Ambulatory Phonation Monitoring in a Sample of 92 Call Center Operators

Q7 *Giovanna Cantarella, *Elisabetta Iofrida, †Paola Boria, †Simone Giordano, †Oriana Binatti, *,‡Lorenzo Pignataro, §Claudia Manfredi, ||Stella Forti, and ¶Philippe Dejonckere, *†‡||Milan, §Florence, Italy, and ¶Brussels, Belgium

Summary: Objectives. The voice is a primary work tool for call center operators, but the main risk factors for voice disorders in this category have not yet been clarified. This study aimed to analyze the vocal behavior in call center operators and search for correlations between the daily voice dose and the self-perceived voice-related handicap.

Study Design. Prospective.

Subjects and Methods. Ninety-three call center operators (aged 24–50 years) underwent ambulatory phonation monitoring during a working day and were administered the Voice Handicap Index (VHI) questionnaire and a questionnaire concerning smoking habits, symptoms, and extrawork activities requiring intensive voice use.

Results. Mean percentage phonation time (PT) during work was 14.74% and ranged from 4% to 31%. There was a significant difference between the percentage PT in working time and in extrawork time; however, subjects with high percentage PT in working time maintained a high value also in extrawork time. The mean PT was 87.5 ± 35.8 minutes and was not correlated with age, gender, number of work hours, symptoms, extraprofessional voice use, and VHI scores. The mean amplitude was significantly higher in subjects with longer PT and higher pitch ($P < 0.001$). VHI score (median = 9) was slightly higher than in the general population but not related to the number of work hours, indicating that work time was not a critical factor in causing the perception of voice problems.

Conclusion. Our study provides data about the voice behavior of a large cohort of call center operators and demonstrates that the number of work hours and the percentage PT are not statistically related to the perception of voice disturbances in this working category.

Key Words: Phonation–Ambulatory phonation monitoring–Call center operators–Voice handicap index–Voice dosimetry.

INTRODUCTION

Currently, the voice is a major work tool for a wide range of occupations and it is a primary tool of trade for call center operators. Voice load is commonly considered to be a main risk factor for the development of voice disorders and this is an important issue in occupations requiring intensive voice use.

The safe limits of phonation time and intensity for persons working in a call center are not defined, and the main risk factors for voice disorders in this category have not yet been clarified. Therefore, it is desirable to gather data about the importance of voice dose and the phonation behaviors of call center operators.

Previous studies[1] have not yet demonstrated a relationship between voice load and vocal problems but they dealt with a limited amount of subjects. Voice load does not seem to clearly correlate with vocal fatigue, but there is no means to objectively and quantitatively measure vocal fatigue,[2] which is a subjective feeling. In a study that analyzed risk factors for voice disorders in teachers,[3] physical and psycho-emotional factors were found to be more relevant than vocal dose and environmental characteristics.

Titze et al[4] measured the distance traveled by the vocal folds during their phonatory vibrations and tried to identify the levels of vocal dose that can be tolerated without damage. They determined that when a woman reads a passage, her vocal folds travel approximately in average 0.5–0.7 m/s. To calculate a safe vocal dose, these authors applied the safety limits used for hand-transmitted vibrations in industry. They calculated a safe dose limit of 520 m, which would be reached at 17 minutes of continuous phonation. This method of calculation has two main limitations. First, the anatomic structure of the vocal folds is ideal for sustaining prolonged vibration, whereas other body tissues, such as the hand, are not. Second, this measurement does not consider pauses in phonation that represent rest breaks and recovery time. The authors themselves hypothesized that due to pauses and to the anatomic characteristics of the multilayered vocal fold structure, the vocal load safety limits could be significantly higher.

The aim of the present study was to quantify and analyze vocal behavior in a large number of call center operators. The study also aims to compare the voice doses with those of other occupational voice users as teachers and search for correlations between the daily voice dose and the self-perceived voice-related handicap, to assess whether the vocal dose has an impact on the subjects' quality of life. The intensity of voice use during working time is also compared with that in nonworking hours.

