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CLINICAL CONTRIBUTION OF A POPULATION-BASED STUDY: EXPLORATION OF MUSCLE TENSION DYSPHONIA

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LIST OF PUBLICATIONS

This thesis is based on the following articles accepted in international peer reviewed journals:

- Van Houtte E, Van Lierde K, D'Haeseleer E, Claeys S. The prevalence of laryngeal pathology in a treatment-seeking population with dysphonia. *Laryngoscope* 2010, 120(2),306-312.

- Van Houtte E, Claeys S, Wuyts F, Van Lierde K. The impact of voice disorders among teachers: vocal complaints, treatment-seeking behavior, knowledge of vocal care and voice-related absenteeism. *J Voice* 2011, 25(5): 570-575

- Van Houtte E, Claeys S, Wuyts F, Van Lierde K. Voice disorders in teachers: Occupational risk factors and psycho-emotional factors. *Logoped Phoniatr Vocol* 2012 ,37(3):107-16

- Van Houtte E, Van Lierde K, Claeys S. The pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *J Voice* 2011, 25(2): 202-207

- Van Houtte E, Claeys S, D'haeseleer E, Wuyts F, Van Lierde K. An examination of Surface EMG for the Assessment of Muscle Tension Dysphonia. *J Voice* 2011 [Epub ahead of print]

- Van Houtte E, Van Lierde K, D'haeseleer E, Van Imschoot B, Claeys S. UES pressure during phonation using high-resolution Manometry and 24-h Dual probe pH-metry in patients with Muscle Tension Dysphonia. *Dysphagia* 2012, 27 (2): 198-209.

LIST OF ABBREVIATIONS

AP: anterior-posterior

CI: confidence interval

CMT: circumlaryngeal manual therapy

CP: cricopharyngeal muscle

DSI: dysphonia severity index

FD: functional dysphonia

EMG: electromyography

sEMG: surface electromyography

ENT: ear, nose and throat

GERD: gastro-esophageal reflux disease

HRM: high-resolution manometry

IQR: inter quartile range

LES: lower esophageal sphincter

LPR: laryngopharyngeal reflux

M-L: medio-lateral

MPT: maximum phonation time

MRI: magnetic resonance imaging

MTD: muscle tension dysphonia

MVC: maximum voluntary contraction

OR: odds ratio

QOL: quality of life

RMS: root mean square

RSI: reflux symptom index

SCM: sternocleidomastoid muscle

TP: thyropharyngeal muscle

UES: upper esophageal sphincter

VC: vital capacity

VHI: voice handicap index

SUMMARY

Nearly one-third of the general population has an impaired voice production at some point during their life. Functional dysphonia is one of the most important types of voice disorders. In theory, functional dysphonia is considered as the impairment of voice production in absence of distinct organic or neurological pathology. In practice, the term functional dysphonia is used as a umbrella diagnosis for a complex voice disorder with subgroups that change in definitions and labels over the years. In this thesis, the subgroup of Muscle Tension Dysphonia was further investigated. MTD defines those patients with dysphonia caused by an excessive tension of the (para)laryngeal muscles.

First, the prevalence of functional voice disorders in a treatment-seeking population with dysphonia was investigated. The results showed that functional voice disorders were the most common diagnosis (30%) across all age groups (except children). This study showed that professional voice users compiled a significant part of the treatment-seeking population. Within the group of working patients, they accounted for 41% with teachers as the main subgroup. Within the group of professional voice users, functional dysphonia was the main diagnosis (41%).

Professional voice users, more specifically teachers, were further investigated because they represent a significant part of the treatment-seeking patients with dysphonia. We investigated personal, work-related and environmental risk factors and psycho-emotional factors of voice disorders in teachers. More than half of the teachers (51,2%) reported a voice disorder at some point during their career. Female teachers reported significantly more voice disorders than male teachers (38% versus 13.2%). A family history of voice disorders, the number of pupils per classroom, temperature changes in the classroom and noise levels within the classroom were identified as vocal risk factors. Furthermore, teachers with voice disorders presented with a higher level of psychological distress compared to teachers without voice disorders. We investigated the treatment-seeking behavior, voice-related absenteeism and knowledge of vocal care. One in four teachers (25.4%) sought medical care and 20.6% had missed at least 1 day of work because of a voice disorder. Only a minority (13.5%) of the teachers received information about vocal use during their education. The high prevalence of voice disorders in teachers and the significant impact on the teachers' wellbeing and functioning argue for implementation of education and prevention programs for teachers.

Because functional dysphonia is a very common voice disorder, a specific subgroup, more precisely Muscle Tension Dysphonia (MTD) was further investigated. MTD is the pathological condition in which an excessive tension of the (para)laryngeal musculature, caused by a diverse number of etiological factors, leads to a disturbed voice. MTD cases

represent a large part of the patients with functional dysphonia, especially in professional voice users. Unfortunately, diagnosing MTD remains problematic since there is no objective tool to differentiate between patients with MTD and normal speakers. Clinical care is hindered by the lack of standard objective measures for the assessment of MTD. Therefore, we investigated the use of surface EMG and high-resolution manometry (HRM) as possible diagnostic tools for MTD.

In the first clinical study, the tension of the extrinsic laryngeal musculature of patients with MTD were recorded using sEMG and compared to subjects without MTD. Our study could not detect differences in the average laryngeal muscle tension between both study groups. However, we found a significant difference in muscle activity range (= the increase in muscle activity from rest level to phonation level). The infrahyoidal muscles of patients with MTD had a significant smaller increase in muscle activity from rest level to phonation level compared to subjects without MTD. Because rest levels were similar in both study groups, this shows a diminished capacity to increase muscle activity during phonation in the patient group. This indicates that the infrahyoidal muscles in patients with MTD are more hypertonic, suggesting that there is a loss of flexibility in the laryngeal framework in patients with MTD.

In the second clinical study, we used HRM to compare the upper esophageal sphincter (UES) pressure of patients with MTD and control subjects. The average UES pressures were not significantly different between the study groups. However there was an increase in UES pressure ratio (= vowel UES pressure/rest UES pressure ratio), which was more pronounced in patients with MTD than in the control group. In the control group, alterations in the UES pressure ratio were rather subtle whereas in the patients with MTD there was a substantial increase in UES pressure ratio. This might indicate that, when there is a normal tension of the laryngeal musculature, there is a balanced interaction between pharynx and larynx during voicing. However, when the tension of the laryngeal musculature is altered, the flexibility between larynx and pharynx is reduced and they become to work as one segment with subsequent changes in the UES pressures. This was the first study to investigate UES pressure using HRM during phonation in patients with MTD. Further research needs to be conducted with more adapted, specialized probes in order to evaluate HRM as a diagnostic tool for MTD.

In conclusion, this thesis showed that functional dysphonia is the most common diagnosis in a treatment-seeking population with dysphonia, especially in professional voice users such as teachers. These professional voice users are at increased risk to develop a voice disorder. Vocal risk factors need to be addressed when treating a dysphonic patient. Within the group of functional dysphonia, the subgroup of MTD was further investigated since objective criteria for the diagnosis are missing. Our clinical studies suggests that there is a loss of flexibility in the larynx of patients with MTD. Further research concerning these anatomical correlates of MTD is necessary to fully understand this pathology, to focus treatment and to decrease the significant burden.

Samenvatting

Bijna een derde van de bevolking heeft op een zeker tijdstip in zijn leven een stemprobleem. Functionele dysfonie is een van de belangrijkste oorzaken van stemstoornissen. Functionele dysfonie is het gevolg van een foutief stemgebruik of zelfs stemmisbruik in afwezigheid van organische of neurologische pathologie. In de klinische praktijk blijkt functionele dysfonie een complexe verzameling te zijn van verschillende subgroepen/types van stoornissen die over de jaren wijzigden in definitie en terminologie. In deze thesis werd de subgroep van 'Muscle Tension Dysphonia' (MTD) verder onderzocht. MTD is de pathologische conditie waarin een verhoogde spanning van de (para)laryngeale spieren, leidt tot een verstoorde stemvorming.

Eerst werd de prevalentie van functionele stemstoornissen onderzocht bij patiënten die de Universitaire stemkliniek NKO van het UZ Gent consulteerden. Onze resultaten toonden dat functionele dysfonie de meest voorkomende diagnose was (30% van alle stempathologie) en dit over alle leeftijdsgroepen (behalve kinderen). Deze studie toonde eveneens dat professionele stemgebruikers een belangrijk deel vormden van de patiëntenpopulatie op de universitaire stemkliniek. Zij maakten 41% uit van alle werkende patiënten, met leerkrachten als voornaamste subgroep. In de groep van professionele stemgebruikers was functionele dysfonie de belangrijkste oorzaak van stemproblemen (41%).

Aangezien leerkrachten een significant deel uitmaakten van de patiënten met stemproblemen, werd deze groep verder onderzocht. Persoonlijke, werkgerelateerde en omgevingsgebonden risicofactoren voor stemproblemen en stressgerelateerde aspecten werden onderzocht. De resultaten toonden dat meer dan de helft van de leerkrachten (51.2%) op een zeker ogenblik in hun carrière een stemprobleem ervaarden. Vrouwen rapporteerden significant meer stemproblemen dan mannen (38% vs 13.2%). Een familiale anamnese voor stemproblemen, het aantal leerlingen per klas, temperatuurverschillen in de klas en lawaai in het klaslokaal werden geïdentificeerd als risicofactoren voor stemproblemen. Bovendien hadden leerkrachten met stemproblemen duidelijk meer stress dan leerkrachten zonder stemproblemen. Hulpzoekend gedrag van leerkrachten, afwezigheid op het werk door stemproblemen en het geïnformeerd zijn over stemgebruik werd eveneens onderzocht. Eén op vier leerkrachten (25.4%) zocht medische hulp voor zijn stemprobleem en één of vijf leerkrachten (20.6%) had minstens één dag werk gemist door het stemprobleem. Slechts 13.5% van de leerkrachten had tijdens hun opleiding informatie ontvangen over stemhygiëne en mogelijke oorzaken van stemstoornissen. De hoge prevalentie van stemproblemen en de belangrijke impact op zowel het persoonlijk als het professioneel leven van de leerkracht tonen de noodzaak tot het integreren van preventieve programma's in de lerarenopleiding.

In het klinisch deel van de thesis werd functionele dysfonie, meer specifiek de subgroep MTD verder onderzocht. Een groot deel van de patiënten met functionele dysfonie, vooral

professionele stemgebruikers, wordt gediagnosticeerd met MTD. De diagnosestelling van MTD is echter moeilijk gezien er geen objectieve techniek bestaat om patiënten met MTD te differentiëren van personen zonder MTD. Om die reden onderzochten we de klinische bruikbaarheid van oppervlakte EMG and hogeresolutie manometrie (HRM) als diagnostisch middel voor MTD.

In de eerste klinische studie werd d.m.v. oppervlakte EMG de spierspanning van de extrinsieke larynxspieren van patiënten met MTD gemeten en vergeleken met een controlegroep zonder MTD. We konden geen significant verschil weerhouden in gemiddelde spierspanning tussen beide studiegroepen. We vonden wel een significant verschil in de range van de spieractiviteit (= toename in spieractiviteit van rust tot fonatie). De infrahyoidale spieren van de patiënten met MTD hadden een significant kleinere range dan de personen zonder MTD. Aangezien de spierspanning in rust in beide groepen vergelijkbaar was, wijst dit op een verminderde capaciteit tot toename van activiteit tijdens fonatie in de groep met MTD. Dit suggereert dat de infrahyoidale spieren van de patiënten met MTD hypertoon zijn en dat er een verminderde flexibiliteit is in de larynx van patiënten met MTD.

