Speech disorders

The speech range profile (SRP): an easy and useful tool to assess vocal limits

Speech range profile (SRP): uno strumento utile e facile per la valutazione dell'estensione vocale

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SUMMARY

This study was carried out to compare the vocal limits obtained by speech range profile (SRP) with those of voice range profile (VRP) in untrained healthy and dysphonic females. Forty-six healthy voice volunteers (control group) and 148 dysphonic patients (dysphonic group) were evaluated using videolaryngostroboscopic assessment and phonetography for voice measurements. For VRP, subjects were asked to sustain the vowel */a/* as soft and as loud possible from the lowest to the highest frequencies using an automated procedure. The SRP was obtained by recording the speaking voice (SV) and the shouting voice (ShV) asking subjects to read a list of sentences aloud and to shout */ehi/* as loud as they could, respectively. All subjects in the control and dysphonic groups were able to perform SRP. fourty of 46 (85%) and 102 of 148 (68.91%) cases, respectively in control and dysphonic groups, were able to perform VRP. Most frequently, the VRP was not recorded because of the inability to perform or, especially in the dysphonic group, for inadequacy of the vocal signal. In the control group, there were no significant differences between the mean values of F_{min}, F_{max}, I_{min} and number of semitones (st) of the VRP and those of the SRP ($p > 0.05$). In the dysphonic group, the mean values of F_{min}, F_{max} and *st* SV+ShV for SRP were significantly higher than those of VRP. Our preliminary results suggest that the SRP may be a useful, alternative tool to assess vocal limits in both euphonic and dysphonic females.

KEY WORDS: Voice range profile • Phonetogram • Speech range profile • Dysphonia

RIASSUNTO

Lo studio è stato condotto, su un campione di donne non-professioniste della voce, con l'intento di valutare in modo comparativo i risultati ottenuti dalla registrazione dell'estensione vocale con la metodica dello "Speech Range Profile" (SRP) e quella del "Voice Range Profile" (VRP). 46 soggetti del gruppo di controllo ("control group") e 148 pazienti disfonici ("dysphonic group") sono stati sottoposti a videolaringostroboscopia e analisi dell'estensione vocale. Per la registrazione del VRP, con metodo automatico, veniva richiesto di pronunciare la vocale /a/ più piano e più forte possibile partendo in ciascun caso dalla tonalità più bassa per arrivare a quella più acuta. L'SRP invece è stato ottenuto con registrazione della "Voce Parlata" (SV) (lettura di materiale di frasi alla voce di conversazione) e di quella "Proiettata" (pronuncia, all'intensità massima possibile, di /ehi/). Tutti i pazienti di entrambi i gruppi riuscivano a eseguire l'SRP, solo una parte, 40/46 (85%) e 102/148 (68,91%), rispettivamente del gruppo di controllo e di disfonici, completavano il VRP (il fallimento era per lo più dovuto ad incapacità o, nel gruppo dei disfonici, all'inadeguatezza del segnale vocale). Nel gruppo di controllo, non vi erano differenze significative tra F_{min}, F_{max}, I_{min} and st del VRP e del SRP ($p > 0,05$). Nel gruppo dei disfonici i valori di F_{min}, F_{max} e st SV+ShV ottenuti con l'SRP erano significativamente più alti di quelli registrati con il VRP. Questi risultati preliminari suggeriscono un possibile ruolo dell'SRP, nell'ambito della valutazione dell'estensione vocale, che solo ulteriori studi potranno confermare.

PAROLE CHIAVE: *Fonetogramma • Disfonia*

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Introduction

Instrumental measures used in the assessment of voice are behavioural tests of vocal performance that should refer to both habitual voice use and maximum performance tasks. Evaluation of habitual voice provides information about how the patient typically uses the voice production system. In contrast, maximum performance tasks, such as minimum and maximum intensity and fundamental frequency, test the physiologic capabilities of the system.

The phonetogram or voice range profile (VRP), included among the basic acoustic measures, is a quantitative voice assessment that describes the laryngeal possibilities with respect to fundamental frequency and sound intensity [1]. Generally, VRP is obtained by asking the subject to produce a sustained vowel at both minimal and maximal intensity across his own maximum frequency range. The role of VRP in clinical practice is under investigation. Indeed, in the literature a large amount of research has

been conducted on the VRP characteristics of dysphonic and non-dysphonic patients (elderly [2], professionally trained and untrained voice users [3], female professional singers [4]). The data collected so far suggested the clinical usefulness of VRP particularly for distinguishing pathological voice [5-7] from normal voice and for investigating the efficacy of voice treatments (phonosurgery [1] or voice therapy). However, there are some factors that limit the use of VRP: task or elicitation variables, the repeated instructions provided to the patient and the number of trials allowed. Moreover, because the VRP is a fundamental frequency (F0)-related measure it cannot be performed in cases of severe dysphonia when the signal is aperiodic or shows strong subharmonics [8 9]. Finally, in a busy clinic, VRP is a time consuming procedure that may be difficult to employ [10 11].