MATERIALS AND METHODS

Participants

The study included subjects who had been working as telephone operators in the Vodafone Call Center in Milano, Italy for at least three consecutive months at the time of the study.

Accepted for publication October 4, 2013.

From the *Otolaryngology Department, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy; †Occupational Medicine, Private Practice, Milan, Italy; ‡Dipartimento di Scienze Chirurgiche Specialistiche, Università degli Studi di Milano, Milan, Italy; §Department of Information Engineering, Università degli Studi di Firenze, Florence, Italy; ||Audiology Unit, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy; and the ¶Neurosciences, University of Leuven and Federal Institute for Occupational Diseases, Brussels, Belgium.

Address correspondence and reprint requests to Giovanna Cantarella, Otolaryngology Department, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Via F.Sforza 35, 20122 Milano, Italy. E-mail: g.cantarella@libero.it

Journal of Voice, Vol. ■, No. ■, pp. 1-6
0892-1997/$36.00

http://dx.doi.org/10.1016/j.jvoice.2013.10.002

All of them worked in similar environmental conditions as far as noise and microenvironment. The only exclusion criterion was previous surgery of the neck, chest, or vocal folds.

Ninety-three subjects volunteered to participate in the study. Twenty-five were males aged 25–42 years (mean 35.5 ± 4.9), and 68 were females aged 24–50 years (mean 36.6 ± 4.2). Subjects belonged to three different working categories: Frontline team (62 subjects) who spent approximately 70% of time receiving phone calls to give information and 30% making calls offering services; Corporate Service (22 subjects) who spent about 55% of time receiving phone calls, 20% to perform phone calls, and 25% answering e-mails; Technical team (eight subjects) spending about 6% of time answering calls, 38% making calls to offer services, and the remaining 56% answering e-mails. The population considered represents the distribution of working categories in the call center under study. None of the recruited subjects was currently in the treatment for voice problems.

The daily work time ranged from 4 to 10 hours/day, but main operators worked either 6 or 8 hours; the distribution can be seen in Figure 1. All the study documents including recordings and submitted questionnaires were anonymous and marked with numbers. The institutional review board of Ospedale Policlinico di Milano approved the study protocol.

General questionnaire

A questionnaire was administered to gather information about the participants' age, gender, smoking habits, and the presence of upper airway symptoms or pathologies, such as respiratory allergies, bronchial asthma, or gastroesophageal reflux. Questions were also asked about involvement in extrawork activities requiring systematic intensive voice use such as teaching, singing, or theater acting.

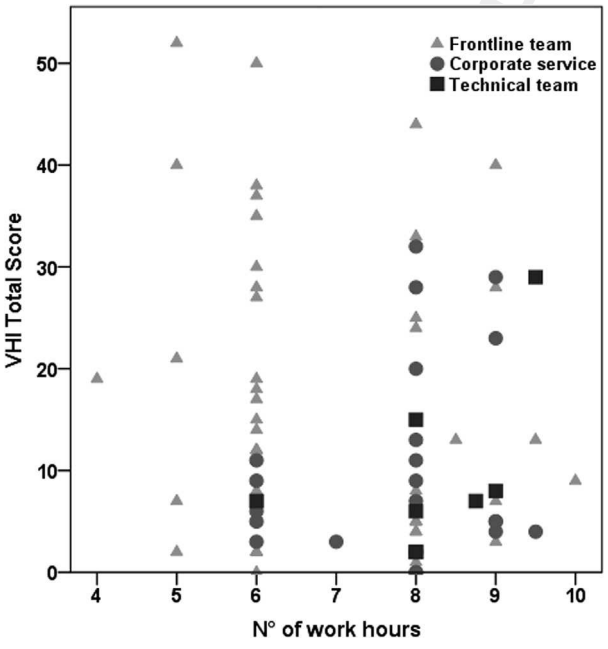

FIGURE 1. Distribution of the number of work hours respect to VHI total scores and the categories of work type.

