetograph Phog 2.5 (Hitech Medical, Täby Sweden) with a head-worn microphone (AKG C420) at a distance of 7 cm from the lips. The phonetogram (VRP) was always recorded last during the examination process to avoid possible laryngeal fatigue.

According the guidelines by the European Union of Phoniatricians [29], the signal was corrected to equal 30 cm distance from the mouth. The teachers phonated with glissandos on the vowel /a/ trying to cover as large an area as possible in frequency and SPL with connected contours. The teachers started at a habitual fundamental frequency gliding downwards to the softest phonation and thereafter, keeping as soft a phonation as possible, working upwards through the frequency range towards the highest possible frequency. The procedure was then repeated in loud voice. When this was completed, the teacher was asked to fill out blank spots and try to "connect" the contours. The teachers were free to take the time they needed to complete the VRP. The glissando was practiced a few times before the recording started. All instructions and prompting was carried out by the same author (VLÅ).

The analysis of the VRP followed the procedure described in Ma et al. [35]. All VRPs were measured by the same author (VLÅ). Four boundary points were analyzed for each recording: the highest frequency, the lowest frequency, the maximum and minimum intensity. The maximum area, in semitones x dB, and the frequency ranges were automatically calculated by the Phog 2.5 software.

Analyzes of F0 and LTAS

The sound-files were explored with the help of Soundswell Voice™ and the fundamental frequency was calculated for each voice. A long-time average spectrum was made to obtain information on the voice source, in particular the tilt of the source spectrum [36]. For the analysis, silence and periods of unvoiced sounds were eliminated. For the latter, a comparison was made of the spectral levels below and above 1 kHz. If the lower frequency band dominated a frame, this frame was retained as voiced; otherwise, it was discarded. The ratio of energy in the frequency bands 0-1kHz and 1-5 kHz was calculated. This measure provides information on the tilt of the source spectrum, i.e., how rapidly the amplitude of the higher partials decreases. The second one was the energy in the frequency band 5-8 kHz.

A large amount of energy in this band can be a sign of noise due to an incomplete glottal closure [37].

Audiometry

Audiometry

Audiograms were obtained by the same audiologist. The equipment used was a GSI16 (Grason-Stadler Inc.) audiometer together with one pair of Telephonics TDH-39P supra-aural earphones with MX-41/AR cushions. The equipment was calibrated in accordance with IEC 60318-3 [38] and ISO 389-1 [39]. Test stimuli were pure tones of 1-2 seconds duration (35 ms rise and fall times). The following test order was used: 1000, 1500, 2000, 3000, 4000, 6000, 8000, 500, 250 and 125 Hz. Audiometry was conducted in accordance with ISO 8253-1 [40] using the manual descending technique (-10/+5 dB). The threshold was defined as the lowest level where three responses had been recorded. The test was performed in a double-walled soundproof booth (complying with the maximum permissible ambient sound pressure level as specified in ISO 8252-1) during one session [40]. The mean value of 500, 1000, 2000, 4000 Hz was calculated for each ear. The sound pressure levels for 3000, 4000 and 6000Hz were also analyzed separately.

Subjective assessments

Questionnaires

Voice Handicap, Self assessment of voice, voice- and teaching related aspects and environment

The teachers were asked to complete the Voice Handicap Index-Throat (VHI-T) [41], which consists of the original three VHI subscales (physical, functional and emotional aspects on voice problems [42], along with a subscale on throat related problems (see appendix for the statements of the throat subscale). Each subscale consists ten statements and the occurrence of symptoms are estimated on a frequency-based scale (0=Never, 1=Almost Never, 2=Sometimes, 3=Almost Always, 4= Always). The total sum of this scale might thus be 160 p. A 100 mm VA-Scale was included for the teachers to mark their perception of their current voice status. The scale was labeled with “no voice problems” resp. “maximum voice problems at it’s ends. In addition, the subjects were asked about demographics and teaching circumstances (posture, native tongue and the language(s) of the students); voice problems

during teaching (frequency of voice problems, time of voice recovery, if problems occur with or without a simultaneous cold), and teaching environment (changes made in teaching style or teaching environment due to voice problems, smell in classroom). These questions were answered on a separate questionnaire.

Demand-control and support

Aspects related to work were measured with *the Job Content Questionnaire (JCQ)*. The JCQ is a self-administrated instrument designed to measure social and psychological characteristics of work according to the high demand/low control model of job strain development and covering issues relevant to work demands such as decision making, social interaction etc.[43, 44]

The 26 questions, rated on a four-graded rating scale (1=disagrees completely, 4= agrees completely), comprise the dimensions of job control, job demands, and job support. The job demands, control, and support variables are further dichotomized into high and low categories based on current means from a large population study [45]. JCQ has been widely used for research, at least 70 publications are presented up to date, however only two in teachers [46, 47] and none in relation to voice problems. The JCQ has been translated and assessed for stability in 23 languages until today [43].

