Natural Voice Use in Patients With Voice Disorders and Vocally Healthy Speakers Based on 2 Days Voice Accumulator Information From a Database

*,†Maria Södersten, *,‡Gláucia Laís Salomão, *,†,§Anita McAllister, and ‡Sten Ternström, *†‡*Stockholm* and §*Linköping, Sweden*

Summary: Objectives and Study Design. Information about how patients with voice disorders use their voices in natural communicative situations is scarce. Such long-term data have for the first time been uploaded to a central database from different hospitals in Sweden. The purpose was to investigate the potential use of a large set of long-term data for establishing reference values regarding voice use in natural situations.

Methods. *VoxLog* (Sonvox AB, Umeå, Sweden) was tested for deployment in clinical practice by speech-language pathologists working at nine hospitals in Sweden. Files from 20 patients (16 females and 4 males) with functional, organic, or neurological voice disorders and 10 vocally healthy individuals (eight females and two males) were uploaded to a remote central database. All participants had vocally demanding occupations and had been monitored for more than 2 days. The total recording time was 681 hours and 50 minutes. Data on fundamental frequency (F0, Hz), phonation time (seconds and percentage), voice sound pressure level (SPL, dB), and background noise level (dB) were analyzed for each recorded day and compared between the 2 days. Variations across each day were measured using coefficients of variation.

Results. Average F0, voice SPL, and especially the level of background noise varied considerably for all participants across each day. Average F0 and voice SPL were considerably higher than reference values from laboratory recordings.

Conclusions. The use of a remote central database and strict protocols can accelerate data collection from larger groups of participants and contribute to establishing reference values regarding voice use in natural situations and from patients with voice disorders. Information about activities and voice symptoms would supplement the objective data and is recommended in future studies.

Key Words: Voice accumulator–Accelerometer–Voice disorders–Voice SPL–Fundamental frequency–Phonation time–Vocal loading.

INTRODUCTION

Little is known about how much people in general speak during a day, how fundamental frequency (F0) and voice sound pressure level (SPL) vary on a long-term basis, and how the level of background noise affects vocal behavior when speaking in everyday situations. Information about long-term voice use would be of value for identifying vocal loading factors for persons with vocally demanding occupations and for patients with voice disorders during vocal rehabilitation.[1] Laboratory standard voice recordings are in general used to evaluate results of interventions, such as voice therapy, phonosurgery, or medical treatments, but may not be representative for the patients' voice use outside the clinic.[2–4] Recently, studies have been conducted collecting long-term voice data in natural settings. Most of those have focused on teachers[5–10] and preschool teachers.[4,11–15] A few have included singers,[16] children,[11] and patients with voice disorders.[17,18] Thus, we are in the beginning of building a basis of knowledge about how individuals with and without voice disorders use their voices in natural communicative situations.

The largest long-term study, so far, was carried out by Hunter and Titze[5] who documented the voice use of 57 teachers during 2 weeks using a voice dosimeter developed at the National Center for Voice and Speech. Each day, data were collected for 6 hours in an occupational setting and for 6 hours in a nonoccupational setting. An important finding was that phonation time per hour at work was more than twice that in the nonoccupational setting. The teachers spoke with approximately 2.5 dB higher SPL and 1–1.5 semitones higher F0 at work, as compared with the nonoccupational setting. The difference was larger for the female teachers than for the male teachers. The mean phonation time per hour during work was high, namely 29.9% (30.7% for female teachers and somewhat lower, 27.4%, for male teachers). Although the phonation time was lower in the nonoccupational setting, it was still rather high; 14.7% for female teachers and 13.7% for male teachers. Hunter and Titze[5] discussed the potentially harmful impact from a vocally demanding nonoccupational setting on a voice already affected from work.

Morrow and Connor[7] compared voice use during work for music and classroom teachers and found that different teaching activities result in different amount of vocal loading. They used the *Ambulatory Phonation Monitor* (APM; KayPENTAX, Lincoln Park, NJ)[19] to document voice use during five full work days for seven elementary music teachers (six females

Accepted for publication September 4, 2014.

From the *Division of Speech-Language Pathology, Department of Clinical Science, Intervention and Technology, Karolinska Institutet, Stockholm, Sweden; †Department of Speech and Language Pathology, Karolinska University Hospital, Stockholm, Sweden; ‡Department of Speech, Music and Hearing, School of Computer Science and Communication, KTH Royal Institute of Technology, Stockholm, Sweden; and the §Department of Clinical and Experimental Medicine, Division of Speech and Language Pathology, Linköping University, Linköping, Sweden.