Evaluation of voice-related disability

The Voice Handicap Index (VHI) questionnaire[5] was administered for the self-assessment of perceived voice-related disability (in terms of reduction in quality of life). This is a validated and widely used 30-item test divided into three subscales that measure the functional, physical, and emotional aspects of the eventual handicap caused by voice impairment. The subscale scores range from 0 to 40, and the total ranges from 0 to 120; a higher score indicates a greater degree of handicap. A score of 12 (calculated as mean + 1 standard deviation) resulted to be the cutoff value in an Italian general population without voice problems[6]; this cutoff was according to the findings of Behrman et al[7] Maertens and de Jong report that 95% of the normal population has a score lower than 32.8, and the median value in the normal population is 6.[8]

Ambulatory phonation monitoring equipment and procedure

The ambulatory phonation monitoring (APM) equipment used in this study was the APM model 3200 by KayPENTAX (Lincoln Park, NJ).[9,10] It consists of an accelerometer that is attached at the anterior base of the neck of the subject under study. The accelerometer gathers acoustic voice raw data at a rate of 20 samples per second; the data are transferred to a microprocessor unit worn in a waist pack. Before starting each new recording, a sound pressure level (SPL) calibration was performed using a microphone positioned 15 cm from the subject's mouth.

The acquired data include:

- Phonation time: expresses the duration of time during which the vocal folds actually have been in phonatory vibration.
- Percentage phonation time: is the percentage of the recording time during which the vocal folds have been in phonatory vibration.
- Fundamental frequency (F_0) average: is the mean frequency at which the vocal folds vibrate, measured in Hertz.
- F_0 mode: is the F_0 value at which most phonation occurs during the recording.
- Mean amplitude (SPL, dB): is the mean value of the amount of energy of the voice sound wave (SPL). The greater the intensity of voice, the greater the amplitude value.
- Total cycles of vibration: represent the number of vibratory cycles of the vocal folds during the recording time.
- Total distance dose (m): is the estimated distance traveled by the vocal folds during their vibratory cycle; the formula to obtain this measure takes into account total phonation time, F_0, and amplitude.

The total duration of data sampling was 21.50 hours, which corresponds to the maximum battery activity of the APM equipment. Data for work hours and extrawork hours were separated. Sleeping time was excluded.

Each participant completed an APM diary indicating any particular condition of voice overload occurring during the day (singing, acting, screaming, and so forth) and upper airway symptoms occurring during the recording hours.

Statistical analysis

Intragroup comparisons (between work and nonwork hours) were analyzed using the Wilcoxon signed rank test. Intergroup comparisons (subjects with VHI score < or ≥ 26) were performed using the Mann-Whitney test. Group differences were examined using general linear models. Correlations between variables were evaluated by the Spearman's Rank correlation. A logistic discriminant analysis was performed to identify variables that distinguish cases (VHI > 12) from noncases (VHI ≤ 12), such as age, gender, phonation time, distance dose, and work category. Two-sided exact tests were used, and *P*-values of less than 0.05 were considered significant. All statistics were calculated using the *Statistical Package for the Social Sciences* (*SPSS*) 17.0 for Windows (SPSS, Inc., Chicago, IL).

RESULTS

All participants completed the APM study without having any local discomfort at the neck, where the sensor was glued.

Twenty-six subjects were habitual smokers (cigarettes per day, 2–20). Six subjects were affected by asthma, 17 by respiratory allergy, and 11 by gastroesophageal reflux symptoms. Ten subjects declared that they had nonprofessional voice use in singing, teaching, or acting in theater.

Thirty-two participants reported mild upper airway symptoms (three mild dysphonia, four rhinitis, 25 cough and/or sore throat) at the time of APM recording. Seventeen subjects indicated in the daily diary during APM recording that they had episodes of extraprofessional voice misuse or abuse due to screaming or singing.

No significant differences were found between the two genders for age, upper airway symptoms, or off-work habits of voice use. The mean number of work hours per day was 7.8 ± 1.3 (range 6–10) for males and 7.1 ± 1.4 (range 4–9) for females, and this difference was statistically significant ($P = 0.039$). Smoking habits were also significantly different, as males smoked 15.4 ± 5.1 (range 10–20) cigarettes per day, whereas females smoked 7.8 ± 4.6 (range 2–20) cigarettes per day ($P = 0.005$).