Burnout or exhaustion disorder

A frequently discussed problem in the society today is burnout or exhaustion disorders [48]. Melamed et al.[49] cite the definition by Shirom [50] of burnout "as the chronic depletion of an individual's coping resources"(47, pp 1). He characterizes burnout by the constellation of emotional exhaustion, physical fatigue, and cognitive weariness. This syndrome does not overlap with any other clinical syndromes such as depression or anxiety [48] and it is conceptually distinct from a temporary state of fatigue, which passes after a resting period. To investigate the possible symptoms of burnout *the Shirom-Melamed Burnout Questionnaire (SMBQ)* was used [49]. This self-administered instrument consists of 22 questions rated on a frequency based eight graded rating-scale (0-7). The overall burnout index is computed as the mean value of four subscales comprising cognitive weariness, emotional and physical exhaustion, tension, and listlessness.

Coping

The way the individual copes with stressful situations has also been discussed as a cause of voice problems [51] and an effect on emotions caused by the vocal disabilities [52]. *The Utrechtse Coping List (UCL,* 53*)* in its short form with 22 questions was used to investigate this aspect. Muelenbroek et al [54] have used the longer version for investigations of voice problems in teacher students. The subscales used in the present paper were passive avoidance, depressive reactions, and active reactions.

Personality.

Baker [55] notes that the role of personality in the origin of voice problems has long been of great interest and various measuring methods have been used to investigate this issue. To investigate the possible role of personality in this population of teachers, the two subscales "Psychic Trait Anxiety" and "Adventure seeking" from the *Swedish Universities Scale of Personality (SSP,* 56) were used, providing a rough estimate of the commonly used dimensions of neuroticism and extraversion, respectively. The SSP items were rated on a four-grade scale, ranging from 'does not apply at all', to 'applies completely'.

The questionnaires were registered and analyzed in SPSS and the results compared within the pairs with paired samples t-tests; chi2 tests and in SAS for Exact Odds Ratios (OR).

Statistics and ethical considerations

The statistical analyses were computed using SPSS 18.1. For most continuous variables, paired samples t-tests were calculated, for the comparison of the assessment of voice quality the Wilcoxon signed rank test was used due to skewed distributions. For the discrete outcomes variables, 2-sided χ^2 tests were used, with exception for the aspect "Thoughts about change of work", which was analyzed by Fisher's exact test due to the expected frequency in one cell being below the recommended frequency of five. The OR calculations for paired samples were performed by SAS® 9.2 for Windows with the lowest level as reference. The inter rater reliability was calculated for each parameter separately, with Intra Class Correlation (ICC). The alpha level for all statistical analyses was set to 0.05. The study has been approved by the Institutional Review Board at Lund University (#248/2008).

Results

Demographics

A paired samples t-test revealed significant differences in age between the groups: Group I (M=48.7 Sd=10.7) and Group II (M=44.6 Sd 9.9) t(30)=2.503, *p*=0.018. There were no significant differences found between the groups for time in occupation as concluded by a paired samples t-test.

Larynx and vocal folds

Most aspects could be rated in all subjects. However, and as shown in Tables 1-6, the number varies somewhat between parameters. The inter-rater reliability of the doubled recordings was r=0,851, calculated with Intra Class Correlation. There were no statistically significant differences between the pairs for any aspect. Morphological changes (Table 1) were found in eight subjects (13%), five in Group I (scaring of mucosa, left vf; paresis of left vf; hypoplasia of hemilarynx; contact granuloma, left; vf thickening of the lower border and hypertrophy false vf, left side) and three in Group II (Dry and hyperemic mucosa; minimal thickening of right vf; false left vf hypertrophy/cyst) shown not significant. Tables 1-4 and Fig. 1 present the results of the assessment of the high-speed recordings.

Voice

The results are based on 31 teachers in Group I and 30 teachers in Group II. Unfortunately, the voice recording of one of the controls could not be analyzed due to technical problems. The inter rating reliability of the three voice-lists was calculated for each parameter and varied between r=0.728- r=0.886 according to the ICC. The ICCs for all parameters are shown in Table 5.

The assessment of voice quality is summarized in Table 6, presenting the average values for the groups. The assessments were made on a 100 mm Visual Analogue Scale, however the software returns the ratings as of 1000 mm. As is evident from Table 6, there were no significant differences found between the groups for any of the voice quality aspect, as shown by the Wilcoxon signed Rank test.