In de tweede klinische studie werd de druk in de bovenste slokdarmsfincter (BSS) gemeten d.m.v. HRM en vergeleken tussen patiënten met en zonder MTD. De gemiddelde BSS druk was niet significant verschillend tussen beide onderzoeksgroepen. Er was wel een significante toename in de drukratio (= BSS druk tijdens fonatie/ BSS druk tijdens rust) in de patiënten met MTD. In de controlegroep was de BSS drukratio relatief stabiel tijdens de fonatieoefeningen in tegenstelling tot de patiëntengroep die een duidelijke toename in BSS drukratio kende. Dit kan erop wijzen dat, wanneer er een normale spierspanning in de larynx is, er een vlotte gebalanceerde interactie bestaat tussen larynx en farynx tijdens stemvorming. Wanneer er echter een verhoogde spanning t.h.v. de larynxspieren is, gaat een deel van de flexibiliteit van tussen larynx en farynx verloren en gaan deze als één segment werken met een verhoogde druk in de BSS als gevolg. Dit was echter de eerste studie die de BSS druk onderzocht tijdens fonatie in patiënten met MTD. Verder onderzoek met aangepaste, specifieke probes moet verricht worden om HRM als diagnostisch middel voor MTD verder te evalueren.

Samenvattend kan worden gesteld dat functionele dysfonie het meest voorkomende type is van stemstoornissen in patiënten die consulteren omwille van heesheid. Professionele stemgebruikers, vooral leerkrachten maken een grote groep uit van de patiënten met functionele dysfonie. Bovendien hebben zij een verhoogd risico op het ontwikkelen van een stemprobleem. Bij het behandelen van een patiënt met heesheid is het belangrijk risicofactoren voor stemproblemen in rekening te brengen. In de groep van functionele stemstoornissen werd de subgroep MTD verder onderzocht aangezien objectieve criteria voor de diagnose van MTD ontbreken. Onze klinische studies suggereren dat er een verlies is van flexibiliteit in de larynx bij patiënten met MTD. Verder onderzoek naar de onderliggende anatomische oorzaak is noodzakelijk om deze pathologie beter te begrijpen, de behandeling beter te kunnen richten en functionele impact te kunnen reduceren.

GENERAL INTRODUCTION

&

PURPOSES

CHAPTER 1.1: FUNCTIONAL VOICE DISORDERS

Voice disorders lead to a medical consult when quality, pitch or loudness differ significantly from what subjects and their surroundings expect from their voice. Voice disorders may result from changes in structure (organic disorders) and/or function (functional voice disorders) of the laryngeal mechanism.

Functional voice disorders account for 10-40% of all laryngeal pathology in a treatment-seeking population with dysphonia [1, 2] in tertiary voice clinics. Even up to 70% of patients visiting voice clinics have been identified with functional dysphonia [3]. Functional voice disorders are believed to occur predominantly in women and commonly follow upper respiratory tract infections [1, 4, 5]. According to the study of Bridger and Epstein [1], the mean age at presentation is 45 years and the female/male ratio is 2:1.

Functional voice disorders are usually the result of misuse or abuse of the anatomically intact vocal system, but they may also result from maladaptive compensatory maneuvers as a consequence of an organic condition [2]. Functional dysphonia with prolonged aberrant vocal use may lead to the development of secondary organic lesions (e.g. nodules). Although these nodules are true pathologic entities, they should be recognized as the result of an underlying and preceding functional disorder [2]. It is clear that functional voice disorders cannot be catalogued as being the opposite of organic voice disorders. In voice literature, functional dysphonia has been recognized for a long period of time as an umbrella diagnosis for impairment of voice production in absence of structural and/or neurological diseases. Over the past decades, nomenclature has changed significantly [6, 7]. Such diversity in terminology is of interest because it reflects professional differences in attitudes and beliefs about their very nature of these complex voice disorders, and the labels dictate how such disorders will be classified and managed at a clinical level. A few of the used terms are: psychogenic dysphonia [8], hyperfunctional dysphonia, muscle misuse dysphonia [7], hyperkinetic dysphonia, functional hypertensive dysphonia, myasthenia laryngis [9], laryngeal tension fatigue syndrome [10], etc.

The label of functional dysphonia has also been questioned because functional implies a disturbance of physiological function rather than in anatomical structure and often carries the meaning of psychogenic. In response to this 'underestimation of the anatomical cause' of functional voice disorders, studies have focused on the pathophysiology of functional dysphonia. In a subgroup of the patients with a functional voice disorder, an imbalance of (para)laryngeal muscle activity seems to cause the voice disorders. For these patients the label Muscle Tension Dysphonia (MTD) became the preferred label. It is important to remember that MTD is not a synonym for patients with a functional voice disorder but specifically defines those patients with dysphonia caused by an excessive tension of the (para)laryngeal muscles. The altered tension of the extrinsic laryngeal musculature results in a changed position of the larynx in the neck. Because of this altered position, the inclination of the cartilaginous structures of the larynx (thyroid, cricoid, and arytenoid) is disturbed, which affects the intrinsic musculature [11]. Tension of the vocal folds is altered and the voice becomes disturbed.

CHAPTER 1.2: VOICE DISORDERS IN THE PROFESSIONAL VOICE USER

Communication has acquired a growing importance in the labor market, particularly for professional voice users who depend on their voice as their main working tool. For these professionals, dysphonia can result in absence from work, reduced productivity, and even the need to change profession [12]. Serious personal and emotional consequences may also result for the individual professional voice user. They feel limited in their current job performances and in their future career options because of their voice disorder [13]. Consequently, professional voice users represent a significant part of the patients with voice disorders frequenting the ENT department. Teachers represent the largest part. Teaching has been identified as a profession with an increased risk for voice disorders [13-16]. The prevalence of vocal dysfunction is significantly higher in teachers (ranging from 11% to 81%) compared with non-teachers (ranging from 1% to 36.1%)[15-19]. This high prevalence is often due to intense and prolonged occupational voice use [20, 21].

Previous studies showed that functional dysphonia is the main diagnosis in professional voice users, ranging from 4% to 82.3% [22]. When a functional voice disorder is present, voice therapy is prescribed. The duration of the voice therapy for professional voice users is often very long (in Belgium reimbursement is possible for 2 years) and therapy failure is high[23]. In a study of Bridger and Epstein [1] only 56% of the patients with functional dysphonia was considered cured. Furthermore, voice disorders may lead to extensive periods of sick leave. In the general population, 7.2% of the individuals missed work for one of more days within the preceding year because of a problem with their voice [12]. Among teachers this rate increases to 20% which is significantly more than the general population [12, 13]. In the majority of the teachers sick leave was limited to one week or less, but a substantial part of the teachers was absent for more than a week. Since teachers are a significant part of the working population, these data stress the important economical burden due to voice-related absenteeism.

The substantial number of teachers frequenting the ENT department, the high failure rate of voice therapy and the socio-economic voice-related burden, underline the need of further investigation. Identifying vocal risk factors is necessary in order to delineate the subgroup of teachers at risk and adapt treatment to the specific needs in this population.

CHAPTER 1.3: MUSCLE TENSION DYSPHONIA: GENERAL FEATURES

The term ''Muscle Tension Dysphonia'' (MTD) was introduced by Morrison and colleagues in 1983 to describe clinical features of young- to middle-aged individuals with extensive voice use in stressful situations [24]. MTD can be described as the pathological condition in which an excessive tension of the (para)laryngeal musculature, caused by a diverse number of etiological factors, leads to a disturbed voice. This label gained international acceptance as it was not limited to one probable cause. It describes the clinical diagnosis in which several etiological factors could play a role. MTD can be evaluated with videostroboscopy and has enabled functional dysphonia to lose its ''subjective'' character. MTD is not a synonym for functional voice disorders but specifically defines those patients with dysphonia caused by an excessive tension of the (para)laryngeal muscles. A number of nonorganic voice disorders (such as hypokinetic dysphonia, mutation dysphonia, and conversion aphonia) do not fall under this category and still need specific labeling. MTD is assumed to be the most common cause of functional dysphonia. Up to 60% to 70% of the patients in voice clinics are diagnosed with MTD [3].

Two forms of MTD were introduced. Primary MTD involves a dysphonia in the absence of concurrent organic vocal fold pathology and is associated with excessive, atypical, or abnormal laryngeal movements during phonation, without obvious psychogenic or neurologic etiology [25, 26]. Primary MTD occurs primarily in women and accounts for 10–40% of the clinical caseloads at a voice center [1, 2]. Secondary MTD indicates a dysphonia in the presence of an underlying organic condition [27]. Till now, a division of MTD into these two categories remains necessary because it has not been elucidated whether MTD leads to organic pathology or whether MTD is the result of organic lesions.

The excessive muscle activity causing MTD, has been attributed to many factors that can be cataloged into three distinct categories.

The first category are the **psychological and/or personality factors**. Based on psychometric evidence, certain personality traits have been found to characterize at least a subset of patients with MTD. A general trend has been noted towards elevated levels of introversion [26], neurotism [26], (social) anxiety [28-30], constraint [26, 28], stress reactivity [26, 28] and depression [30]. Researchers point out that although personality tendencies may exist in patients with MTD, personalities are generally complex and unique. Other factors must be considered, such as the nature and the degree of stress experienced, life experience, and support and coping strategies.

Secondly, **vocal abuse/misuse** has been acknowledged as a cause of MTD [2, 6, 7]. Misuse of the voluntary muscles used in phonation, including muscles of the larynx, pharynx, jaw, tongue, neck, and respiratory system can contribute to incorrect vocal techniques. Furthermore, disturbed respiratory and phonatory gestures lead to improper resonance focus, loss of control of pitch and loudness and eventually to decompensation of the voice. This is mainly seen in professional voice users (such as teachers, lawyers, salesmen, etc.) and elite vocal performers (singers) with higher vocal demands. They do not only have daily prolonged voice use but they also rely on their voice to control, entertain or convince their audience.

Thirdly, MTD can be the result of an **overcompensation to an underlying disease** such as organic fold lesions, laryngopharyngeal reflux (LPR)[31], altered hormonal status [32, 33], aging of the larynx [34] and upper respiratory tract infection [6]. This type of MTD is referred to as secondary MTD, which is the result of a patient's overcompensation to an underlying organic cause. In an attempt to maintain normal pitch and volume in a structurally altered larynx, vocal fold tension and stiffness are increased and the voice becomes disturbed [35, 36].

The cause of the elevated tension in the (para)laryngeal musculature is mostly multifactorial. A combination of these factors may become so decisive over time that at a certain point the voice decompensates [7]. The laryngeal musculature tries to find a new point of balance but progressively the larynx enters a state of hypertension. Underlying organic pathology such as reflux laryngitis, vocal nodules, polyps, cysts, Reinke's edema, etc. can cause, precipitate or aggravate MTD [6, 31]. Whether the MTD results from the organic pathology or organic pathology results from MTD is still a subject of debate.

Diagnosis of MTD is based on several key features. The history of vocal misuse/abuse, psychological influences, and stressful situations has to be evaluated. Auditory-perceptual features of MTD can include strained or effortful vocal quality, aberrant pitch, breathiness and vocal fatigue [35]. Clinical examination includes a routine examination of the ear, the nose and the throat and especially an evaluation of visible and palpable tension around the larynx, which is assessed by laryngeal palpation [37]. Next, the patient should be evaluated with laryngoscopy/videostroboscopy [38]. Finally, a detailed logopedic voice assessment with a perceptual evaluation, aerodynamics, acoustics, voice range, DSI measurements and an evaluation of the phonation during circumlaryngeal massage should be assessed. These elements of diagnosis of MTD will be discussed in the next chapter.

CHAPTER 1.4: EXAMINATION OF THE PATIENT WITH MUSCLE TENSION DYSPHONIA

1.4.1 INTAKE

The intake is an important part in the management of every patient with a voice disorder. When evaluating a patient with a voice disorder, a general voice intake should obtain:

(1) a detailed medical history relevant to the dysphonia: an occupation requiring extensive voice use (teacher, singer, telemarketers, etc), voice-related work absenteeism, prior episodes of voice disorders, stress and psychological aggravating factors, related pain symptoms such as throat pain, neck pain, headache, etc.[39] and recent surgical procedures involving the neck or recent endotracheal intubation [40]

(2) acute and chronic conditions that may influence the voice: gastro-esophageal reflux disease (GERD), infection of the throat and/or larynx, neck or laryngeal trauma, stroke, diabetes, Parkinson's disease, multiple sclerosis, myasthenia gravis, asthma, chronic pulmonary obstructive disease, allergic rhinitis, psychiatric disorders [40]

(3) a history of tobacco use

(4) a review of current medications: anticoagulants, ACE-inhibitors, antihistaminica, anticholinergica, antipsychotica, hormones and inhaled steroids [40].