The subgroup of patients affected by upper airway symptoms (n = 32) did not differ significantly from the remaining subjects on any of the variables measured by APM recording or the daily number of work hours.

The VHI provided information about the participants' perception of their vocal health.

The mean total VHI score was 13.6 ± 12.2 (range 0–52), and the median value 9 (percentiles 25–75: 5–19) (Table 1).

Although these values are slightly higher than those of the general population (median 9 vs 6, percentiles 25–75: 5–19 vs 2–12, according to the study by Maertens and de Jong[8]), 56 subjects (60.9%) scored within the normal range: ≤ 12. The VHI score did not differ between genders. The VHI values were not significantly related to the number of work hours (Figure 1). Also no correlation was found between VHI scores and nonwork voice use. The logistic discriminant analysis indicated that none of the analyzed variables was a significant predictor of VHI score (pathologic: >12). The data obtained by APM recordings are displayed in Table 1.

The mean global (work + nonwork) phonation time was 87.5 ± 35.8 minutes and ranged from 17 to 186 minutes, whereas the mean percentage phonation time was 7.1% and ranged from 1.3% to 22.6% (Figure 2). No significant

TABLE 1.
VHI Questionnaire Scores and Data Obtained by APM in the Call Center Operators Under Study Q6

	Males	Females	*P*	Both
Questionnaire				
VHI functional scale	4.2 ± 4.3 (0–16)	4.9 ± 4.3 (0–20)	ns	4.7 ± 4.3 (0–20)
VHI physical scale	5.5 ± 6.0 (0–20)	6.9 ± 6.4 (0–30)	ns	6.5 ± 6.3 (0–30)
VHI emotional scale	2.0 ± 2.3 (0–7)	2.5 ± 3.7 (0–13)	ns	2.4 ± 3.4 (0–13)
VHI total	11.7 ± 11.4 (0–40)	14.3 ± 12.5 (0–52)	ns	13.6 ± 12.2 (0–52)
Data of APM				
Phonation time (min)	87.9 ± 38.0 (33–164)	87.3 ± 35.2 (17–186)	ns	87.5 ± 35.8 (17–186)
Phonation time (%)	7.1 ± 3.5 (2.6–17.1)	7.1 ± 3.5 (1.3–22.6)	ns	7.1 ± 3.5 (1.3–22.6)
F_0 mode (Hz)	117.0 ± 18.4 (92–152)	190.1 ± 20.5 (152–224)	<0.001	171.0 ± 39.9 (92–224)
F_0 average (Hz)	133.8 ± 19.0 (99.7–163.3)	217.8 ± 20.2 (175.3–276.6)	<0.001	195.8 ± 42.0 (99.7–276.6)
Amplitude average (dB SPL)	71.3 ± 4.5 (65.0–80.2)	70.2 ± 6.0 (56.8–86.2)	ns	70.5 ± 5.7 (56.8–86.2)
Total distance dose (m)	2646.8 ± 1372.0 (660.3–5583.6)	2833.2 ± 1611.0 (438–7256.8)	ns	2833.2 ± 1611.0 (438–7256.8)
Total cycles of vibration	692 133.2 ± 325 920.9	1 155 509.0 ± 473 201.6	<0.001	1 033 007.4 ± 483 167.8

Notes: Values are means ± standard deviations, the range is in brackets.
Abbreviation: ns, nonsignificant.

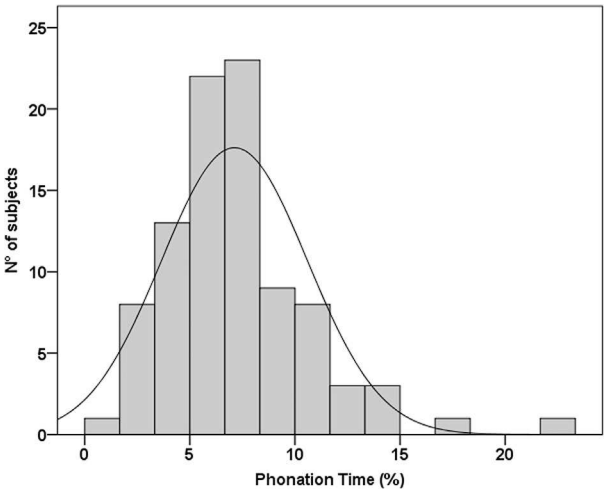

FIGURE 2. Distribution of the phonation time in percent.