The reliability and validity of the VRP is a matter of concern [12], anespecially whether it can adequately reflect the individual's functional speech performance [13]. The profile contours have been examined for differences in vocal capabilities across groups of trained and untrained vocal users, males and females, and healthy and dysphonic individual [1 4 14-16]. This research has suggested that VRP is more useful as a within-subject measure than as a between-groups measure.

Even if several authors have suggested establishing consistent methodology for elicitation of VRP, to date there are no standardized methods for eliciting maximum phonational frequency and intensity ranges. Factors such as elicitation methods, variability in task instructions, coaching provided to the patient, number of repeated trials and examiner experience may affect determination of vocal limits [17-20].

For this reason, attention has recently given to the speech range profile (SRP) obtained during functional speech activity. Few authors [12 21] have studied the role of SRP for assessment of dysphonia, highlighting the simplicity of the procedure and the shorter amount of time required compared to traditional VRP.

The aim of our study is to compare the range profile obtained by SRP with those obtained by VRP in untrained healthy and dysphonic females. We discuss the role of SRP as a diagnostic tool, emphasizing its advantages in routine voice assessment.

Materials and methods

A total of 46 healthy voice volunteers (*control group*), recruited among the companions of patients, doctors and residents of our department, and 148 dysphonic patients (*dysphonic group*) referred to our voice clinical service, between October 2010 and January 2012, were selected on the basis of the Voice Handicap Index (VHI) questionnaire that assesses the patient's perception of their voice, clinical history and videolaryngostroboscopic assessment.

All subjects met the following inclusion criteria: non-professional female speakers, normal hearing as defined by pure-tone thresholds at frequencies from 0.25 to 8 KHz (≤ 20 dB HL), older than 18 years and younger than 70 years. In addition, subjects in the control group had a VHI [22] ≤ 20, no evidence of impairment of motility/movement disorder and no inflammatory/precancerous/congenital lesions, signs of muscle tension dysphonia or history of laryngeal diseases or laryngeal or neck surgery. In the dysphonic group, subjects were included who suffered from dysphonia (VHI greater than 20) from at least three months. Exclusion criteria were history of pulmonary disease, laryngeal surgery, previous speech therapy, malignant or premalignant laryngeal lesions, hormonal voice disorders, and spasmodic or psychogenic dysphonia.

The mean age was 36.61 years (range 19-60 years; SD = 12.81) in the control group and 40.08 years (range 18-68 years; SD = 12.84) in the dysphonic group. All subjects in both groups were submitted to maximum performance vocal tests as described below.

Procedure

Voice analysis was performed in a quiet room, with the Voice Range Profile program (VRP-model 4326) using the Computerized Speech Lab (model 4300B; Kay Elemetrics), recording with a Shure model SM48 microphone (Evanston, IL) positioned at an angle of 45° at a distance of 30 cm from the patient's mouth. The microphone saturation input was fixed at 6/9 of CH1 and the environmental noise was <30 dB SPL. Each subject recorded two profiles: the VRP and SRP.

Voice Range Profile

To obtain a VRP, an automated procedure was used. Subjects were instructed to phonate using a sustained vowel */a/* as soft and as loud possible from the lowest to the highest frequencies. Prior to recording subjects were asked to practice for at least three times pitch gliding as vocal warming-up to facilitate the production of maximum vocal performance. The low VRP intensity contour was obtained before the upper intensity contour. Low loudness had to be obtained without whispering, while the maximum loudness had to be reached without causing discomfort in the throat. In order to motivate patients to perform to their maximum capacity, the investigator provided verbal support and auditory examples if necessary. The VRP was performed and recorded twice for each intensity contour. The required time to obtain the VRP was a mean of 20 min. The following parameters were analyzed: lowest frequency (F_{min}, Hz), highest frequency (F_{max}, Hz), number of semitones (*st*) and minimum intensity (I_{min}, dB SPL).