In patients with MTD, factors that are believed to cause or aggravate the voice disorder should be questioned thoroughly. As discussed in chapter 1.3, these factors can be divided into three distinct categories: (1) psychological and/or personality factors, (2) vocal misuse/abuse in the context of extraordinary voice demands (e.g. professional voice users) and (3) underlying organic disease such as GERD or upper respiratory tract infection that could have led to an overcompensation.

The impact of the voice disorder should also be assessed. It is important to evaluate the severity of the voice disorder and the impact on the quality of life (QOL) of the patient. Dysphonia may lead to decreased voice-related QOL and a decrease in physical, social and emotional aspects of global QOL similar to those associated with other chronic diseases such as congestive heart failure and chronic pulmonary disease [41].

1.4.2 LARYNGEAL PALPATION

Palpation of the extrinsic laryngeal muscles can yield information about laryngeal tension and posture at rest and during phonation. In the past, techniques and scoring systems for laryngeal palpation have been introduced. Nonetheless these systems claim to be simple and easy learned, differences between examiners in palpation scores will always exist. Especially patients with a limited ability to palpate such as those with a short fatty neck, previous trauma, surgery or radiation are difficult to examine [37]. Despite these disadvantages, laryngeal palpation provides a useful information for assessment of patients with voice disorders. Integration of this examination into routine laryngeal examinations can help the clinician to make a more accurate diagnosis and plan appropriate treatment.

Following areas should by palpated at rest and with voicing [42]:

- Suprahyoid tension: the examiner should palpate upward into the muscle region extending from the body of the hyoid forward toward the submental area.
- Thyrohyoid space tension and tenderness: the examiner palpates the thyrohyoid membrane with the tip of the index finger on one side and the thumb on the other side. Is it open and relaxed, is the space between the thyroid and hyoid narrowed?
- Cricothyroid space and mobility: this space should be palpated with the index fingertip. Does this space open and closes when reaching low and high pitches?
- Laryngeal excursion: the degree of up and down mobility of the larynx throughout the pitch range may be palpated or visualized.
- Pharyngo-laryngeal muscles (inferior constrictor muscles) and lateral laryngeal gutters: this can be palpated by placing the fingers behind the posterior edge of the thyroid lamina. Tightness of inferior constrictor muscles and freedom of the laryngeal gutters should be evaluated.
- The sternocleidomastoid muscles.

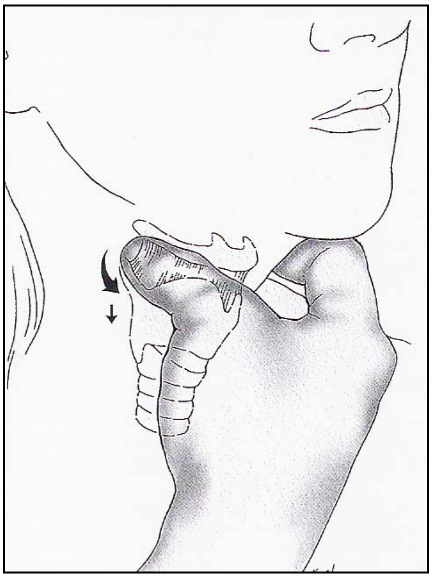

Fig. 1. Palpation of the thyrohyoid space (Roy et al)[43].

In patients with MTD, following features are frequently noted when performing the laryngeal palpation: tightness of the suprahyoidal and infrahyoidal musculature, laryngeal rise, decreased thyrohyoid space, sites of focal tenderness during rest and phonation [7, 24, 37] and an increased tension of the sternocleidomastoid muscles [44].

1.4.3 LARYNGOSCOPY AND VIDEOSTROBOSCOPY

Laryngoscopy and videostroboscopy does not only allow an evaluation of organic pathology (nodules, cysts, papillomas, edema, erythema, etc.) but also provides information about functional abnormalities. The following functional aspects needs to be evaluated during laryngoscopy: mobility of the vocal folds during inspiration and phonation, length of the vocal folds, change in length of the vocal folds during high en low phonation, closure of the glottis, internal shape of the larynx (anterior-posterior and medio-lateral contraction). Stroboscopic examination adds substantially to the diagnostic abilities. Stroboscopic light allows routine slow-motion evaluation of the mucosal cover layer of the vocal folds. Fundamental frequency, symmetry of movements, glottic closure, amplitude of vibration, mucosal wave and presence of non-vibrating portions of the vocal fold can be evaluated [45].

In the past, many different terms have been used to distinguish the image on videostroboscopy in patients with MTD. Although there is no internationally accepted classification system, the following patterns are most frequently used: MTD 1—laryngeal isometric contraction with posterior open chink because of a hypertonic state of the posterior cricoarytenoid muscle, MTD 2—supraglottic contraction in which the ventricular folds are adducted to the midline, MTD 3—anteriorposterior contraction that results in a reduced space between the epiglottis and the arytenoids prominences, and MTD 4—extreme anterior-posterior contraction or squeeze [46]. These (supra)glottal constriction patterns assist the diagnosis of MTD [7, 24, 37], but can also occur in people without voice disorders [47]. The term MTD is however only used when the situation becomes symptomatic. The occurrence of these features in normal speakers implies the need for objective measures that describe MTD and are not seen in people without voice disorders.

There is an ongoing interest in exploring the use of high-speed imaging to supplement or replace videostroboscopy in the endoscopic assessment of vocal fold vibration. High-speed imaging is a recent technique in which increased light sensitivity is enabling high quality endoscopic imaging of the vocal folds motion at unprecedented image capture rates (4000-10 000 frames per second). This quality suggests that high-speed imaging could be used to observe complex laryngeal movements and thereby providing new insights into the mechanism of disordered voice production [48].

1.4.4 LOGOPEDIC ASSESSMENT

The quality, pitch and intensity of the voice needs to be determined using subjective and objective voice assessment techniques. Observation of the phonation during these assessments is necessary. The possible psychosocial handicapping effect of the voice disorders, especially in professional voice users and elite vocal performers also needs to be determined.

Subjective voice assessment

The GRBASI scale is used as the perceptual assessment scale. The GRBASI scale is the most widely used scale for perceptual evaluation, proposed by the Japan Society of Logopaedics and Phoniatrics [49]. It uses a four-point grading scale (0 = normal, 1 = slight, 2 = moderate, 3 = severe) for five different parameters (G= overall grade of hoarseness, R= rough, B= breathy, A= asthenic, S= strained) to rate the degree of vocal quality. A sixth parameter I for instability of the voice was added to the GRBASI scale.
Perceptual features of MTD can include strained or effortful vocal quality, aberrant pitch, breathiness and vocal fatigue [35].

Objective voice assessment

The objective voice assessment comprehends the aerodynamics, acoustics, voice range, an evaluation of the phonation during circumlaryngeal massage and measurement of the Dysphonia Severity Index (DSI). The DSI is based on the weighted combination of the following set of voice measurement: maximum phonation time (MPT), highest frequency (F_0), lowest intensity (I), and the jitter. The length of the MPT is measured in seconds. The DSI is constructed as: 0.13 maximum phonation time (MPT) + 0.0053 F high – 0.26 I low – 1.18 jitter (%) + 12.4. The DSI ranges from + 5 to -5, respectively for normal and severely dysphonic voices. The more negative the patient's index is, the worse is his or her vocal quality [50]. A cut-off value of + 1.6 is considered as a normal voice. In patients with MTD, an abnormal DSI (< + 1.6) is expected. Unfortunately, the DSI gives merely a global evaluation of the voice quality and can be abnormal in numerous causes of voice disorders. It is not typical or pathognomonic for MTD. Calculation of the DSI is an important part of the general workup of a dysphonic patient but does not allow to diagnose MTD.

Psychosocial impact of vocal problems

The psychosocial handicapping effect of the voice disorders, as perceived by the patient, can be measured by means of the Voice handicap Index (VHI) [51]. The VHI questionnaire, which contains 30 items, assesses the patient's judgment about the relative impact of his or her voice disorder on daily activities. The VHI is scored from 0 to 120, with the latter representing the maximum perceived disability due to voice difficulties based on the patient response. The VHI can be helpful to establish a voice-related decrease in the patient's quality of life (QOL) as well as an instrument to measure functional outcomes in treatments of voice disorders. Similar to the DSI, the VHI gives an overall idea about the impact of the voice disorder on the patient's life. It is an valuable tool in the general evaluation of the dysphonic patient but does not allow to diagnose MTD. The VHI has also proved to be a useful instrument to monitor the treatment efficacy in patients with MTD [52].

1.4.5 Experimental diagnostic tools

Since videostroboscopic features of MTD may also exist in normal subjects [47], research concerning an objective diagnostic tool for MTD is necessary.

Surface Electromyography

Surface Electromyography (sEMG) enables the recording of the collective behavior of motor units lying under the surface electrode. The larger extrinsic musculature (suprahyoid and infrahyoid muscles) maintain the larynx in a stable and natural position, in which the intrinsic laryngeal musculature can contract freely and undisturbed. In patients with MTD, an altered tension of the extrinsic musculature is believed to result in a disturb function of the intrinsic musculature[11]. Therefore it is worthwhile to investigate the tension of the extrinsic laryngeal musculature using surface EMG.

A few studies found a measurable difference in the tension (e.g. an increased tension) of the (para)laryngeal musculature between patients with MTD and without MTD using sEMG [53, 54]. Hočevar-Boltežar et al. [53] evaluated 11 patients with MTD and five subjects without MTD, and their results showed a six- to eightfold increase of EMG activity and/or an alternation of the EMG activity in the perioral and supralaryngeal muscles before and during phonation in most of the patients with MTD. Redenbaugh and Reich [54] examined seven subjects without MTD and seven vocally hyperfunctional speakers with surface EMG and concluded that the hyperfunctional speakers showed significantly higher EMG values during rest and vowel phonation than the normal speakers. These results imply a possible role for surface EMG in the diagnosis of MTD.

High-resolution manometry

Manometry measures pressure within the esophageal lumen and sphincters, and provides an assessment of the muscular activity. Manometric techniques have improved in a step-wise fashion from a single pressure channel to the development of high-resolution manometry (HRM) with up to 36 pressure sensors. This technique is a widely recognized method to evaluate the swallowing function. However, it has been rarely used to evaluated phonation. Vocal fold lengthening is influenced not only by the (para)laryngeal muscles but also by the cricopharyngeal muscle and the thyropharyngeal muscle which constitute the upper esophageal sphincter (UES) [55]. Based on the pathophysiology of MTD, a persistent phonation with an abnormal laryngeal posture due to increased (para)laryngeal muscle tension, could also lead to an increase in the pressure in the hypopharynx and the UES. The increased pressure in the UES could be due to a mechanical squeeze of the sphincter and the pharynx. It is hypothesized that this squeeze is caused by surrounding structures, such as posterior movement of the larynx pressing the sphincter and the hypopharynx against the spine due to increased (para)laryngeal muscle tension [56].

A study conducted by Perera and colleagues [56] investigated phonation using HRM in normal speakers. Their results showed that phonation was accompanied by an increase in the upper esophageal sphincter (UES) pressure. The change in UES pressure was significantly higher compared with the esophageal body and the lower esophageal sphincter (LES). This phenomenon was observed for both high and low pitch.

CONCLUSION & PURPOSES

Nearly one-third of the general population has impaired voice production at some point in their lives [57]. Dysphonia is more prevalent in certain groups such as teachers, but all groups and both genders can be affected [12, 57-59]. In addition to the impact on the quality of life (QOL)[41], dysphonia leads to frequent health care visits and several lost billions due to lost productivity annually from work absenteeism.