difference in phonation time was found between the two genders. As expected, the average F_0, the F_0 mode, and the total number of vibratory cycles were significantly higher in females. None of the remaining APM variables were correlated with the other collected data, such as age, gender, number of hours worked per day, symptoms, extraprofessional habitual voice use, and VHI scores. The APM variables of the subjects reporting voice misuse or abuse during activities on the day of APM did not differ from those of the remaining subjects under study. The variable "average amplitude" was significantly correlated with the total phonation time (Spearman Rho = 0.420; $P < 0.001$) and with the percentage phonation time (Spearman Rho = 0.373; $P < 0.001$); it was higher in subjects with longer phonation time. Considering amplitude average values separately for work and extrawork hours, the correlation with phonation time remains significant in both groups (Figure 3). The graphs in Figure 3 also display a significant correlation between amplitude average and F_0 average, being amplitude average higher in subjects with higher F_0.

Table 2 reports the APM data, analyzing the phonatory behavior during work hours and outside of work separately; all variables, except amplitude average, were significantly different. As expected, phonation time in minutes and percentage was higher during work hours (and, consequently, the total cycles of vibration and the total distance were also higher), whereas F_0 was significantly lower.

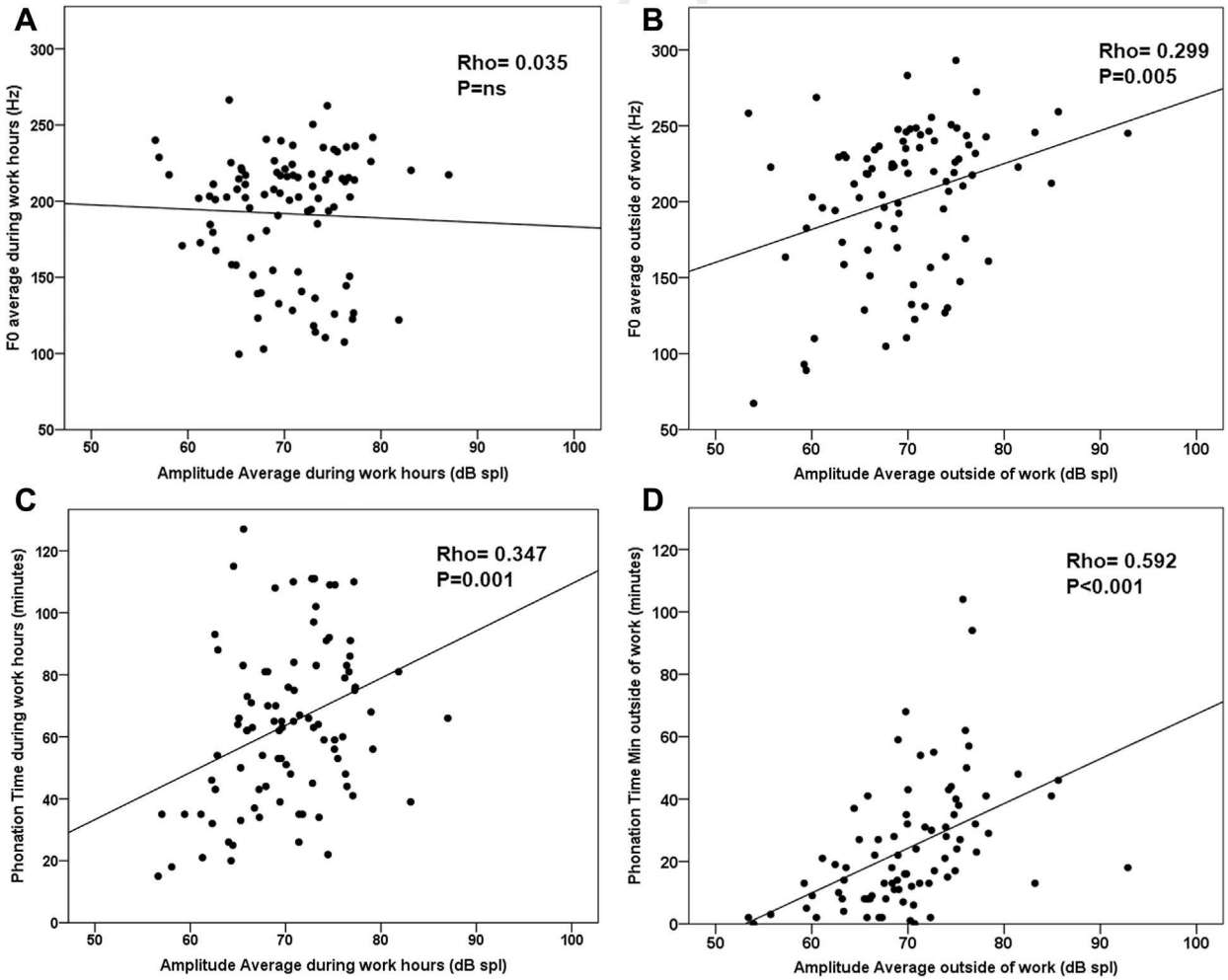

FIGURE 3. The upper graphs (**A–B**) show the correlation between F_0 average and amplitude average during work (**A**) and extrawork (**B**) hours. The graphs on the bottom (**C–D**) show the correlation between phonation time and amplitude average during work (**C**) and extrawork (**D**) hours.

TABLE 2.
Data Obtained by APM During Work Hours and Extrawork Hours in the Call Center Operators

	During Work Hours	During Extrawork Hours	*P*
Phonation time (min)	64.07 ± 26.84 (15–135)	24.36 ± 20.42 (1–104)	<0.001
Phonation time (%)	14.74 ± 5.75 (4–31)	6.23 ± 4.85 (0.3–22.53)	<0.001