Speech Range Profile

In order to obtain the SRP, we recorded the speaking (SV) and shouting voice (ShV). The SV was carried out by ask-

ing subjects to read aloud twice 20 sentences at their most comfortable pitch and loudness as in daily conversation. Subjects were allowed to practice reading the sentences aloud before actual recording. The sentences were chosen to be characterized by different prosodic features (i.e.: interrogative, affirmative, exclamatory) and to express different feelings (i.e.: happiness, sadness, disbelief, disappointment) (Table I). The ShV was obtained by asking patients to say twice */ehi/* as loud as they could. The examiner provided suggestions such as *"Imagine being in a street where there is a lot of traffic noise. You have to call someone who is away from you, on the other side of the street"*. The subjects were asked to practice the performance for at least three times before the recording. Overall, the procedure to obtain the SRP required an average time of 10 min for each subject.

Table I. The list of sentences used for the speaking voice (SV) analysis.

1.	Che ore sono? *(What time is it?)*
2.	Come ti chiami? *(What's your name?)*
3.	Che tempo fa? *(What's the weather like?)*
4.	Ti è piaciuto il film? *(Did you like the movie?)*
5.	Verrai alla festa? *(You will come to the party?)*
6.	Cosa c'è per cena? *(What's for dinner?)*
7.	Hai lavorato tanto? *(You worked so hard?)*
8.	Non venire più. Sono stanca dei tuoi tira e molla *(Go away. I'm tired of your shilly-shallying)*
9.	Guardate! Non sono più solo! *(Look I'm no longer alone!)*
10.	Ti prego perdonami! *(Please forgive me!)*
11.	Non ne posso più. Questa storia deve finire *(I can't take it anymore. This has got to stop)*
12.	Che bello! Sarà un viaggio magnifico *(How beautiful! Will be a nice trip!)*
13.	Non ti chiedo pietà. Voglio giustizia *(I do not ask for mercy. I want justice to be done)*
14.	Smettetela. Non voglio più ascoltarvi *(Stop it I do not want to listen to you)*
15.	Mi piace tanto. Me lo regali? (*I like it very much. Will you give it to me?)*
16.	Non voglio più faticare. Tanto non serve a nulla *(I do not want to sweat, it's useless)*
17.	Vieni qui voglio vedere come ti sei ridotto *(Come here, I want to see what a mess you're in!)*
18.	Insomma mi vuoi ascoltare una buona volta? *(Will you listen to me this time?)*
19.	No! A queste condizioni non ci sto *(No, I don't agree with these conditions)*
20.	Non è possibile! È meraviglioso *(That's not possible! It's wonderful)*

To test the repeatability of the SRP, we recorded it three times in 40 randomly selected subjects (20 subjects of control group and 20 of dysphonic group). Each test was performed after one hour from the other.

The parameters analyzed in the SRP were: lowest frequency (F_{min}, Hz) of the SV, highest frequency (F_{max}, Hz) of the ShV, number of semitones (*st* SV+ShV) between the F_{min} of the SV and F_{max} of the ShV and minimum intensity of the SV (I_{min}, dB SPL). F_{min} and F_{max}, for both VRP and SRP, were considered eligible when they were detected at least twice in the profile area.

Statistical analyses were performed with the software package SPSS (version 10.0 for Windows; SPSS Inc., Chicago, Ill). The analysis of variance (ANOVA) was used for continuous variables. A p value < 0.05 was considered to be significant.

Results

By videolaryngostroboscopic assessment, we identified different vocal fold lesions or defects in the dysphonic group as reported in Table II. All subjects in the control and dysphonic groups were able to perform SRP, whereas 40/46 (85%) and 102/148 (68.91%) cases, respectively in the control and dysphonic groups, were able to perform the VRP.

In 31/148 (20.94%) cases in the dysphonic group, the vocal signal was inadequate for acoustic analysis. Moreover, the patient's embarrassment and lack of ability to match the pitch did not allow obtaining VRP recordings in 6/46 cases in the control group and in 15/148 in the dysphonic group (5 cases of unilateral vocal fold paralysis, 1 case of cyst, 3 cases of polyp, 2 cases of Reinke's oedema, 2 for muscle tension dysphonia and 2 for nodules).

Table II. Distribution of vocal cord diseases observed by videolaryngostroboscopic assessment.