Voice Range Profile, F0 and Long Time Average Spectrum analyzes

Table 7 presents the measurements of the VRP and F0. No significant differences were found between the pairs, neither for women nor for men for any of the measures.

Audiometry

The results of the audiograms are based on audiograms from 22 teachers from Group I and 29 controls from Group II. The difference in number of obtained audiograms was due to unfortunate logistic complications. Thus, a group-wise comparison was made. There were no significant differences between the groups at any other level. Tinnitus was reported by seven persons, three in Group I, and four in Group II. The use of hearing aid was reported by three participants, two in Group I, and one in Group II.

Questionnaires

Voice Handicap Index-Throat, Self-assessment of voice problems and VAS judgment

The paired samples t-test revealed statistically significant differences for all four subscales of the VHI-T as well as for VHI-T total. The results are summarized in Table 8.

The teachers rated their over-all voice problems on a 100 mm Visual Analogue Scale. A paired samples t-test revealed significant differences between the groups, Group I (M=34, Sd=23.0) and Group II (M=13 Sd=16.3), t(25)=4.890 p=<.001, OR= 1.12.

For the frequency of occurrence of voice problems, a chi-square test showed significant differences between the two groups: $\chi 2$, (5 n=60)=20.138, *p*=0,01, OR= 3.99, the OR indicating that teachers with voice problems were close to four times as likely to rate a high frequency of voice problems. The occurrence of voice problems is shown in Table 9 . There were also significant differences between the groups for voice problems occurring without a concurrent upper-airway infection, $\chi 2$, (2 n=60)=18.670 *p*=0.0008. OR=3.60, as shown in Table 10.

A Chi-square test also revealed significant differences between the groups for the time-span for voice recovery $\chi 2$, (7 n=60)=17.608, *p*=0.014, cf. Table 11 with OR= 2.03.

Teaching and environmentally related issues

Fisher's exact test showed differences (p=0.029) between the case-control pairs for considerations about changing occupation due to voice problems, where 18% in group I had considered a change of occupation but none in group II, OR=2.03. No further differences were found within the pairs for either social status, number of children, age, or time in occupation. Nor were there any differences in most teaching related aspects. Most teachers taught in their native language and stood up during teaching. Most students were speaking the same language as the teacher. Similarly, there were no differences in changes in teaching methods or teaching environment due to possible voice problems.

Control-demand-support, burnout, coping and personality

No differences were found within the pairs for symptoms of burnout syndrome (SMBQ), personality traits (SSP), or for coping strategies (UCL) using paired-samples t-tests. The mean values for SMBQ-global were: Group I=2.7 (Sd1.0) and Group II=2.5 (Sd1.1) which can be compared to reference scores of 3.2 for females and 2.9 for males in a Swedish, healthy population [57]. However, among the three main dimensions Job Demand, Job Control and Job Support of the Job Content Questionnaire (JCQ), significant differences were found for the sub-scale "Job-Control": Group I (M= 3.48 Sd=.20) and Group II (M=3.27 Sd=.29), t(28)=3.047 p=0.005. The ratings of Job Demand and Job Support showed no statistical differences. Job Demand: Group I (M= 2.84 Sd=.51) and Group II (M=2.72 Sd=.45), t(28)= 0.946 p=0.352 Job Support: Group I (M= 3.79 Sd=.35) and Group II (M=3.78 Sd=.06), t(28)=3.047 p=0.888.

As shown by the t-test, the ratings of "Job Demands" are moderately and equally high in both groups while "Job Control" is significantly higher in Group I. The JCQ results were summarized through combinations of the dichotomized ratings of the three main dimensions Demand, Control and Support, in order to define a specific work situation: High demands and low control is defined as "Job Strain", high demands and high control form the category "Active", low demands and low control is defined as "Passive", and low demands and high control form the category "Relaxed". In addition, low support (support from colleagues and management) in combination with "Job Strain" is defined as "Iso-strain", a particularly unfavorable work situation. Table 12 shows the distribution of the subjects according this classification. A larger number of teachers from Group I are found in the "Active" category, where a combination of high

demands and high control is represented, while more of the teachers in Group II are found in "Job Strain" category due to ratings of high demands and low control. However, the chi-square and Fisher's exact test showed no significant differences in Job strain (p=0.056) between the groups. Iso-strain was not found for any teacher.

Correlations

Correlations were computed with Spearman's rho for aspects that could be expected to correlate: frequency of symptoms, voice quality ratings, age, morphological findings and recovery time. Almost all correlations were below .5 for most aspects. These are weak to moderate correlations and are thus not presented. However, in individuals from Group I who had deviant morphological laryngeal structure (top row in Table I), the correlation between the rating of morphological structure and Grade, VHI-T, and Recovery time were: structure and grade: 0.577; structure and recovery-time: 0.866 and structure and VHI-T: 0.881. Grade, VHI-T and recovery for the controls with remarks on laryngeal structure did not correlate.