F_0 mode (Hz)	169.22 ± 36.95 (92–224)	174.48 ± 46.14 (68–248)	0.001
F_0 average (Hz)	191.73 ± 40.94 (100–267)	202.87 ± 48.25 (67–293)	<0.001
Amplitude average (dB SPL)	70.23 ± 5.84 (57–87)	69.75 ± 6.96 (53–93)	ns
Total cycles of vibration	723 896.99 ± 319 492.19 (197 006–1 673 900)	304 976.12 ± 284 306.71 (2447–1 317 112)	<0.001
Total distance dose (m)	1976.32 ± 992.73 (349–4641)	894.81 ± 897.27 (6–3792)	<0.001

Notes: Values are means ± standard deviations, the range is in brackets.
Abbreviation: ns, nonsignificant.

As expected, the total phonation time (but not the percentage phonation time) during work was related to the number of work hours, but no correlation was found between the total phonation time of the whole recording day and the number of work hours.

Considering separately the two genders, only the data concerning F_0, total cycles, and total distance were different, as expected.

No significant differences were found among the three different working categories (Frontline team, Corporate Service, and Technical team) of subjects for general characteristics, reported upper airway symptoms, and VHI scores. The Technical team subjects worked for a significantly longer time than Frontline team ($P = 0.036$) and Corporate Service ($P = 0.025$, Table 3).

APM-recorded amplitude average was higher in the Technical team compared with Frontline team considering the whole recording day ($P = 0.033$) and working hours ($P = 0.035$), whereas no difference was found for extrawork hours. Percentage phonation time was higher in the Technical team compared with Corporate Service subjects considering the whole recording day ($P = 0.019$) and only working hours ($P = 0.013$), whereas no difference was found with the Frontline team.

DISCUSSION

The main purpose of this study was to obtain data about voice use in a wide sample of call center operators, as there is no such information available in the current literature. Data obtained by voice monitoring were analyzed for correlations with self-perceived voice-related quality of life and with subjects' characteristics.