	Incidence	Percentage
UVFP	25/148	16.89%
Reinke's oedema	21/148	14.18%
Vocal cyst	15/148	10.13%
Vocal polyp	34/148	22.97%
Vocal nodules	37/148	25%
Muscle tension dysphonia	16/148	10.81%

UVFP = unilateral vocal fold paralysis

Analysis of the three repeated recordings of SRP in randomly selected subjects of the control and dysphonic groups showed no significant differences between the values of F_{min}, F_{max}, I_{min} and *st* ($p > 0.05$) (Table III).

For statistical analysis, we included only subjects who were able to perform both SRP and VRP (control group 40/46, dysphonic group 102/148). For both groups, the mean values of F_{min}, F_{max}, I_{min} and *st* of the SRP and the VRP are shown in Tables IV and V.

In the control group, statistical analysis did not reveal any significant differences between the mean values of F_{min}, F_{max}, I_{min} and *st* of the VRP and those of SRP ($p > 0.05$). In the dysphonic group, the mean values of VRP parameters were statistically different compared to those of SRP. In particular, the mean values of F_{min}, F_{max} and *st* SV+ShV of SRP were significantly higher ($p<0.05$) compared to VRP, whereas the mean value of I_{min} of SRP was significantly lower ($p < 0.05$).

Table III. Mean values, standard deviations and statistical significance of the differences between each parameters obtained in three repeated recordings of SRP.

	1st recording	2nd recording	3rd recording	p
F_{min} (Hz ± SD)	164.66 (± 11.76)	169.23 (± 13.32)	163.96 (± 10.63)	> 0.05
F_{max} (Hz ± SD)	406.68 (± 64.25)	424.76 (± 37.81)	418.36 (± 39.49)	> 0.05
I_{min} (dB)	66.58 (± 3.18)	65.74 (± 2.49)	68.82 (± 2.98)	> 0.05
st	16.64 (± 3.78)	15.94 (± 1.29)	17.51 (± 2.15)	> 0.05

SRP = speech range profile; F_{min} = minimum frequency; F_{max} = maximum frequency; I_{min} = minimum intensity; st = number of semitones; SD = standard deviation.

Discussion

For many years, VRP was used in the classification of singing voice and in diagnosis of dysodia [3]. Nevertheless, due to the ease of handling and the advantage in providing visual results, over time VRP has become widely used to check the frequency range of phonation even in non-professional voice users [24]. At present, the basic protocol for functional assessment of voice pathology proposed by the European Laryngological Society (ELS) [1] includes VRP.

As widely accepted in the literature, the critical points of a phonetogram are the highest and lowest frequencies and the softest intensity [5 25 26]. However, even if these three points may reflect the individual's physiological vocal limits or capacity, several author [12 17 18] have discussed their reliability and validity. Indeed, the VRP is subject to different procedural factors that can lead to high intra- and inter-subject variability [27]. Basing on our long-standing clinical experience, we noted that non-professional voice users often show trouble in performing VRP, with both the traditional and the fully automated procedures.

Traditional VRP is recorded using sustained phonation. Accordingly, it cannot obtain information about the real speech abilities that one may exhibit during connected speech, projected voice and shouting voice. Some researchers [21 28 29] have utilized SRP to obtain a two dimensional graphical representation of frequency and intensity during speech performances such as counting or reading aloud. Ma et al. [12] studied the effects of voice disorders in vocally untrained women, comparing VRP and SRP of dysphonic cases with those of healthy controls. Moreover, Siupsinskiene [3 29] studied the differences of quantitative parameters of VRP and SRP between trained and untrained voices in order to examine the effects of training on vocal capabilities. They showed the utility of selected parameters for evaluation of voice in healthy and dysphonic professional speakers. Nevertheless, currently there is not yet a standardized protocol to obtain the SRP. To our knowledge, no studies have compared performance obtained with VRP and SRP in the same group of speakers. In this study, after evaluating the repeatability of the SRP procedure, we compared the range profiles obtained with the SRP to those obtained with the VRP in untrained healthy and dysphonic females.

Table IV. Mean values, standard deviations and statistical significance of the differences between each parameter obtained by VRP and SRP in the control group (40/46 subjects).

	VRP	SRP	p
F_{min} (Hz ± SD)	158.63 (± 12.93)	162.37 (± 15.49)	> 0.05
F_{max} (Hz ± SD)	469.53 (± 70.38)	444.80 (± 46.98)	> 0.05
I_{min} (dB)	64.42 (± 2.29)	63.57 (± 2.99)	> 0.05
st	19.28 (± 3.05)	18.85 (± 1.71)	> 0.05

VRP = voice range profile; SRP = speech range profile; F_{min} = minimum frequency; F_{max} = maximum frequency; I_{min} = minimum intensity; st = number of semitones; SD = standard deviation.