In the first part of the thesis, the general prevalence of laryngeal pathology in a treatment-seeking population with dysphonia in the Voice Clinic at the Ghent University Hospital was evaluated. The relation between the laryngeal pathology and the age, gender and occupation of the patient was investigated, with specific attention to the subgroup of professional voice users.

In the second part of the thesis, the subgroup of teachers was further investigated. Attention was paid to not only risk factors of dysphonia but also to psycho-emotional impact, treatment-seeking behavior and work-related absenteeism.

The third and clinical part of the thesis intended to enhance the diagnosis of MTD using two different techniques: surface EMG en high-resolution manometry.

In the first clinical study, patients with MTD were evaluated with surface EMG during phonation exercises. Our goal was to evaluate if sEMG could function as an objective diagnostic tool for MTD in comparison with subjects without MTD. The use of sEMG to monitor changes in neck tension in patients with MTD could lead to a more standardized diagnosis and improved information about patients progress.

In the second clinical study, UES pressure was investigated during phonation using high-resolution manometry in patients with MTD in comparison with subjects without MTD.

We investigated if UES pressure recordings could differentiate patients with MTD from subjects without MTD. The current study is the first to evaluate the effect of phonation on the UES pressure in patients with MTD in comparison with normal speakers.

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AIMS OF THE STUDIES

AIMS OF THE STUDIES

The principal aims of the studies outlined in this thesis were to delineate the clinical concept of 'Muscle Tension Dysphonia' by objectifying the tension in the paralaryngeal muscles and to propose further diagnostic guidelines.

Specific aims of this thesis were:

1. To evaluate the laryngeal pathology and its distribution (occupation-gender-age) in a treatment-seeking population in a University Voice Clinic.

2. To evaluate the personal, work-related and environmental vocal risk factors and psycho-emotional factors of voice disorders in teachers in Flanders.

3. To get insight in the consequences (treatment-seeking behavior and work-related absenteeism) of occupational voice problems in teachers in Flanders.

4. To propose Muscle Tension Dysphonia as an clinical and diagnostic term and to emphasize its role in both organic as functional voice disorders.

5. To evaluate the use of surface EMG as diagnostic tool in the assessment of Muscle Tension Dysphonia.

6. To evaluate the use of UES manometry as diagnostic tool in the assessment of Muscle Tension Dysphonia.

PREVALENCE OF FUNCTIONAL VOICE DISORDERS IN A TREATMENT-SEEKING POPULATION WITH DYSPHONIA

The Prevalence of Laryngeal Pathology in a Treatment-Seeking Population With Dysphonia

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Abstract

Objectives/Hypothesis. This article describes the prevalence of laryngeal pathology in a treatment-seeking population with dysphonia in the Flemish part of Belgium.

Study Design. Retrospective investigation.

Methods. During a period of 5 years (2004–2008), data were collected from 882 patients who consulted with dysphonia at the ear, nose, and throat department of the University Hospital in Ghent (Belgium). Laryngeal pathology was diagnosed using videostroboscopy. Ages ranged from 4 years to 90 years.

Results. Functional voice disorders were most frequently diagnosed (30%), followed by vocal fold nodule (15%), and pharyngolaryngeal reflux (9%). The role of age, gender, and occupation was investigated. Pathologies were significantly more common in females than in males, representing 63.8% and 36.2% of the population, respectively. Professional voice users accounted for 41% of the workforce population, with teachers as main subgroup. In professional voice users, functional dysphonia occurred in 41%, vocal fold nodules in 15%, and pharyngolaryngeal reflux in 11%. Our data were compared with data from other countries.

Conclusions. Functional voice disorders were overall the most common cause of voice disorders (except in childhood), followed by vocal fold nodules and pharyngolaryngeal reflux. Professional voice users accounted for almost one half of the active population, with functional voice disorders as the main cause of dysphonia.

Key Words: Prevalence, voice disorders, dysphonia, laryngeal pathology, stroboscopy

Introduction

Voice disorders lead to a medical consult when quality, pitch, or loudness differ significantly from what patients and their surroundings expect from their voice. Especially when associated with other complaints, such as prelaryngeal pain, pharyngolaryngeal reflux, vocal fatigue, throat irritation, and throat clearing; an ear, nose, and throat (ENT) consult is demanded by the patient. Voice disorders may result from changes in the structure (organic disorders) and/or function (functional disorders) of the laryngeal mechanism. Unfortunately, there is only very limited information on the prevalence of a treatment-seeking population at an ENT department. Conflicting definitions of voice disorder and methodological differences in procedures, populations, and sizes (such as data restricted to the pediatric population or to specific groups as professional voice users) are causes of variations in the overall prevalence. In the absence of these data it is difficult to precisely identify populations at risk, to delineate the causes and effects of voice disorders, and to develop early screening procedures to identify those at risk. Most other studies conducted their investigations through interviews by telephone or using a voice disorder questionnaire, and it is often difficult to determine how the sample cohort was identified, how the survey was conducted, and who responded. Few studies objectified the complaints with laryngoscopic or videostroboscopic evaluation. This study was designed to determine the current age-specific and gender-specific prevalence of voice disorders, the amount of functional versus organic voice disorder, and the number of voice disorders in professional voice users versus nonprofessional voice users in a treatment-seeking population. Comparisons were made to the findings of Coyle et al. (2001) and Herrington-Hall (1988). Current data on the voice-disordered treatment-seeking population are needed to permit the otolaryngologist to appropriately focus research, education and clinical management.

Materials and Methods

Subjects

The present study was a retrospective investigation. From January 2004 to December 2008, all patients who presented themselves for the first time at the ENT department of the University Hospital in Ghent with a voice problem (e.g., hoarseness, vocal fatigue, discomfort, increased effort in using their voice, or change in voice quality) were included in the subject selection. Every patient was examined by an otolaryngologist, flexible endoscopy, and a videostroboscopy was made at the first consultation. If videostroboscopy was not possible (e.g., very young children, very strong vomiting reflex, refusal by the patient), the patient was not included in the study. Medical records from the department were used to obtain patient data.

Data Analysis

Patient records were reviewed for age, gender, occupation, pathology, and treatment. Data were recorded in a Microsoft Excel (Microsoft Corp., Redmond, WA) spreadsheet and analyzed. We evaluated a total of 882 patients. For each patient the following data were collected: 1) date of first consultation, 2) age, 3) gender, 4) occupation, 5) laryngeal pathology, and 6) treatment. Within this group, 12 laryngeal pathologies were reported (see Table I). When patients presented with more than one problem, the main problem was listed in the data set. This classification may seem somewhat artificial or limited, because voice literature has extensively confirmed that dysphonia patients are multifactorial in their diagnoses.[1] In a number of patients this was indeed the case, but in this study, patients were categorized according to their primary diagnosis seen at the first consultation. If organic pathology (e.g., vocal nodules, polyps, cysts, gastroesophageal reflux) was detected on videostroboscopy, this diagnosis took precedence above the nonorganic diagnosis, and the organic diagnosis was listed in the data set. This study was conducted in the voice clinic at the ENT department and did not focus on premalignant and malignant pathologies, because these patients are referred to, examined, and treated at a different department (Head and Neck Surgery) at our institution. The percentage of premalignant and malignant pathologies is thus an underestimation of the prevalence.

Treatment was divided into four groups: vocal hygiene, voice therapy, surgery, and medication (e.g., antibiotics, proton pump inhibitors, nasal or oral cortisone). According to age, groups were divided into six categories. To make comparison possible with previous investigations,[2,3] the same age categories were used: 0 to 14 years (childhood), 15 to 24 years (adolescence), 25 to 44 years (young adulthood), 45 to 64 years (late adulthood), and >65 years (seniors). Relations between laryngeal pathology and age, gender, and occupation were investigated.

Results

Pathology-Related Data

A total number of 882 patients were examined, and 12 laryngeal pathologies were identified. The following classification was used: 1) gastroesophageal reflux disease (GERD), laryngitis, inflammation of the arytenoids; 2) vocal fold nodules and hypertrophy of the vocal folds; 3) polyp and cyst; 4) vocal fold paralysis; 5) functional disorder; 6) psychogenic dysphonia; 7) edema and Reinke's edema; 8) premalignant and malignant pathologies; 9) laryngeal papillomatosis; 10) hormonal and age-related dysphonia; 11) normal on exam; and 12) other (e.g., hematoma, voice problems after intubation, granuloma, epiglottitis, muscle diseases). In the category vocal fold nodules, not only patients with the end result of subepithelial scar deposition (e.g., vocal nodules) are listed, but also the patients with vocal fold hypertrophy, because these are the changes seen on videostroboscopy before the actual vocal fold nodules are formed. The pathophysiology relies on the midmembranous vocal folds experiencing maximal friction and collision forces. This repeated collision initially results in a localized vascular congestion with edema with eventual hyalinization of the Reinke's space, with thickening of the overlying epithelium and development of epithelial hypertrophy.

The term ''functional voice disorders'' was used when a posterior glottis insufficiency, a supraglottic lateral contraction, or an anterior-posterior contraction could be detected on videostroboscopy. If these videostroboscopic features were present in absence of structural or neurological pathology, patients were diagnosed as having primary muscular tension dysphonia (MTD). MTD is the label used to describe functional voice problems related to dysregulated or imbalanced laryngeal and paralaryngeal muscle activity, and can be either primary or secondary. This matter will be discussed further in the study. Since the videostroboscopic features (especially posterior glottis insufficiency) can also be seen in normal speakers [2], the label MTD was only used when a distinct voice problem was present.

Although psychogenic dysphonia has been considered in the voice literature as part of functional dysphonia, we defined it as a different category. Patients were diagnosed with psychogenic dysphonia when stress, emotion, or psychological conflicts were clearly the cause of the voice disorders and organic pathology was absent. These patients were also aware of the cause of their voice disorder and the focus of their treatment was on psychological counseling rather than on voice therapy.

The category of age-related dysphonia includes patients with vocal changes due to aging of the larynx, which is described in the literature with the label ''presbyphonia''. Examination of the larynx with videostroboscopy shows bowing of the vocal folds with a persistent glottic gap during voicing.

The term ''normal on exam'' was used when no abnormalities on videostroboscopy could be detected (e.g., normal glottic closure, normal mucosal wave, normal tension in the larynx) and the otolaryngologist could not state that the condition of the voice condition was insufficient.

Figure 1 contains the different diagnoses and their frequencies. Results revealed that the most common disorders in this treatment-seeking population included functional voice disorders (30%), vocal fold nodules and hypertrophy of the vocal cords (15%), and GERD, laryngitis, and inflammation of the arytenoids (9%).

Table I. Distribution of laryngeal pathology according to age.

TABLE I.
Distribution of Laryngeal Pathology According to Age.

	0–14 Years				15–24 Years				25–44 Years				45–64 Years				>65 Years			
	M	F	T	%	M	F	T	%	M	F	T	%	M	F	T	%	M	F	T	%
GERD, laryngitis, inflammation	1	2	3	3.7	2	5	7	4.5	12	18	30	14	9	19	28	10	5	7	12	9
Vocal fold nodules and hypertrophy	27	24	51	63	2	38	40	25.6	4	27	31	14	3	8	11	4	1	1	2	1
Polyps and cysts	1	2	3	3.7	2	7	9	5,8	8	16	24	11	14	11	25	9	8	3	11	8
Vocal fold paralysis	1	0	1	1.2	2	2	4	2.6	4	6	10	5	12	19	31	11	9	14	23	17
Functional disorder	7	6	13	16	7	59	66	42.3	15	49	64	30	34	51	85	29	17	20	37	27
Psychogenic dysphonia	0	0	0	0	0	1	1	0.6	0	9	9	4	0	10	10	3	0	0	0	0
Edema and Reinke's edema	3	3	6	7.4	0	8	8	5.1	2	14	16	7	5	18	23	8	1	3	4	3
Premalignant and malignant disorders	0	0	0	0	1	0	1	0.6	0	0	0	0	10	5	15	5	13	1	14	10
Laryngeal papillomatosis	0	0	0	0	0	1	1	0.6	1	1	2	1	2	1	3	1	1	2	3	2
Age-related dysphonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	10	16	12
Normal on exam	2	2	4	5	3	11	14	9	10	3	13	6	14	11	25	9	6	6	12	9
Varia (e.g., hematoma, post-intub)	0	0	0	0	3	2	5	3.2	13	7	19	9.5	20	13	33	11	1	2	3	2

M = male; F = female; T = total; GERD = gastroesophageal reflux disease.