Discussion

Voice function is a complex phenomenon and has an undisputable relation to the voice load and occupational demands. As far as we know, this study differs from earlier studies with respect to the matching of the participants. To isolate the possible influences from environment and the persons' behavior in the classroom, we selected gender- and age-match pairs from the same schools and examined differences in their laryngeal, vocal, hearing and psycho-social aspects. By selecting subjects from the same schools, we wanted to control the influence from the work-environment. Overall, the present results show very small differences within the pairs. The most noteworthy differences are the findings of VHI-T and the time it takes to recover from voice problems. Apart from these differences, there were no statistically significant differences in structure or function that may explain why the teachers that do have voice problems actually have them in contrast to their peers. The results might indicate that the differences would be more clear in action i. e. in the teaching situation. The present paper aimed at investigating the subjects' medical/functional characteristics to clarify their relation to the reports of voice problems/voice health.

The selection of the case-control pairs in this study was based on the teachers' own assessment of the statement "I have voice problems" in the earlier questionnaire survey [1]. The definition of "voice problem" is thus based on the individuals' conception of their own voice. Despite the large number of studies of teachers' voices today, there is still no consensus about the criteria for defining a voice disorder [58]. Commonly, the definition has been based on the number and frequency of symptoms of voice disorders [5, 8, 21] or on the clinician's observations of laryngeal findings or on remarks on the voice quality [21, 22]. The question of the individual's perception of the symptoms has seldom been raised. In analogy with others, our results show that even the teachers who assess themselves as being voice-healthy report a number of symptoms. There were as many morphological laryngeal findings in the controls as in the group of teachers with voice problems. However, the control subjects obviously don't view their voice symptoms – or the effect of them - severe enough to call them problematic. Not being aware of a functional deficiency, due to not having been exposed to higher vocal demands might also contribute to the rating. We thus consider it to be very important to include the subjects' own conception of the voice function, not least in clinic. According Deary et al: "People's ratings of their symptoms are an important guide in gauging the severity of medical disorders, and are specially useful in assessing the response to treatment" (15, p . 374).

Time aspects might have brought bias into the results. Between 6-9 months elapsed between the questionnaire study [1] and the present investigation. We think this is unlikely, however, since the present reports of voice function by the two groups are almost identical to those in the questionnaire study [1].

The teachers' motives for participating in the study are not known. However, the selection can be considered to be reasonably free from bias since the selection of both cases and controls was made within a group of teachers who rated their voices and voice problems during compulsory meetings. Thus, there is no reason to believe that the teachers attended the meeting out of special interest in their voice.

Laryngeal findings

High speed digital imaging was used for the laryngeal examinations. One reason is that this is the current standard technique at our department and another one is that it is a new tool in the voice clinic, and there is thus a need of compiling normative data from high-speed examinations [59]. Kendall [30] concludes that the use of high-speed filming offers benefits over standard videostroboscopy for studying aperiodic vocal fold motion which is often thought to be a contributing factor in voice disorders. All subjects could be examined which is probably due to the short time of the examination. Due to the high frame rate (2000 for males and 4000 in females) only a very short sequence is needed. There is not yet any gold standard for the assessment of high-speed digital image recordings.

Most subjects in our study were found to be medically normal in all laryngeal aspects. There were findings of asymmetry and structural deviations but without any significant differences within the matched pairs. The importance of asymmetrical vocal fold adduction movements as an explanatory factor in voice disorders has been long discussed [31]. Lindestad et al. found that laryngeal adduction asymmetries were frequent in normal voices (ibidem), but no findings of morphological deviations are mentioned.

It is, however, no surprise that there are no differences between the groups. Most studies that have included laryngeal examinations in investigations of teachers' voices have been unable to establish a connection between the laryngeal status and the subjective symptoms: Urrutikoetxea et al. [4] examined 1 046 teachers and found structural deviations in 20.8%. Ilonmäki et al. [21] found severe organic changes in 14% of the 78 pre-school teachers investigated. Sala et al. [8] made organic findings in 29% of 262 teachers. None of these studies found a correlation between laryngeal findings and subjective symptoms of voice disorders. So, does a laryngeal deviation have no impact on vocal behavior? There is firm clinical evidence about such a relationship, but little is known about an individual's capacity to cope with the effects. This calls for further comparative studies with non-teachers. The findings of Sala et al. [8] indicate that there may be differences in the occurrence of laryngeal findings between teachers and voice healthy non-teachers. They found 29% of the teachers at day-care centers to have laryngeal deviations but only 7% in a group of nurses. In a recent study of 882 patients referred to ENT clinics, van Houtte et al. [60] found 50% of voice professionals, including teachers, to have some kind of structural

deviations, compared to 60% in the entire group. However, this was found in a treatment–seeking group in contrast to other studies and little is known about the prevalence of laryngeal deviations in a voice healthy population without a heavy voice load.