Table V. Mean values, standard deviations and statistical significance between each parameter obtained by VRP and SRP in the dysphonic group (102/148 subjects).

	VRP	SRP	p
F_{min} (Hz ± SD)	145.55 (± 27.07)	163.67 (± 29.39)	< 0.05
F_{max} (Hz ± SD)	355.27 (± 81.01)	373.81 (± 64.63)	< 0.05
I_{min} (dB)	68.29 (± 5.0)	66.06 (± 3.99)	< 0.05
st	13.91 (± 3.36)	15.92 (± 3.11)	< 0.05

VRP = voice range porfile; SRP = speech range profile; F_{min} = minimum frequency; F_{max} = maximum frequency; I_{min} = minimum intensity; st = number of semitones; SD = standard deviation.

Our results showed that all patients in both groups were able to perform the SRP in contrast to VRP. For VRP recordings, only vocal signals with jitter values beyond the threshold are accepted [8 9]. Indeed, in the dysphonic group the inadequacy of the vocal signal was the most frequent condition that prevented the recording. Other factors such as the patient's embarrassment and lack of ability to match the pitch also made it difficult to perform VRP recordings in both dysphonic and healthy speakers.

The literature reports that to obtain a satisfactory VRP around 20-30 min are necessary [10 11]. In our experience, the time spent for the VRP is consistent with these data. In contrast, overall the procedure that we utilized for SRP required an average time of 10 min for each subject. Our SRP included the reading aloud and shouting voice tasks that are easy to perform because they reflect habitual speech behaviours.

In the control group, the differences between the VRPs and SRPs parameters were not significant. In the dysphonic group, the mean values of all parameters of SRP were statistically different compared with the VRP ones.

The mean SRP I_{min} was significantly lower than that of the VRP. For dysphonic patients, sustained phonation at softest intensity levels as required by VRP implies a high phonatory threshold pressure. Indeed, in the presence of a vocal fold disease that impairs the mass or motility, vibration at a very low airflow rate is limited [25]. The reading aloud task of the SRP allows a more physiological use of voice and better regulation of subglottal pressure. In the dysphonic group, the mean SRP F_{min}, SRP F_{max} and SRP *st* were significantly higher than that of VRP. To elicit the vocal limits, using the VRP fully automated procedure, it is necessary to realize rapid variations of the vocal fold tension. An increase of the fold mass or an impairment in motility or mucosal wave may not allow to quickly and accurately adjust the vocal fold length needed to obtain frequency variations. VRP using sustained vowel prolongations may not always reliably elicit true physiological voice limits. In particular, to elicit the SRP F_{max} we asked patients to shout */ehi/* as loud as possible. This task was always very easy to perform by the patient, while sustained phonation gliding to the highest tone often led to voice breaks or being out of tune.

In conclusion, our data suggest that the SRP is a reproducible procedure which is easier and faster to administer than the VRP. Both untrained healthy and dysphonic females demonstrated greater compliance in performing it. In the healthy group, the vocal limits derived from the two vocal profiles were similar, while in dysphonic subjects the SRP area was larger compared with that of VRP. This suggests that in healthy subjects the SRP can be an alternative procedure to VRP. On the other hand, in dysphonic patients, considering the aforesaid limits of VRP, one may assume that the SRP provides reliable vocal limits, although further evidence it is needed to demonstrate this with certainty.

Nevertheless, it is important to highlight that determination of F_{max} using the shouting voice is not recommended in the early postoperative assessment after phonosurgery. Nonetheless, the procedure allows understanding the limits of speaking voice by providing an overall estimation of early functional outcome.

Further research is needed to evaluate the role of SRP in untrained males, as well in children, adolescents and older individuals. Moreover, it will be necessary to assess the sensitivity of SRP in detecting changes following medical, surgical and behavioural voice treatments.

References

1 Dejonckere PH, Bradley P, Clemente P, et al. *A basic protocol for functional assessment of voice pathology, especially for investigating the efficacy of (phonosurgical) treatments and evaluating new assessment techniques*. Eur Arch Otorhinolaryngology 2001;258:77-82.

2 Teles-Magalhaes LC, Pegoraro-Krook MI, Pegoraro R. *Study of elderly females' voice by phonetography*. J Voice 2000;14:310-21.

3 Siupsinskiene N. *Quantitative analysis of professionally trained versus untrained voices*. Medicina (Kaunas) 2003;39:36-46.