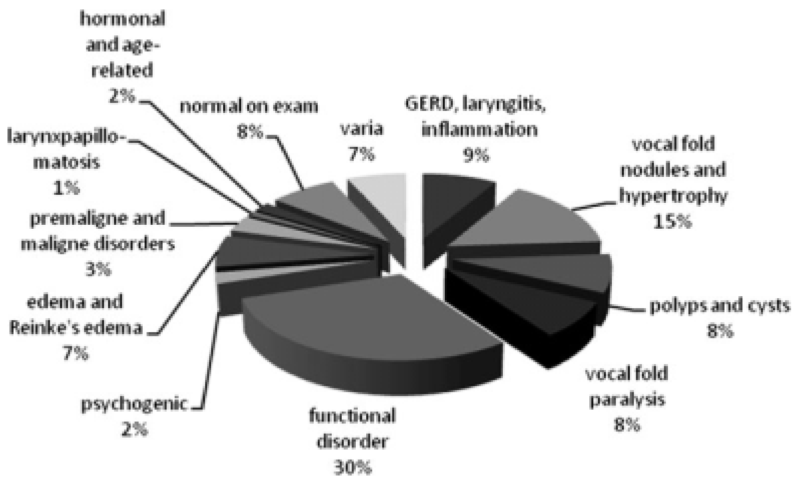

Fig. 1. Distribution of laryngeal pathology in the treatment-seeking population. GERD = gastroesophageal reflux disease.

AGE-RELATED DATA

Ages were divided into following categories: 0 to14, 15 to 24, 25 to 44, 45 to 64, and over 64 years. Ages ranged from 4 years to 90 years with a median age of 42 years. Also, younger children frequented the ENT department with voice problems, but could not be included because videostroboscopic evaluation needed to be possible for inclusion in the study. Table II contains the distribution of the age groups in the investigated population and the comparison to previous studies.[3,4] The distribution of the age groups in this study group can be seen in Figure 2. Individuals between the ages of 0 to 14 years (children) and >65 years (seniors) were least frequently seen. Voice problems were most frequently reported in the working, active groups (25–44 and 45–64 years). The group mostly visiting the ENT department was the group ages 45 to 64 years, which accounted for 34.3%, and which was consistent with the study of Herrington-Hall et al.[4] and Coyle et al.[3] A significantly larger group of adolescents (17.4%) and a significantly smaller group of seniors (14.5%) consulted our ENT department in comparison with previous studies.[3,4]

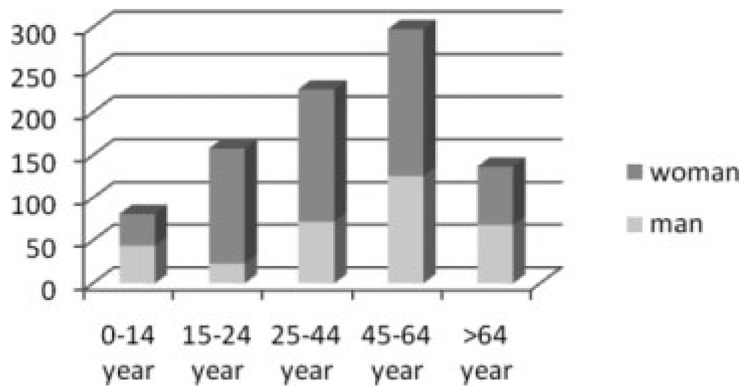

Fig. 2. Distribution according to age in the treatment-seeking population.

Table 2. Distribution of age in Herrington-Hall et al. (1988)[3], Coyle et al. (2001)[2], and the current study.

TABLE II.
Distribution of Age in Herrington-Hall et al. (1988),[3] Coyle et al. (2001),[2] and the Current Study.

	% of Total Sample		
Age Group, yr	Herrington-Hall[3]	Coyle et al.[2]	Current Study
0–14	7.4	3.5	9.0
15–24	7.4	4.1	17.3
25–44	28.2	26.4	24.9
45–64	34.5	38.9	34.3
>64	22.6	27.1	14.5

The category ‘‘children’’ contains patients up to the age of 14 years. This category accounted for 9% (n= 81) of the overall treatment-seeking population, with boys representing 51.8% and girls 48.2%. Vocal fold nodules were the most frequent diagnoses, representing 63% of the pathologies found in this age group. Analysis to gender showed no female or male predisposition; vocal fold nodules were seen in 27 boys and 24 girls (Table I). In the age group 15 to 24 years, vocal fold nodules decreased to 25.6%, and functional voice disorders increased to 42.3%. In the young adult groups (25–44 years), functional voice

disorders represented the main pathology with 30%, followed by vocal fold nodules (14%) and GERD with laryngitis (14%). In the age group 25 to 44 years, functional voice disorders remained the primary diagnosis with 29%, followed by vocal fold paralysis (11%) and GERD and laryngitis (10%). In the geriatric population, functional dysphonia was detected in 27%, followed by vocal fold paralysis (17%) and premalignant and malignant pathology (12%).
The prevalence of vocal fold paralysis increased with age. Vocal fold paralysis accounted for 5% in the young adult group, 11% in the late adult group, and 17% of the laryngeal pathology in the geriatric group. This result is consistent with previous studies.[3,4]

GENDER-RELATED DATA

Of the treatment-seeking group 63.8% (n= 563) were females and 36.2% (n= 319) were males. In the age group 15 to 24 years, up to 86% of the patients were females (see Table I). The number of female patients decreases in the following age groups (25–44 years and 45–64 years), 68.3% and 57.7%, respectively, finally leading to an equal amount of both genders visiting the clinic in the geriatric age group. The distribution of the laryngeal pathology of men and women can be seen respectively in Figure 3 and Figure 4. Psychogenic dysphonia (21 females vs. 0 males) and edema and Reinke's edema (14 males vs. 47 females; ratio M:F, 1:3.6) occurred significantly more in females than in males. Premalignant and malignant pathologies (23 males vs. 7 females; ratio M:F, 1:0.30) occurred more significantly in males. But as already stated, these numbers could not be considered as accurate because patients with these pathologies are mostly diagnosed and treated by our colleagues at the Department of Head and Neck Surgery. In this study, functional voice disorders did not occur significantly more in women. These results were consistent with the results of Coyle et al.[3] Pathologies not significantly related to gender were GERD and laryngitis, vocal fold nodules, polyps and cysts, vocal fold paralysis, functional voice disorders, laryngeal papillomatosis, and age-related pathologies.

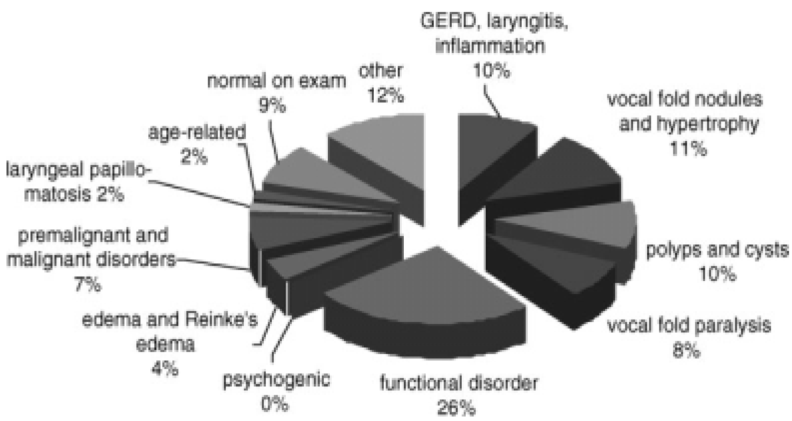

Fig. 3. Distribution of laryngeal pathology in men.
GERD = gastroesophageal reflux disease.

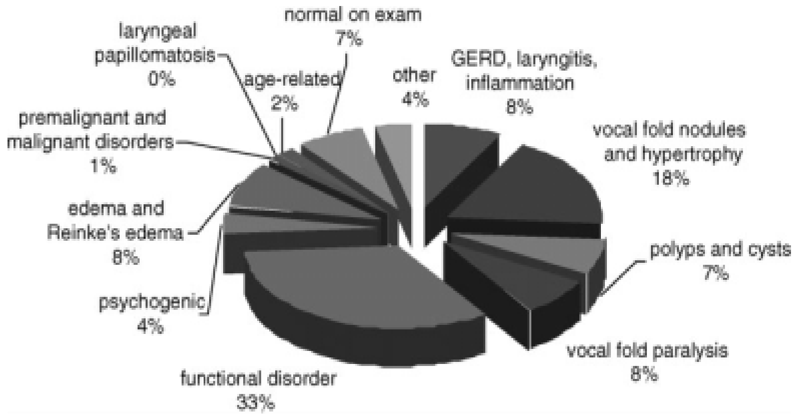

Fig. 4. Distribution of laryngeal pathology in women.
GERD = gastroesophageal reflux disease.

Occupation-Related Data

The working class groups (25–44 years and 45–64 years) compiled the largest treatment-seeking group. In this workforce population, three main groups were distinguished: professional voice users (41%), unemployed and disabled people (7%), and nonprofessional voice users (52%). Patients were labeled as professional voice users when they depend on their voice as their main working tool. Teachers compose 56% of the professional voice users, and elite vocal performers (actors, singers) account for 16%. The group of variant professional voice users (28%) consists of telemarketers, broadcasters, tour guides, and salesmen.

In the professional voice users, the three main pathologies were functional voice disorders (41%), vocal fold nodules and hypertrophy (15%), and GERD, laryngitis and inflammation (11%) (see Fig. 5). In the nonprofessional voice users, functional dysphonia only accounted for 24.3% and a shared second place for GERD and laryngitis and vocal fold paralysis each accounting for 10.6%. Vocal fold nodules only accounted for 6.2% (see Fig. 6).

Of the professional voice users, 69.5% were females and 30.5% were males. Among the teachers, 78.4% were females and 21.6% were males. In females with professional voice use, the three main pathologies were functional voice disorders (43%), vocal fold nodules (19.4%) and edema and Reinke's edema (9.7%). In their male colleagues functional voice disorders accounted for 36%, followed by GERD and laryngitis (15.9%) and polyp and cysts (14.5%).

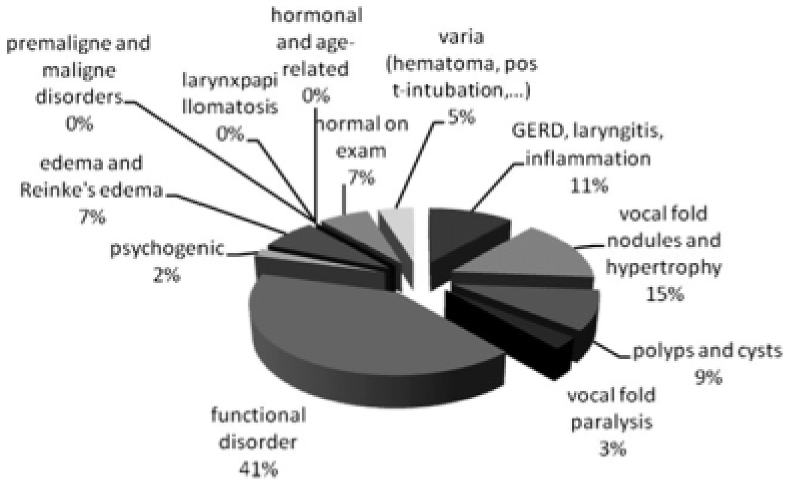

Fig. 5. Distribution of laryngeal pathology in professional voice users. GERD = gastroesophageal reflux disease.