The vocal doses recorded in this study showed wide intersubject variability, both at work and during nonwork hours. The mean percentage phonation time during call center work was 14.74 and ranged from 4% to 31%, which is significantly more than during nonwork hours. However, these values are considerably lower than those observed (with similar instrumentation) by Hunter and Titze[11] in 57 teachers, who demonstrated an average occupational voicing percentage of 29.9% versus a nonoccupational voicing percentage of 14.4%. In an earlier study on 31 teachers, Titze et al[12] reported corresponding percentages of 23 and 12–13%. This seems to indicate that call center employees demonstrate no more than a moderate occupational voice load. The average voice amplitude was higher in subjects with longer phonation time and higher F_0. This finding indicates that "intensive talkers" also tend to use a higher voice volume. Intensity and pitch of the normal speaking voice are known to be to some degree connected to each other: the spontaneous pitch rises when the vocal intensity increases.[13] Interestingly, in the call center operators, the F_0 was significantly higher during off-work hours; this indicates a tendency to use off-work, a higher pitch compared with that used during a "stereotyped" professional talk.

In the investigated sample, the "Technical team" was theoretically the one with the least voice load as only 44% of the working time was devoted to phone calls; in contrast, it showed the highest percentage phonation time and voice amplitude in comparison with the other groups. These findings further demonstrate that the percentage daily time spent on telephone calls is not a determinant factor for the working voice load.

TABLE 3.
Data Concerning the Three Categories of Call Center Employees Under Study

	Frontline Team (N = 62)	Corporate Service (N = 22)	Technical Team (N = 8)
Working hours	7.80 ± 1.14	7.02 ± 1.42	8.16 ± 1.04
Phonation time (%)			
Whole recording	6.28 ± 2.53	7.14 ± 3.65	9.29 ± 3.67
Working hours	12.53 ± 4.20	15.12 ± 6.10	17.88 ± 4.97
Amplitude average			
Whole recording	70.68 ± 6.90	69.99 ± 5.22	73.96 ± 4.45
Working hours	70.45 ± 6.55	69.69 ± 5.65	73.76 ± 4.41

The majority (60.9%) of our subjects scored within the normal limits of VHI. The VHI score was not related to the number of work hours, indicating that the duration of work time does not seem to be a critical factor in causing the perception of voice handicap.

To the best of our knowledge, the present study is the first to provide a database of APM recordings in and off working hours in a wide number of call center operators and search for correlations with self-perceived voice handicap. The findings show a wide range of total phonation time in subjects working for the same number of hours and with a similar work schedule. An interesting question is the reason for this variability, considering that working requirements are similar. A partial explanation lies in the behavioral characteristics of the subjects: there appears to be a significant correlation between the percentage phonation time in working time and in outside working time ($r = 0.378$, $P < 0.001$). Similarly, the total distance dose in working time and in outside working time are significantly correlated with each other ($r = 0.389$; $P < 0.001$). This indicates that "talkative" persons demonstrate also a higher occupational vocal load. The investigation of other variables, such as stress levels and personality characteristics, not considered in this study, could add further understanding to the vocal behavior of call center employees and to their perception of vocal disability.

There is a lack of large-sample studies involving phonation monitoring. Occupational physicians need to identify the professions and activities that are really at risk for occupational voice disorders. The self-evaluation of voice use is often unreliable due to abusive patterns that are habitual and unconscious. Therefore, it would be desirable to use an objective noninvasive means to gather data about vocal behavior and develop databases representative of the vocal dose ranges that are proper for occupations requiring a significant vocal load.

In conclusion, our study demonstrates that, in the examined sample of call center operators, the number of work hours and the percentage phonation time are not statistically related to the self-perception of voice problems. Our data show that it is not possible to define clear-cut "safety" limits of vocal load in the call center setting. Beside the physical voice dose, other risk factors[3] for voice disturbances such as environmental conditions, general health status, and mental stress deserve attention within the scope of preserving vocal health.