Some clues might be found in our results. In the five teachers with voice problems where morphological findings were made, correlations were found for the voice quality parameter Grade of voice disorder and for both VHI-T and Recovery time. None of these aspects correlated in the controls. However, the methods of exploring laryngeal aspects vary between studies and the results are thus hard to compare.

Voice

Similarly, there were no differences within the pairs with respect to voice quality assessments and the acoustic measurements, F0, VRP and LTAS. This is in line with the findings by Ohlson et al. [11] who compared a group of teachers with a group of nurses and found no differences between the groups in LTAS, voice quality, or VRP. In contrast, voice quality differences between teacher-groups were found in a recent study by Tavares and Martins [26], but this might be explained by the large amount of laryngeal pathology in their material.

Gotaas and Starr [27] compared teachers experiencing vocal fatigue to teachers, who did not experience vocal fatigue, and concluded that there were no voice-quality differences between the groups on non-vocal fatigue days. With three exceptions, all teachers in our study were examined after their workday. There were significant differences within the pairs in their own assessment of current voice problems and voice quality, but we did not ask about their views on vocal effort during their past workdays, and a lack of voice load can thus be a confounding factor in the results. It is important to emphasize that the present perceptual ratings of voice quality were all on low grades on the VA-scale and thus have to be interpreted with caution. A finding underlining the lack of correlation between symptoms and findings was some of the ratings of Grade (>200) that was assessed in subjects who subjectively rated their voice problems to 0. Obviously, there are difficulties in assessing quality aspects of normal or nearly normal voices.

The results of the VRP and the LTAS showed no significant differences between the groups. However, Subsinskiene [61] did find differences in VRP results between healthy trained and non-trained professional speakers: pitch range and area of high frequencies differed significantly. The VRP shows the physiological and acoustical constraints [62]. Thus, the difference in findings between studies may have it's explanation in the compared groups. In contrast to the present study,Siupsinskiene compared well- and non-trained professionals. It may thus be assumed that the voice training had influenced the vocal possibilities. The effect of voice training is also supported by the conclusion of Holmberg et al. [63] in their study of changes across voice therapy for patients with vocal fatigue. The sound pressure level, both at it's softest and loudest reflects the underlying voice function. It was thought that VRPs would reveal differences between the cases and the controls in the level of their upper and lower phonatory contours. Studies by i.e. Titze [62] Halpern, et al. [64] show that changes in the softer range reflects changes in the vocal capacity. It is, however, important to note that this is not a field study but rather a snapshot of the status of the teachers. In other studies, the voice has been measured during a workday. In these studies [22-25, 65], differences have been found in individuals who report only few symptoms of voice problems. Field measurements with a voice accumulator have been made in the current subject pool.

Audiometry

Generally, the pure-tone hearing thresholds showed no differences between the groups. However, the present finding is inconclusive due to the unfortunate variation of number of performed measurements in the two groups (Group I: n=22, Group II: n=29) and further research is required to elucidate any relationship between hearing thresholds and voice problems. Further, little is known about the relationship between individuals' hearing and the perception of his/her own voice in relation to the sound environment. Hearing is most likely important for the relation between voice and the perception of the acoustical properties of the room. Further research is warranted in this area.

Subjects' assessment of voice handicap and voice function

The main differences between the pairs in this study were the subjects' own assessment of their voice, voice handicap, and in the recovery time. The VHI, and the VHI-T

(the VHI with a subscale on throat problems [41], have been shown to separate subjects with and without voice disorders [41, 42, 66]. It is noteworthy that the highest OR of the VHI-T subscales was found on the emotional subscale, which indicates that teachers with voice problems are twice as likely as their voice healthy colleagues to score high on this subscale. This higher scoring on the emotional subscale may indicate that if the individual considers the symptoms as communicatively hindering and even embarrassing, (s)he is more apt to consider the symptoms problematic.

Furthermore, the discrepancy within the pairs in terms of the recovery-time from voice-symptoms after vocal load is very interesting. Similar findings were made by Sala et al. [8] where the day-care centre teachers reported a longer time for the symptoms to disappear than the group of nurses. This might indicate micro-structural changes in the larynx that we are not able to detect with today's technology. Further studies are warranted in the area of vocal recovery /vocal loading in and during teaching.