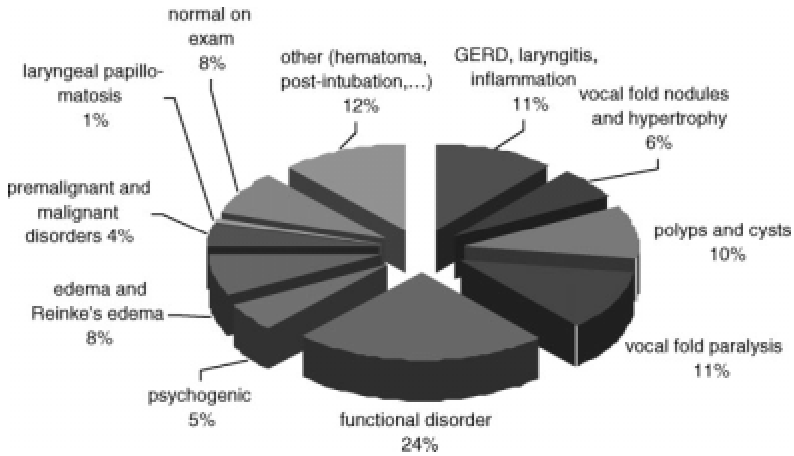

Fig. 6. Distribution of laryngeal pathology in professional nonvoice users. GERD = gastroesophageal reflux disease.

Discussion

In this study we evaluated the prevalence of laryngeal pathology and its distribution in a treatment-seeking population. Patients who presented themselves with hoarseness or dysphonia were classified according to the clinical findings, their age, gender, and professional voice use.

Distribution of Pathologies

Definitions. Organic voice disorders are disorders caused by a structural (e.g., vocal fold nodules, polyps, cysts, laryngeal papillomatosis, premalignant and malignant pathology) or neurological abnormality (e.g., vocal fold paresis and paralysis) of the larynx.

Functional voice disorders are characterized by an impaired voice sound and/or reduced vocal capacity in absence of causal structural or neurological laryngeal pathology. Functional dysphonia is believed to be caused by poorly regulated activity of the intrinsic and extrinsic laryngeal muscles, but the origin of this dysregulated laryngeal muscle activity has not been fully elucidated.

According to age. Children (0–14 years) were least frequently seen at our department compared to previous studies.[3,4] Consistency with the literature, the most prevalent pathology in this age group was vocal fold nodules.[5,6] Once puberty rushes in, vocal fold nodules remain a significant cause of dysphonia, but functional voice disorders increase significantly and peak in the adolescent group (15–24 years), representing 43% of the laryngeal pathology. Adolescence has been observed as a period of vocal instability associated with mutation, as the result of the growth of phonatory, resonance, and respiratory organs. Moreover, this age group includes young adults in the beginning of a relational, educational, or professional carrier that coexist with a lot of stress. Stress, emotion, and psychological conflict are frequently presumed to cause or exacerbate functional symptoms.[7] Above the age of 15, functional voice disorders remain the main cause of voice problems in all age groups.

GERD with laryngitis, polyps, and cysts were most frequently found in the young adults (25–44 years). GERD was diagnosed in 25.9% of the patients in the study of Coyle[3] versus 9% in the current study. A possible explanation is the growing knowledge of the impact of reflux on laryngeal complaints, which has led to a more prompt treatment with proton pump inhibitors by the general practitioners. GERD is increasingly diagnosed and prescriptions for proton pump inhibitors have increased 14-fold.[8] Possibly, only the most severe or persistent cases eventually reach the ENT department.

Edema and Reinke's edema were most frequently found in late adulthood (45–64 years). The percentage of vocal fold paralysis increases as age increases.

According to gender. Almost twice as many women consulted the ENT department in comparison to men. It has been hypothesized that women are more vulnerable for voice disorders because of structural differences in their laryngeal anatomy. Women have shorter vocal folds and produce voice at a higher fundamental frequency. Consequently, there is less tissue mass to dampen a larger amount of vibrations. At the molecular level, women have less hyaluronic acid in the superficial layer of the lamina propria. Hyaluronic acid plays an important role in wound repair. Lower amounts of hyaluronic acid in the female vocal fold perhaps indicates that there is less protective tissue dampening and, therefore, potentially a reduced wound-healing response.[7]

FUNCTIONAL VOICE DISORDERS

This investigation illustrates that one fourth to one third of the overall treatment seeking adolescents, adults, and seniors struggle with a functional voice disorder. This number rises to 41% in the subgroup of professional voice users. Explanations for this high degree of functional voice disorder can be listed as followed. First, there has been a change in nomenclature, which may result in confusion or misinterpretation when comparing results. Over the years, functional voice disorders received many different diagnostic labels: hyperfunctional, psychogenic, tension-fatigue, muscle misuse, or MTD. At our department, we prefer the term MTD. The latter has become more recently the preferred diagnostic label to describe functional voice disorders presumably related to dysregulated or imbalanced laryngeal and paralaryngeal muscle activity.[9,10] The theory that MTD is a multifactorial entity has long been recognized.[1] Second, there is the implementation of videostroboscopy as a diagnostic tool. There are two main features of MTD seen on videostroboscopy: contraction of supraglottic structures and a posterior open chink. These are both the result of an excessive tension in the (para)laryngeal musculature. Due to this increased tension, the distance between hyoid bone and cricoid cartilage is shortened (elevation of the larynx), the inclination between cricoid and thyroid cartilage is altered, side-to-side or anterior-posterior supraglottic contractions occur, and false vocal folds are pressed together. In the past, MTD has been divided into several types according to the videostroboscopic image. However, international classification of MTD has not yet gained acceptance. Third, the high number of functional voice disorders may be the result of a growing awareness of importance of voice quality on daily functioning. MTD is a diagnosis one should be focusing on in the future, especially in professional voice users with high vocal demands.

THE RELATION BETWEEN ORGANIC AND FUNCTIONAL VOICE DISORDERS

There is no universally accepted classification system for voice problems, apart from two major classes of voice disorders related to etiology: organic and functional. However, this dichotomy is somewhat problematic because it has been confirmed that prolonged phonation under increased laryngeal muscle tension levels (e.g., primary MTD) may lead to mucosal changes, including vocal fold nodules, polypoidal degeneration, or chronic laryngitis.[1] Computer modeling of vibration of the vocal folds indicates the presence of high mechanical stress at the midpoint of the vocal folds, when vibrating in a mode other than normal phonation.[11] On the other hand, minor mucosal changes can lead to glottal insufficiency due to the mass effect. In an attempt to compensate for the mass effect, tension in the laryngeal musculature increases, which enhances the glottal insufficiency and results in a secondary MTD.[1]

The close relationship between these two types of voice disorders may also explain why some patients with the same laryngeal pathology perform worse on the additional voice tests (e.g., dysphonia severity index, perceptive voice analysis) than others, or why voice overuse, abuse, or a temporary organic event (e.g., acute laryngitis) results in dysphonia in some and not in others. At this moment, we are not able to give a complete physiological explanation for it.

VOICE PROBLEMS AND PROFESSIONAL VOICE USERS

Communication has acquired a growing importance in the labor market, particularly for those professionals that depend on their voice as their main working tool. For these professionals, dysphonia can result in absence from work, reduced productivity, and even the need to change profession.[12] In this study, functional voice disorders in professional voice users were the main cause of dysphonia (41%), followed by vocal fold nodules (15%), and GERD and laryngitis (11%). In previous studies, the percentages of functional voice disorders in professional voice users ranged from 4% to 82.3%.[12,13] Explanations of the wide diversity of these numbers are: 1) the diagnosis of functional dysphonia is too often a subjective one due to different nomenclature, 2) the implementation of videostroboscopy increased diagnostic sensitivity, and 3) there has been a growing awareness concerning the problem of functional dysphonia.

Up to one fifth of all active individuals visiting the ENT department with dysphonia were teachers with a distinct female dominance (78.4% females and 21.6% males). They were the largest group among the professional voice users. Teaching has been identified as a profession with increased risk for dysphonia, in females more than males.[3,12,14–17] Functional voice disorder, vocal fold nodules and cysts, and polyps were the primary diagnoses in our study. Compared to the nonprofessional voice users, they suffered from almost twice as many functional voice disorders and vocal fold nodules, probably due to the cumulative effect of vocal use and misuse.

The abundant number of teachers frequenting the ENT underlines the need of further investigation to identify specific risk factors to identify the subgroup of teachers at risk and adapt treatment to the specific needs in this population. Special attention should go to prevention and vocal hygiene, which should be the first step of treatment of dysphonia before other treatments, such as medication, speech therapy, or surgery are considered. Dysphonia, especially in professional voice users, demands a multidisciplinary approach.

CONCLUSION

The most frequently detected pathologies in this treatment-seeking population are functional voice disorders (30%), followed by vocal fold nodules (15%), and pharyngolaryngeal reflux with laryngitis (9%). In children, vocal fold nodules accounted for 63% of the pathology, with no female or male predisposition. Functional voice disorders are the main cause of dysphonia in all age groups, starting from the age of 15 years, and accounts for 43%, 30%, 29% and 27% in the respective age groups 15 to 24 years, 25 to 44 years, 45 to 64 years, and >64 years. Functional dysphonia has received many different diagnostic labels over the years. The term ‘‘muscle tension dysphonia’’ is currently the most appropriate term, because functional voice disorders are presumably related to dysregulated or imbalanced laryngeal and paralaryngeal muscle activity. The abundant percentage of functional voice disorders in this cohort, underlines the importance of further investigation towards etiology, diagnostic, and therapeutic management of this type of dysphonia, especially in professional voice users. Vocal fold paralysis increases with increasing age: 5% in the young adult group (25–44 years), 11% in the late adult group (45–64 years), and 17% in the geriatric group (>64 years). Laryngeal pathologies with female predisposition are edema and Reinke’s edema and psychogenic dysphonia. Laryngeal pathologies with male predisposition are premalignant and malignant pathologies. Professional voice users accounted for 41% of the workforce population, with teachers being the main subgroup. Female professional voice users frequented the ENT department more than twice as much as their male colleagues (69.5% vs. 30.5%). Functional voice disorders accounted for 41% of the laryngeal pathology in this group.

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VOICE DISORDERS IN PROFESSIONAL VOICE USERS

VOICE DISORDERS IN TEACHERS: OCCUPATIONAL RISK FACTORS AND PSYCHO-EMOTIONAL FACTORS

VOICE DISORDERS IN TEACHERS: OCCUPATIONAL RISK FACTORS AND PSYCHO-EMOTIONAL FACTORS

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ABSTRACT

Background. Teaching is a high-risk occupation for developing voice disorders. The purpose of this study was to investigate previously described vocal risk factors as well as to identify new risk factors related to both the personal life of the teacher (fluid intake, voice-demanding activities, family history of voice disorders, and children at home) and to environmental factors (temperature changes, chalk use, presence of curtains, carpet, or air-conditioning, acoustics in the classroom, and noise in and outside the classroom).

Methods. The study group comprised 994 teachers (response rate 46.6%). All participants completed a questionnaire. Chi-square tests and logistic regression analyses were performed.

Results. A total of 51.2% (509/994) of the teachers presented with voice disorders. Women reported more voice disorders compared to men (56.4% versus 40.4%, $P < 0.001$). Vocal risk factors were a family history of voice disorders ($P = 0.005$), temperature changes in the classroom ($P = 0.017$), the number of pupils per classroom ($P = 0.001$), and noise level inside the classroom ($P = 0.001$). Teachers with voice disorders presented a higher level of psychological distress ($P < 0.001$) compared to teachers without voice disorders.

Conclusion. Voice disorders are frequent among teachers, especially in female teachers. The results of this study emphasize that multiple factors are involved in the development of voice disorders.