4 Lamarche A, ternstrom S, Pabon P. *The singer's voice range profile: female professional opera soloists*. J Voice 2008;4:410-26.

5 Heylen L, Wuyts FL, Mertens F, et al. *Evaluation of the vocal performance of children using a voice range profile index.* J Speech Lan Hear Res 1998;41:232-8.

6 McAllister A, Sederholm E, Sundberg J, et al. *Relations between voice range profiles from patients with organic vocal fold pathologies*. J Voice 1994;8:230-90.

7 Behrman A, Agresti CJ, Blumstein E, et al. *Meaningful features of voice range profiles from patients with organic vocal fold pathologies.* J Voice 1996;12:540-50.

8 Pabon JPH, Plomp R. *Automatic phonetogram recording supplemented with acoustical voice-quality parameters*. J Speech Hear Res 1988;31:710-22.

9 Speyer R, Weineke GH, van Wijck-Warnaar I, et al. *Effects of voice therapy in the voice range profiles of dysphonic patients*. J Voice 2003;17:544-56.

10 Pabon J. *Objective acoustic voice-quality parameters in the computer phonetogram.* J Voice 1991;5:203-16.

11 Titze IR, Wong D, Milder MA, et al. *Comparison between clinician-assisted and fully automated procedures for obtaining a voice range profile*. J Speech Hear Res 1995;38:526-35.

12 Ma E, Robertson J, Radford C, et al. *Reliability of speaking and maximum voice range measures in screening for dysphonia*. J Voice 2007;21:397-406.

13 Kent RD, Kent JF, Rosenbek JC. *Maximum performance tests of speech production*. J Speech Hear Disord 1987;52:367-87.

14 Awan SN. *Phonetographic profiles and F0-SPL characteristics of untrained versus trained vocal groups*. J Voice 1991;5:41-50.

15 Akerland L, Gramming P, Sundberg J. *Phonetogram and averages of sound pressure levels and fundamental frequencies of speech: comparison between female and nonsingers*. J Voice 1992;6:55-63.

16 Gramming P. *Non-organic dysphonia: phonetograms for pathological voices before and after therapy*. Scand J Logopedics Phoniatrics 1988;1:3-16.

17 Coleman RF. *Sources of variation in phonetogram*. J Voice 1993;7:1-14.

18 Gramming P, Sundeberg J, Akerlund L. *Variability of phonetograms*. Folia Phoniatr 1991;43:79-92.

19 Sihvo M, Laippala P, Sala E. *A study of repeated measures of softest and loudest phonation*. J Voice 2000;14:161-9.

20 Zraick RI, Nelson JL, Montague JC, et al. *The effect of task on determination of maximum phonation frequency range*. J Voice 2000;14:154-60.

21 Hacki T. *Comparative speaking, shouting and singing voice range profile measurement: physiological and pathological aspects*. Logoped Phoniatr Vocol 1996;21:123-9.

22 Jacobson BH, Johnson A, Grywalsky C, et al. *The voice handicap index (VHI): development and validation*. Am J Speech Lang Pathol 1997;6:66-70.

[23] Woisard-Bassols V. *Bilan clinique da la voix*. In: *Encyclopedie Medico Chirurgicale*, 20-753 A-10 Oto-Rhino-Laryngologie.

[24] Dejonckere PH. *Perceptual and Laboratory Assessment of Dysphonia*. In: Rosen CA, Murry T, eds. *Voice Disorders and Phonosurgery*. Otolaryngol Clin North Am 2000;I(Suppl.):731-50.

[25] Van de Heyning PH, Belgian Study Group on voice disorders. *Research work of the Belgian study group on voice disorders.* Acta Otorhinolaryngo Belg 1996;50:321-86.

[26] Wuyts FL, De Bodt MS, Molenberghs G, et al. The *Dysphonic Severity Index: an objective measure of vocal quality based on multiparameter approach*. J Speech Lang Hear Res 2000;43:793-809.

[27] Gramming P, Akerlund L. *Non-organic dysphonia. II. Phonetograms for normal and pathological voices*. Acta Otolaryngol Stockh 1988:106:468-76.

[28] Emerich KA, Titze IR, Svec JG, et al. *Vocal range and intensity in actors: a studio versus stage comparison*. J Voice 2005;19:78-83.

[29] Siupsinskiene N, Lyck H. *Effects of vocal training on singing and speaking voice characteristics in vocally healthy adults and children based on choral and nonchoral data*. J Voice 2011;25:177-89.

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