Control-demand-support, burnout, coping and personality

There is an increasing number of studies linking psychological factors to functional dysphonia [15, 67]. These factors include higher levels of anxiety, lower levels of sense of control, quality of life, and coping [15, 16, 18]. Roy et al. [68] found that the majority of people with functional dysphonia were introverts. Andersson and Schalén [17] noted that interpersonal conflicts related to family and work were one of the important contributing factors in psychogenic voice disorders, and Gassull et al. [51] found in a recent study that teachers with voice problems were highly reactive to stress.

We used a battery of questionnaires to investigate those aspects that have been found to contribute to the etiology of dysphonia and also the Job Content Questionnaire (JCQ) to cover aspects of demand-control-support. The JCQ was the only scale that showed some differences between the groups. The underlying theory of the JCQ is that a combination of high demands and low control/low support causes *job strain* which is defined as harmful. That is, when there is a combination of high psychological demands and a low worker's decision latitude there is an increased risk of harmful job strain. If the social support at the work-place is low, this further increases the risk. However, the active or passive behavior of

the employee needs to be taken into account. An active behavior gives rise to “good stress”, predicting motivation, new learning behavior, and new coping strategies [43]. The differences within the pairs did not support the hypothesis of a higher degree of job-strain (high demands and low control) in the teachers with voice problems. Instead the results showed that both groups rated high degrees of job demands and job support but differed in the aspect of job control, where the group with voice problems rated significantly higher values.

The results may be due to a selection bias. In the questionnaire study, we asked the respondents who wanted to further take part of the project to mark this on the questionnaire. This may have caused the more active teachers with feelings of control of their social life and work situation to step forward. The non-difference within the pairs may also depend on the normality of the data, as there were no large differences in any scale as compared to a normal population. Buck et al, [69] found differences between groups of dysphonics, functional vs organic, but only a minority (17 %) of patients in the functional group showed clinically significant levels of psychological distress. The difference between the present study and others might also be due to the use of different instruments. We used a battery of tests that have been developed for a Swedish population (Swedish Universities Scale of Personality [56], or had been tried and on a Swedish population (Job Content Questionnaire and Shirom-Melamed Burnout Questionnaire, [43, 50]. The Utrechtse Coping Lijst, measuring coping, has been used in teachers with voice problems [54]. It was, however a time-consuming battery of tests, tat took the most part of the examination to complete. There is no consensus about which questionnaire/questionnaires to use for investigating psychological factors in dysphonic patients or in research-groups and further studies are thus warranted in this area. However, for the investigation of work-related issues we found the Job Content-model very useful, and thus recommend it for further investigations of work-related dimensions in connection to voice problems.

Conclusion

For the two groups in this study the main differences were found for the VHI-T and time for recovery after voice problems. Thus, the combination of the number of symptoms and of how often the symptoms occur, along with the time it takes to recover, seems to underlie

the individual's perception of the voice problem. The results also underline the importance of investigating the individual's view of the severity of the voice dysfunction. It is, furthermore, important to consider that the inclusion of the subjects was based on their own assessment of their voice function. The teachers with voice problems were not referred to a voice clinic as voice patients. The controls exist in the same surrounding with the same kind of external voice load. Why, then, do the controls not report voice problems? A speculation might be that when rating the statement "I have problems with my voice" one's daily voice use is included in this consideration. As clinicians, we base our judgment on what is seen or heard at the examinations we perform in clinic. What is seen or heard might not be representative of what actually happens when the subjects act in their daily life. The difference between teachers with or without voice problems might thus be the reaction to the teaching situation, where the voice is exposed to a number of different and interacting loading factors. The results from the questionnaire study [1] support this line of reasoning. The subjects who rated themselves as having a voice problem were significantly more reacting to most vocally loading factors as compared to the voice healthy (self-assessed) subjects.

The main conclusion of this study is that the cause of voice dysfunction in the group of teachers with self-reported voice problems is not found in the vocal apparatus or within the individual. It may instead be found in the interplay of the individual's behavior and the work-environment which we plan to study in a future project.

Future research

It is important to record voice use in the daily communicative setting, Thus, a field study has been carried out of voice use during teaching in 14 voice affected teachers and their 14 age- and gender matched voice healthy peers.

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Table 1 Number of subjects' assessed laryngeal status according high-speed recordings in 31 teachers with voice problems (Group I) and 31 teachers with healthy voices (Group II). 0= no deviance, 3= severe deviance.