Key words: Occupational disease, psychological distress, teachers, vocal risk factor, voice disorders

Introduction

Vocal dysfunction is a major problem for teachers. They are at increased risk for developing a voice disorder due to prolonged and intense occupational voice use [1–4]. The prevalence of voice disorders in these professional voice users ranges from 11% to 81% [5–8]. These voice disorders may lead to a lower quality of teaching and a serious personal and emotional burden for the teacher [9]. Teachers feel limited in their current job performance and in their future job or career options [5]. Furthermore, teachers represent a significant part of the population who seek medical help and therapy for voice disorders [2,4,10,11]. Vocal dysfunction may lead to extensive periods of sick leave, which implies significant financial costs.

The current literature on vocal problems among teachers lists numerous hypotheses about the causes of vocal dysfunction. A frequently reported causal factor is vocal abuse and misuse due to the vocal demands of teaching [11,12]. Other factors include years of teaching[13,14], deterioration of general health and allergy [7], environmental factors such as dry air, dust, classroom acoustics, excessive background noise [12,15,16], and also psycho-emotional factors and stress [1,7,13]. Unfortunately, the findings of these studies are often inconsistent. Furthermore, previous studies do not include the impact of after-school voice-demanding activities (number and age of children at home, hobbies such as singing, being a trainer at a sport club, etc.).

The purpose of this study was to investigate previously described vocal risk factors as well as to identify new risk factors related to both the personal life of the teacher (fluid intake, voice-demanding activities, family history of voice disorders, and children at home) and environmental factors (temperature changes, chalk use, presence of curtains, carpet, and air-conditioning, acoustics in the classroom, and noise in and outside the classroom).

Methods

Description of the questionnaire

The questionnaire (Appendix 1) was based on existing questionnaires in the literature[1,2,5,7,8,12,13], the investigators ’ clinical experience, and suggestions from teachers. A brief description of the background and the aim of the study was included with the questionnaire. The main question was: ‘ Have you ever had a voice disorder during your profession as a teacher? ’ (question 22). A voice disorder was defined as any time the voice did not perform or sound as it usually does and interfered with communication [2]. The answer was: ‘yes’ or ‘no’. This question reflects the career prevalence rate of voice disorders among teachers, and all additional analysis was based upon this career prevalence.

The questions regarding personal and work-related characteristics mainly involved yes/no questions. A yes/no question was also used to investigate if the subject had a voice-demanding hobby (question 8). If the answer was yes, subjects were asked to specify their hobby and to indicate how many hours a week they practiced this hobby. A hobby was considered voice-demanding when the teacher was a member of a choir, a theatre company, or a youth movement, or if he/she was a sport coach or supporter of a sport club. Questions concerning the use of nicotine, alcohol, caffeine consumption, daily fluid intake (questions 4 – 7) and years of teaching, hours of teaching per week, number of students per classroom (questions 19 – 21) were divided into quantitative categories. A visual analogue scale (VAS) was used to investigate the potential effect of gastroesophageal reflux [17]. This scale measured 10 cm with on the left side ‘ no complaints ’ and on the right side ‘ extreme complaints ’ . The subjects were asked to place a mark (a vertical line or a cross) on the line to note the degree to which they experienced the complaint. Yes or no questions were also used to investigate the environmental risk factors: do you use chalk, is there carpet or air-conditioning in the classroom, are there curtains, are there frequent temperature changes in the classroom (questions 30, 32 – 35, respectively). A visual analogue scale was used to score the level of noise outside the classroom (due to traffic and nearby classrooms) and inside the classroom (due to murmuring of the pupils or tools in the classroom) and to score the acoustics in the classroom (questions 26 – 28).

The Depression Anxiety Stress Scale 42 (DASS 42) was used to evaluate the psycho-emotional impact [18]. Eight questions related to stress were used in this survey (questions 36 – 43). The subjects were asked to read each statement and to mark a number from 0 to 3 which indicated to what extent the statement applied to them over the past week. The rating scale was as follows: 0: did not apply to me at all, 1: applied to me to some degree, or some of the time, 2: applied to me to a considerable degree or a good part of time, 3: applied to me very much or most of the time. The questions evaluating the psycho-emotional distress referred to how the teacher had felt during the last week, regardless whether or not the teacher had suffered from a voice disorder during this week.

SAMPLING PROCEDURES

The questionnaires were distributed between October 2008 and June 2009. A list obtained from the website of the State Office of Education was used to select at random schools located in the provinces of Flanders, the northern section of Belgium. All levels and types of schools were included in the survey, such as kindergarten schools, elementary schools, and high schools. In total, 42 schools were included in the study. The initial contact with each school was made by calling the principal. The purpose of the study was briefly explained, and the principal was asked if his school wanted to participate in the survey. If so, a questionnaire was made for each teacher and distributed to all the teachers by the principal. It was the teachers' personal choice to complete the survey or not. The questionnaires were then collected by the investigators. In total, 2133 questionnaires were distributed, and 994 were returned complete and used for the analysis. The response rate was 46.6% (994/2133). Based on the Belgian Statistics of Education, the demographic distribution of the participants appeared to be representative for the entire population of Belgian teachers.

STATISTICAL ANALYSIS

All data were evaluated using the statistical program SPSS version 18 (SPSS Inc., Chicago, IL). The relationships between voice disorders and various factors were assessed. All analysis was based upon the career prevalence rates. The Fisher exact test was used to examine differences between teachers with and without voice disorders with respect to demographic characteristics, living habits, teaching characteristics, environmental factors, and psycho-emotional factors. In all statistical tests, two-tailed tests of significance and confidence intervals (CI) were based on the level of $P < 0.05$. Odds ratios (ORs) (adjusted for age and gender) and 95% confidence intervals (CIs) were calculated using multivariate logistic regression. The teachers without voice disorders were used as the reference group. An OR of 1.0 means no association exists between the risk factor and the voice disorder. An OR greater than 1.0 means there is a positive correlation with the investigated risk factor, and an OR of less than 1.0 means there is a negative correlation between the risk factor and the voice disorder.

RESULTS

PROFILE OF THE PARTICIPANTS

In total, 994 teachers completed the questionnaire. They consisted of 67.4% (n = 670/994) females and 32.6% (n = 324/994) males. The teachers were aged between 21 and 65 years (mean age 38.9 years). The greatest number of the teachers worked at the secondary school level (69.6%, n = 690/994). Teachers working in the primary schools accounted for 23.5% (233/994), and kindergarten teachers represented 6.9% (68/994). The two largest groups from this survey had been teaching for 1 – 5 years (25.6%, 254/994) and for 25 – 30 years (19.8%, 197/994). More than half of the teachers (n = 509/994, 51.2%) reported voice disorders at some point during their career. The career prevalence was significantly higher in female teachers compared to their male colleagues (56.4% versus 40.4%, $P < 0.001$). Figure 1 represents the age distribution in decades for male and for female teachers with voice disorders. Voice disorders were significantly more present with age in male teachers (P = 0.010), whereas in female teachers the prevalence of voice disorders did not change significantly across the age span (P = 0.348).

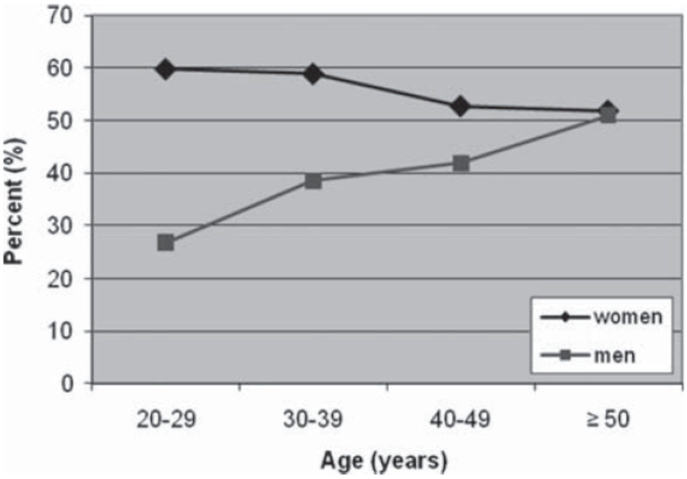

Figure 1. Career prevalence rates of a voice disorder according to gender. A voice disorder was defined as any time the voice does not work, perform, or sound as it normally should, so that it interferes with communication (2).

DEMOGRAPHIC CHARACTERISTICS, LIFE-STYLE, AND GENERAL HEALTH

Table I displays the results of the relation between the occurrence of voice disorders and demographic features, life-style, and allergy, divided by sex. Female teachers showed an unexpected result: non-smoking female teachers reported significantly more voice disorder than their smoking colleagues (59.0% versus 38.0%, P < 0.001). A family history of vocal problems was significantly more present (P = 0.032) in female teachers with voice disorders in comparison with female teachers without voice disorders. Alcohol and caffeine consumption, allergy, and daily fluid intake showed no significant difference between teachers with and without voice disorders. Teachers were also asked to specify if they practiced any voice-demanding hobbies. The voice-demanding hobby was divided into five categories: being member of a choir, a theatre company, or a youth movement, or being a sports coach or a supporter of a sport club. Statistical analysis did not reveal any correlation between the practice or the type of any of these voice-demanding hobbies and the presence of a voice disorder.

Teachers were also asked if they had children at home and what the age of their children was, but these factors did not significantly correlate to the occurrence of voice disorders. When teachers were asked about their personal perception of their voice quality, only 0.2% evaluated their voice as ‘very bad’, 3.5% as ‘bad’, 31.3% as ‘average ’, 51.5% as ‘good’, and 13.4% as ‘excellent ’.

Table I. Cross-tabulations of the relation between demographic features, life-style, and allergy and voice disorders

	Men			Women		
	Voice disorder			Voice disorder		
Factor	No	Yes	*P*	No	Yes	*P*
Age						
20–30 y	60 (73.2%)	22 (26.8%)	0.010*	80 (40.2%)	119 (59.8%)	0.348
30–40 y	32 (61.5%)	20 (38.5%)		79 (41.1%)	113 (58.9%)	
40–50 y	50 (58.1%)	36 (41.9%)		79 (47.3%)	88 (52.7%)	
50–60 y	51 (49.0%)	53 (53.0%)		54 (48.2%)	58 (51.8%)	
Smoking						
no	170 (59.0%)	118 (41.0%)	0.719	242 (41.0%)	348 (59.0%)	<0.001*
yes	23 (63.9%)	13 (36.1%)		49 (62.0%)	30 (38.0%)	
Alcohol consumption						
none	11 (47.8%)	12 (52.2%)	0.473	27 (36.0%)	48 (64.0%)	0.531
1–6/week	127 (59.6%)	86 (40.4%)		229 (44.3%)	288 (55.7%)	
1–2/day	38 (59.4%)	26 (40.6%)		24 (43.6%)	31 (56.4%)	
>2 /dag	17 (70.8%)	7 (29.2%)		11 (50.0%)	11 (50.0%)	
Caffeine consumption						
none	8 (72.7%)	3 (27.3%)	0.532	13 (33.3%)	26 (66.7%)	0.346
1–2/day	81 (61.4%)	51 (38.6%)		141 (42.0%)	195 (58.0%)	
2–4/day	71 (60.2%)	47 (39.8%)		95 (46.1%)	111 (53.9%)	
>4 /day	33 (52.4%)	30 (47.6%)		42 (48.3%)	45 (51.7%)	
Allergy						
no	152 (61.8%)	94 (38.2%)	0.144	221 (44.1%)	280 (55.9%)	0.719
yes	40 (51.9%)	37 (48.1%)		71 (42.3%)	97 (57.7%)	
Voice-demanding hobby						
no	144 (57.6%)	106 (42.4%)	0.530	264 (45.4%)	317 (54.6%)	0.146
yes	49 (66.2%)	25 (33.8%)		28 (31.5%)	61 (68.5%)	
Children at home						
no	68 (%)	44 (%)	0.632	90 (39.3%)	139 (60.7%)	0.149
yes	124 (%)	87 (%)		153 (39.0%)	239 (61.0%)	
Family history of voice problems						
no	186 (60.6%)	121 (39.4%)	0.074	276 (44.8%)	340 (55.2%)	0.032*
yes	6 (37.5%)	10 (62.5%)		16 (29.6%)	38 (70.4%)	
Fluid intake per day						
0–2 glasses	7 (77.8%)	2 (22.2%)	0.468	17 (40.5%)	25 (59.5%)	0.946
3–5 glasses	56 (56.0%)	44 (44.0%)		111 (44.4%)	139 (55.6%)	
6–8 glasses	75 (57.7%)	55 (42.3%)		119 (42.8%)	159 (57.2%)	
>8 glasses	54 (64.3%)	30 (35.7%)		45 (45.0%)	55 (55.0%)	

The Fisher exact test was used in the statistical analysis of the data.
*$P < 0.05$.