REFERENCES

1. Schloneger MJ. Graduate student voice use and vocal efficiency in an opera rehearsal week: a case study. *J Voice*. 2011;25:e265–e273.
2. Vilkman E. Occupational safety and health aspects of voice and speech professions. *Folia Phoniatr Logop*. 2004;56:220–253.
3. Kooijman PG, de Jong FI, Thomas G, et al. Risk factors for voice problems in teachers. *Folia Phoniatr Logop*. 2006;58:159–174.
4. Titze IR, Svec JG, Popolo PS. Vocal dose measures: quantifying accumulated vibration exposure in vocal fold tissues. *J Speech Lang Hear Res*. 2003;46:919–932.
5. Jacobson BH, Johnson A, Grywalsky A, et al. The voice handicap index: development and validation. *Am J Speech Lang Pathol*. 1997;6:66–70.
6. Forti S, Amico M, Zambarbieri A, et al. Validation of the Italian Voice Handicap Index-10. J Voice. 2013;In press. http://dx.doi.org/10.1016/j.jvoice.2013.07.013. Q5
7. Behrman A, Sulica L, He T. Factors predicting patient perception of dysphonia caused by benign vocal fold lesions. *Laryngoscope*. 2004;114:1693–1700.
8. Maertens K, de Jong FI. The voice handicap index as a tool for assessment of the biopsychosocial impact of voice problems. *B-ENT*. 2007;3:61–66.
9. Hillman RE, Heaton JT, Masaki A, et al. Ambulatory monitoring of disordered voices. *Ann Otol Rhinol Laryngol*. 2006;115:795–801.
10. Cheyne HA, Hanson HM, Genereux RP, et al. Development and testing of a portable vocal accumulator. *J Speech Lang Hear Res*. 2003;46:1457–1467.
11. Hunter EJ, Titze IR. Variations in intensity, fundamental frequency, and voicing for teachers in occupational versus nonoccupational settings. *J Speech Lang Hear Res*. 2010;53:862–875.
12. Titze IR, Hunter EJ, Svec JG. Voicing and silence periods in daily and weekly vocalizations of teachers. *J Acoust Soc Am*. 2007;121:469–478.
13. Debruyne F, Buekers R. Interdependency between intensity and pitch in the normal speaking voice. *Acta Otorhinolaryngol Belg*. 1998;52:201–205.

AUTHOR QUERY FORM

ELSEVIER	**Journal:** YMVJ **Article Number:** 1209	**Please e-mail or fax your responses and any corrections to:** **E-mail: todd.reiss@elsevier.com** **Fax: 567-525-5773**

Dear Author,

Please check your proof carefully and mark all corrections at the appropriate place in the proof (e.g., by using on-screen annotation in the PDF file) or compile them in a separate list. Note: if you opt to annotate the file with software other than Adobe Reader then please also highlight the appropriate place in the PDF file. To ensure fast publication of your paper please return your corrections within 48 hours.

For correction or revision of any artwork, please consult http://www.elsevier.com/artworkinstructions.

Any queries or remarks that have arisen during the processing of your manuscript are listed below and highlighted by flags in the proof.

Location in article	Query / Remark: Click on the Q link to find the query's location in text Please insert your reply or correction at the corresponding line in the proof
	If there are any drug dosages in your article, please verify them and indicate that you have done so by initialing this query
Q1	Please provide the department (if any) for affiliation "†."
Q2	Please check if "Neurosciences" could be changed to "Department of Neurosciences" in affiliation "¶."
Q3	Please check if "University of Leuven" and "Federal Institute for Occupational Diseases" could be treated as two different affiliations. If so, please provide the corresponding affiliation designator in the author group. Also provide the department name (if any) and city name for "Federal Institute for Occupational Diseases."
Q4	Please check if the term "outside of work" could be changed to "extrawork hours" in the sentence "Table 2 reports the APM data …" and in the subsequent occurrences and also in the artwork of "Figure 3A−D."
Q5	Please update Ref. 6.
Q6	Please provide the first column head in Tables 1−3. And also check the edits to the tables, and correct if necessary.
Q7	Please confirm that given names and surnames have been identified correctly.

	Please check this box or indicate your approval if you have no corrections to make to the PDF file ☐

Thank you for your assistance.