Parameter	**0**	**1**	**2**	**3**	**Total**
Morphological changes					
GI	26	3	2	0	31
GII	25	6	0	0	31
Ab-adduction of VFR					
GI	27	1	2	0	30
GII	27	3	0	0	30
Ab-adduction of VF L					
GI	24	3	2	0	29
GII	26	4	0	0	30
Corniculate tub. Rest					
GI	19	6	2	2	29
GII	23	7	0	0	30
Corniculate tub. Phon					
GI	16	13	1	1	31
GII	10	20	1	0	31
Mucosal wave ampl. R					
GI	18	8	5	0	31
GII	13	14	4	0	31
Mucosal wave ampl. L					
GI	20	6	2	3	31
GII	18	12	1	0	31
Mucosal wave, propagation R					
GI	15	9	7	0	31
GII	12	11	8	0	31
Mucosal wave, propagation L					
GI	18	4	6	3	31
GII	17	9	5	0	31

Phase difference					
GI	23	6	0	1	30
GII	23	8	0	0	31
False vocal cords act R					
GI	19	9	2	1	31
GII	21	6	3	0	30
False vocal cords act L					
GI	13	15	2	1	31
GII	16	11	2	1	30

Table 2 Position of the most anterior corniculate tubercle in 31 teachers with voice problems (Group I) and 31 teachers with healthy voices, (Group II)

	Right	Left	No difference	Total
Group I	8	7	16	31
Group II	12	7	11	30

Table 3 Distribution of assessed degree of closure in two groups of teachers: N=31 teachers with voice problems (Group I) and N=31 teachers with healthy voices (Group II). 1-6 denotes increasing degree of incomplete closure.

Degree of closure	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Group I	6	17	5	1	1	1	31
Group II	8	10	11	1	1	-	31
Total	14	27	16	2	2	1	62

Table 4: Number of subjects with deviating pattern of glottal closure in two groups of teachers. Group I: teachers with voice problems N=31 and Group II: teachers with healthy voices N=31 A: spindle shaped incomplete closure, closure at the vocal processes. B: spindle-shaped incomplete closure at the posterior third of the folds, closure at the vocal processes. C: Spindle-shaped incomplete closure at the anterior third of the folds, closure at the vocal processes. D: Spindle shaped incomplete closure at the posterior and the anterior thirds of the folds, closure at the vocal processes and at the middle of the membranous portion ("hourglass").

Type of closure	**A**	**B**	**C**	**D**	**Total**
Group I	2	4		3	9
Group II	1	2		3	6
Total	3	6	0	6	15

Table 5. Intra Class Correlations (ICC) of the Inter-rating reliability of the auditory perceptual voice ratings.

Parameter	**ICC**
Hyperfunction	0,886
Breathiness	0,861
Vocal fry	0,879
Hard Glottal Attacks	0,728
Instability	0,801
Grade of voice disorder	0,853

Table 6 Mean values of voice parameter judgments for N=30 teachers with voice problems (Group I) and 31 teachers with healthy voices (Group II), assessed on a 1000 mm VA-Scale (see text for further details).

Parameter	**Group I,**	**Group II**
	Mean (Sd)	**Mean (Sd)**
Hyperfunction	46 (98)	61 (106)
Breathiness	95 (128)	45 (67)
Vocal Fry	67 (69)	103 (101)
Hard glottal attacs	23 (62)	13 (18)
Instability	11 (29)	8 (37)
Grade of voice disorder	78 (124)	65 (65)

Table 7. Values of Voice Range Profiles (VRP) and F0 in running speech: Area dB (semitones*dB), minimum and maximum dB, minimum and maximum F0 (Hz) F0 in running speech for women and men in two groups of teachers. Teachers with voice problems (Group I) and teachers without voice problems (Group II). (Mean and standard deviation.)

			Group I		Group II	
			F N=26	M N=5	F N=26*	M N=5
VRP	Area	Area	828 (254)	822 (246)	868 (198)	906, (131)
	F0 statistics	F0	362 (67)	230 (44)	370 (54)	230 (31)
		Min F0	118 (18)	73, (13)	115 (19)	67 (11)
		Max F0	1004 (277)	750 (221)	1006 (204)	666 (146)
	SPL statistics	SPL	69 (7)	(70) (8)	69 (4)	72 (4)
		Min dB	50 (4)	56 (18)	48 (3)	50 (4)
		Max dB	94 (9)	94 (11)	93 (7)	98 (7)
Running speech	F0		203 (21)	131 (12)	199 (13)	127 (12)

*running speech: n=25, see text.

Table 8. Mean and t and *p* values for paired samples t-test along with Odds Ratios for VHI-T in two groups of teachers: Teachers with voice problems (Group I, N=31) and teachers without voice problems (Group II, N=31).