Address correspondence and reprint requests to Maria Södersten, Department of Speech and Language Pathology, B69, Karolinska University Hospital, SE-141 86, Stockholm, Sweden. E-mail: maria.sodersten@ki.se

Journal of Voice, Vol. 29, No. 5, pp. 646.e11-646.e19
0892-1997/$36.00

http://dx.doi.org/10.1016/j.jvoice.2014.09.006

and one male) and five female elementary classroom teachers. There were statistically significant differences between the groups for all measures with higher mean F0 (MF0), 269 Hz, for the female music teachers as compared with 236 Hz for the elementary teachers. The music teachers spoke with approximately 5 dB higher SPL, 82.3 dB, as compared with 77.2 dB for the classroom teachers. The phonation time was also significantly higher for the music teachers, as well as the cycle and distance dose parameters.[7]

Lyberg Åhlander et al[6] monitored 28 teachers (24 females and 4 males) with the APM during one working day and investigated the physical environment, such as room acoustics, activity noise level, and air quality. None of the teachers had a diagnosed voice disorder, but according to questions about voice symptoms, they were divided into two groups: voice symptoms (n = 14) and vocally healthy (n = 14). Interesting findings were that the female teachers with voice symptoms spoke with an MF0 of 234 Hz during teaching, which was significantly lower than the vocally healthy teachers' value of 240 Hz. They also spoke with significantly lower SPL, 70 dB, than the vocally healthy, 74 dB. The correlation between F0 and SPL was negative in the group of teachers with voice symptoms. The authors proposed that this finding might reflect a voice disorder.

A large study of 51 preschool teachers working in day care centers was conducted by Sala et al[13] who used two noise exposure analyzers to measure speaking time, speech levels, and background noise levels during one working day. The results were compared with those for a control group of 25 nurses. The preschool teachers spoke significantly more (40% speaking time) than the nurses (28%), with significantly higher speech levels of an average 78 dB (at 30 cm), as compared with the nurses' 72 dB; and in work environments with high background noise levels, too high for comfortable speech communication. The voice use of 12 vocally healthy preschool teachers was studied during 2 days, during and after work, by Szabo Portela et al.[14] They found that the preschool teachers spoke with a high MF0 of 266 Hz during work, which decreased significantly to 246 Hz after work. Thus, also during leisure time, they spoke with a rather high pitch, in agreement with the teachers in the study by Hunter and Titze.[5] The phonation ratio for the preschool teachers was 12% during work and significantly lower (5.5%) during leisure time. Thus, the phonation ratio was lower than what was found for teachers.[5–7] To speak in high background noise levels at day cares, preschools, and schools have been identified as a potential risk factor for voice problems.[4,6,13,20] Different vocal strategies have been found for 12 vocally healthy preschool teachers when they spoke in noisy preschool environments.[12] Vocal behaviors in relation to background noise could merit further investigation, based on the findings by Lindström et al[12] and Lyberg Åhlander et al,[6] who found that teachers with voice symptoms did not increase F0 when they increased SPL, as would be expected in healthy voices.[21] However, that behavior could also be interpreted as a strategy to reduce vocal loading.

Very few studies have so far included patients with voice disorders. Watanabe et al[18] compared variation in speaking time during 1 week in one female patient with spasmodic dysphonia. They used a speech accumulator and compared findings with a control group of 20 speakers. It was hypothesized that the patient would speak less than the control group because of her severe voice disorder; however, that was not the case. Thus, measuring the amount of voice use in daily life provides some documentation of a patient's participation in different communicative situations. Other patients who may avoid participating in social situations because of their weak voice are individuals with Parkinson disease (PD). Schalling et al[17] recently measured phonation time, voice SPL, and level of background noise with *VoxLog* (Sonvox AB, Umeå, Sweden) in five male patients and one female patient with PD during 4 days. Phonation time varied from 2.1% to 7.9% among the patients, suggesting that all except one patient spoke very little. On the other hand, it is not yet known how much vocally healthy elderly individuals speak in everyday life. The patients with PD spoke with a reduced vocal loudness level and raised the voice level significantly when they used the feedback system provided by the *VoxLog* device. When they spoke too softly, as determined individually, the *VoxLog* prompted them with tactile feedback.[17]

In summary, data from long-term monitoring can give quantitative evidence for high vocal loading and also information about participation in communicative situations. To understand the specific difficulties that patients with voice disorders may have in everyday situations, there is a need to collect data from patients with different voice disorders. Several attempts have been made to develop methods for documentation of long-term voice use in natural settings.[22–28] A few portable recording systems have reached commercial status. Those are the APM, the *VocaLog* (Griffin Laboratories, Temecula, CA), and the *VoxLog*. Through the use of these systems, data can now be collected and compared by clinicians and researchers in different parts of the world and hopefully accelerate the gathering of information on mentioned parameters.

The purpose of the present study was to use large long-term voice data, uploaded to a central database from different hospitals in Sweden, to investigate voice use and levels of background noise for patients with voice disorders and vocally healthy participants. This is the first study to present and analyze long-term voice use data from a common remote access database. Collecting such data is important to increase our knowledge regarding habitual voice behavior in patients with different voice disorders and identify potential risk factors related to work environment. The project was approved by the Regional Ethics Committee in Stockholm, Etikprövningsnämnden, protocol 2011/2:1, project 2010/1953-31/2.

METHOD

VoxLog

VoxLog is a small portable voice accumulator (90 × 60 × 15 mm) with both an accelerometer and a microphone placed in a neck collar (Figure 1A). The *VoxLog* is carried in a waist bag or fastened with a clip in a waistband (Figure 1B). The accelerometer detects pressure changes on