Subscale	**Group I M(Sd)**	**Group II M(Sd)**	***t(df)***	**p**	**OR**
Throat	15.3 (5.9)	8.7 (5.0)	5.451 (29)	0.0001	1.43
Physical	13.8 (8.6)	6.7 (6.6)	4.394 (29)	0.0001	1.27
Functional	8.5 (7.0)	2.5 (3.6)	4.199 (29)	0.0001	1.26
Emotional	9.0 (9.5)	1.7 (3.2)	4.248 (29)	0.0002	2.03
VHI-T Total	46.7 (22.2)	19.3 (15.0)	6.406 (29)	0.0005	1.93

Table 9 Occurrence of voice problems in two groups of teachers. Teachers with voice problems (Group I) and teachers without voice problems (Group II).

%	No voice probl	Every year	<once a month	>once a month	Every week	Every day	%
Group I (N=31)	0	32	6	26	19	16	100
Group II (N=29)	34	41	7	14	3	0	100

Table 10 Occurrence of voice problems in teachers who have voice problems without a simultaneous upper-airway infection. Teachers with voice problems (Group I) and teachers without voice problems (Group II), in percent.

	Every year	<once a month	>once a month	Every week	Every day	%
Group I (N=26)	27 (7)	4 (1)	27 (7)	23 (6)	19 (5)	100 (26)
Group II (N=10)	40 (4)	20 (2)	30 (3)	0	10 (1)	100 (10)

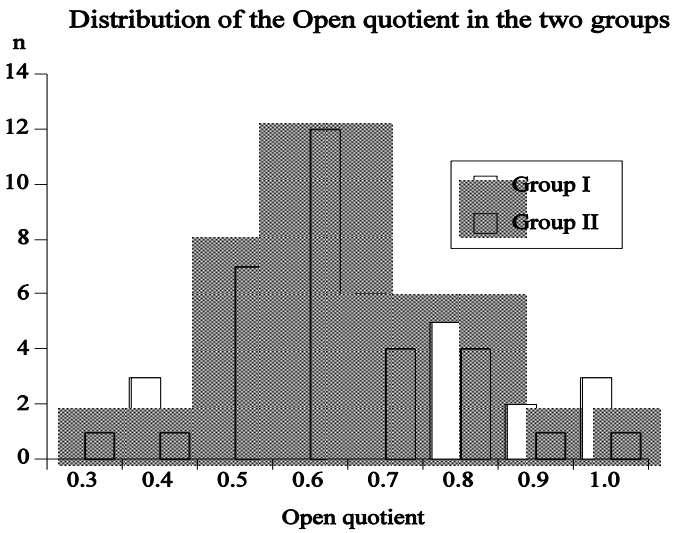
Table 11 Time for recovery from voice problems in two groups of teachers, teachers with voice problems (Group I) and teachers without voice problems (Group II), in percent.

	No voice probl	One hr or less	A couple of hrs	Over night	Weekend	Holiday	Never	%
Group I (N=31)	0	13	10	27	23	17	10	100
Group II (N=29)	34	17	7	24	7	10	0	100

Table 12. Number of teachers for each category of the JCQ. Group I: teachers with voice problems and Group II: voice-healthy teachers. Percentages in parentheses. For further explanation, see text.

	Job strain	Relaxed	Active	Passive	Total
Group I	1 (3,2)	11 (35)	18 (58)	1 (3,2)	31 (100)
Group II	6 (20)	10 (33)	11 (36)	3 (10)	30* (100)

*The result of Group II is based on questionnaires from 30 teachers, due to one questionnaire not completed.



Figur 1 The distribution of subjects' glottal open phase according kymogram in 31 teachers with voice problems (Group I) and 31 teachers with healthy voices (Group II). Open quotient defined as percentage of vibratory cycle time

Appendix.

The statements of the Throat sub-scale, supplement to the Voice Handicap Index. Statements presented in Swedish with English within brackets (statements are only validated in Swedish). The statements are rated on the frequency based rating scale of the VHI: 0=Never; 1=Almost Never 2=Sometimes; 3=Almost Always; 4=Always

Statement
T1 Jag är torr i halsen (*My throat is dry.)*
T2 Jag måste harkla mig (*I need to clear my throat.)*
T3 Jag har mycket slem i halsen (*I have a lot of phlegm in my throat.)*
T4 Jag känner att det sitter något i halsen (*It feels as if something is stuck in my throat.)*
T5 Det svider i halsen (*My throat is burning.)*
T6 Jag känner ett tryck utanpå halsen (*I feel a pressure on the outside of my throat.)*
T7 Det känns som om jag har en klump i halsen (*It feels like a lump in my throat.)*
T8 Jag är irriterad i halsen (*I have an irritation in my throat.)*
T9 Jag har ont i halsen (*I have a sore throat.)*
T10 Jag har rethosta (*I have a dry cough.)*