TEACHING-RELATED AND ENVIRONMENTAL RISK FACTORS

The relation between teaching-related factors (questions 17 – 22) and the occurrence of voice disorders was assessed (Table II). As shown also in Figure 1, voice disorders were more frequently reported by male teachers with increasing years of teaching, whereas for female teachers voice disorders are approximately equally distributed across the years of teaching. The survey also showed that grade level was of no influence for male teachers. However, in kindergarten there were almost no male teachers, which may have biased the results. A significantly higher rate of female teachers in primary school reported voice disorders in comparison with their female colleagues in kindergarten and secondary school (*P* = 0.030). The number of lecture hours per week was not a risk factor for either gender.

This was in contrast with the number of pupils per classroom, which was a risk factor for male as well as female teachers (*P* = 0.047 for men and *P* = 0.002 for women).

Table II. Cross-tabulations of the relation between teaching-related factors and voice disorders

	Men			Women		
	Voice complaints			Voice complaints		
Factor	No (*n*, %)	Yes (*n*, %)	*P*	No (*n*, %)	Yes (*n*, %)	*P*
Grade level						
Kindergarten	3 (75%)	1 (25%)	0.575	29 (45.3%)	35 (54.7%)	0.030*
Primary	44 (63.7%)	25 (36.3%)		57 (34.8%)	107 (65.2%)	
Secondary	146 (58.2%)	105 (41.8%)		205 (46.7%)	234 (53.3%)	
Years of teaching						
1–5 years	65 (73.9%)	23 (26.1%)	0.018*	68 (41.0%)	98 (59.0%)	0.944
6–10 years	29 (64.4%)	16 (35.6%)		57 (41.6%)	80 (58.4%)	
11–15 years	16 (53.3%)	14 (46.6%)		41 (45.6%)	50 (54.4%)	
16–20 years	9 (47.4%)	10 (52.6%)		32 (48.5%)	34 (51.5%)	
21–25 years	23 (60.5%)	15 (39.5%)		33 (45.2%)	40 (54.8%)	
> 26 years	51 (49.5%)	52 (50.5%)		61 (44.5%)	76 (55.4%)	
Lecture hours per week						
< 15 hours	18 (64.2%)	10 (35.8%)	0.116	56 (46.3%)	65 (53.7%)	0.081
16–20 hours	47 (61.8%)	29 (38.2%)		73 (52.1%)	67 (47.9%)	
21–25 hours	86 (53.7%)	74 (46.3%)		127 (40.1%)	190 (59.9%)	
> 25 hours	41 (69.5%)	18 (30.5%)		36 (39.5%)	55 (60.4%)	
Number of pupils per classroom						
< 15	49 (69.0%)	22 (31.0%)	0.047*	60 (55.0%)	49 (45%)	0.002*
15–20	73 (61.9%)	45 (38.1%)		112 (46.6%)	128 (53.4%)	
21–25	69 (51.9%)	64 (48.1%)		117 (37.0%)	199 (63.0%)	

The Fisher exact test was used in the statistical analysis of the data.
*$P < 0.05$.

Table III shows the results of the environmental factors question 30 to 35. A significant relation was found between the occurrence of voice disorders and frequent temperature changes in the classroom (*P*= 0.018 for men and *P*= 0.041 for women). Temperature changes in the classroom were based on the teachers' own perception. In female teachers, frequent temperature changes were shown to be significantly related to a higher prevalence of voice disorders. In men, a constant classroom temperature was shown to correlate to a lower occurrence of voice disorders. Teachers were not more likely to report voice disorders in the presence of chalk, carpets, curtains, or air-conditioning.

Table III. Cross-tabulations of the relation between environmental factors and voice disorders

	Men			Women		
	Voice complaints			Voice complaints		
Factor	No	Yes	P	No	Yes	P
Use of chalk						
no	43 (62.3%)	26 (37.7%)	0.679	53 (48.2%)	57 (51.8%)	0.294
yes	150 (58.8%)	105 (41.2%)		238 (42.7%)	320 (57.3%)	
Carpet in classroom						
no	181 (58.8%)	127 (41.2%)	0.267	263 (43.3%)	344 (56.7%)	0.691
yes	12 (75.0%)	4 (25.0%)		29 (46.0%)	34 (54.0%)	
Curtains in classroom						
no	67 (59.3%)	46 (40.7%)	0.941	102 (46.6%)	117 (53.4%)	0.282
yes	126 (59.7%)	85 (40.3%)		190 (42.1%)	261 (57.9%)	
Air-conditioning						
no	188 (59.3%)	129 (40.7%)	0.706	288 (43.7%)	371 (56.3%)	0.764
yes	5 (71.4%)	2 (28.6%)		4 (36.4%)	7 (63.6%)	
Temperature changes						
no	135 (64.6%)	74 (35.4%)	0.018*	207 (46.4%)	239 (53.6%)	0.041*
yes	58 (50.4%)	57 (49.6%)		85 (38.1%)	138 (61.9%)	

The Fisher exact test was used in the statistical analysis of the data.
$*P < 0.05$.

RISK FACTORS OF VOICE DISORDERS

The results of the multivariate logistic regression on the risk factors for the teachers with and without voice disorders are reported in Table IV. The regression analysis was corrected for gender and age. The risk of developing a voice disorder was almost twice as high for female teachers in comparison to their male colleagues (OR 1.95, $P < 0.001$). The occurrence of voice disorders was significantly higher in non-smoking teachers (OR 0.462, $P= 0.001$). When a family history of voice disorders was present, there was an increased risk for the development of a voice disorder (OR 2.22, $P = 0.005$). Allergy and gastro-esophageal reflux disease (GERD) did not contribute to an increased risk for voice disorders. Regression analysis showed that the number of pupils per classroom remained a significant risk factor after correcting for the other variables (OR 2.01, $P= 0.001$). Grade level, years of teaching, and number of lecture hours per week were not found to be risk factors for the development of voice disorders.

Concerning the impact of environmental factors, the noise from inside the classroom (e.g. noise from students, ventilation, and technical equipment) (OR 1.13, $P= 0.001$) and frequent temperature changes in the same classrooms (OR 1.43, $P = 0.017$) showed a higher risk for the occurrence of voice disorders. There was no association between the risk of voice disorder and daily fluid intake, use of chalk, or acoustics in the classroom.

Table IV. Risk factors of voice disorders associated with demographic personal, teaching-related and environmental factors

Factor	Sig.	OR	95% CI for OR Lower	Upper
Personal characteristics				
Age	0.630	0.994	0.968	1.020
Gender	< 0.001*	1.947	1.424	2.663
Smoking	0.001*	0.462	0.299	0.716
Allergy	0.429	1.135	0.829	1.552
Family history of voice disorder	0.005*	2.218	1.265	3.890
Daily fluid intake	0.810	0.920	0.464	1.821
Gastro-esophageal reflux	0.136	1.063	0.981	1.153
Teaching-related factors				
Grade level taught	0.224	1.483	0.786	2.796
Years of teaching	0.648	1.270	0.455	3.550
Number of lecture hours per week	0.996	1.001	0.585	1.712
Number of pupils per classroom	0.001*	2.005	1.349	2.980
Environmental factors				
Noise from outside the classroom	0.200	0.956	0.893	1.024
Noise from inside the classroom	0.001*	1.125	1.047	1.209
Acoustics in the classroom	0.337	1.033	0.967	1.104
Use of chalk	0.216	1.284	0.864	1.910
Temperature changes in the classroom	0.017*	1.425	1.066	1.905

Multivariate logistic regression models were used to calculate adjusted odds ratios (ORs) and 95% confidence intervals (CI). Odds ratios were adjusted for age and gender.
Statistical level was* $P < 0.05$.

PSYCHO-EMOTIONAL FACTORS

Table V shows that there was a significant relation between the psycho-emotional factors (questions 36 – 43) and the occurrence of voice disorders. Teachers with voice disorders scored significantly higher on the statements: 'I was upset about small things' ($P < 0.001$ for men and $P = 0.014$ for women), 'I was quite nervous' ($P < 0.001$ for men and $P = 0.012$ for women), 'I found it difficult to be tolerant when I got disturbed' ($P < 0.001$ for men, $P = 0.031$ for women), 'I was very tense' ($P < 0.001$ for men, $P = 0.071$ for women), 'I was very rushed' ($P < 0.001$ for men, $P = 0.034$ for women), 'I found it difficult to relax' ($P < 0.001$ for men and $P = 0.002$ for women), and 'I found it difficult to calm down when something had upset me' ($P < 0.001$ for men, $P = 0.005$ for women).

Table V. The occurrence of psycho-emotional factors in relation to voice disorders

	Men			Women		
	Voice Disorder			Voice Disorder		
Factor: during the last week	No	Yes	*P*	No	Yes	*P*
I was upset about small things						
not at all	143	66	<0.001***	150	154	0.014*
1 day/week	42	46		99	154	
>1 day/week	7	16		38	61	
7 days/week	1	2		5	9	
I found it difficult to relax						
not at all	122	48	<0.001***	90	85	0.002**
1 day/week	50	44		93	114	
>1 day/week	18	29		90	135	
7 days/week	3	10		19	44	
I was quite nervous						
not at all	102	34	<0.001***	85	84	0.012*
1 day/week	72	63		118	146	
>1 day/week	17	24		71	118	
7 days/week	2	10		18	30	
I was impatient when there was a delay						
not at all	86	39	0.001**	108	122	0.072
1 day/week	70	48		104	131	
>1 day/week	33	38		68	101	
7 days/week	3	6		12	24	
I found it difficult to calm down when something had upset me						
not at all	141	60	<0.001***	148	149	0.005**
1 day/week	41	51		104	147	
>1 day/week	10	17		29	73	
7 days/week	1	3		11	9	
I found it difficult to be tolerant when I got disturbed						
not at all	105	36	<0.001***	141	155	0.031*
1 day/week	73	64		105	140	
>1 day/week	14	24		38	69	
7 days/week	1	7		8	13	
I was very tense						
not at all	125	64	0.001**	122	131	0.071*
1 day/week	56	40		105	150	
>1 day/week	9	23		52	73	
7 days/week	3	4		13	24	
I was very rushed						
not at all	105	41	<0.001***	90	88	0.034*
1 day/week	69	60		116	159	
>1 day/week	15	22		72	105	
7 days/week	4	8		14	25	

*$P<0.05$, **$P<0.01$, ***$P<0.001$.

DISCUSSION

RISK FACTORS FOR VOICE DISORDERS IN TEACHERS

This survey was conducted in order to identify vocal risk factors in teachers. The results of this study indicate that more than half of the teachers (51.2%) experienced a voice disorder during their career, suggesting that teaching is a profession with very high vocal demands. Roy et al. [3] compared a population of teachers with non-teachers and reported a lifetime prevalence of voice disorders of 57.7% for teachers versus 28.8% for non-teachers. Smith et al. [4] compared teachers with individuals working in other occupations (administrators, technicians, etc.). The prevalence of ever having a voice disorders was significantly higher in the teacher population versus the control group (32% versus 1%). The career prevalence of the current study was consistent with previous research by Thibeault et al. [14] who reported a career prevalence of voice disorders of 58% in teachers. The study of de Jong et al. [19] reported a career prevalence of voice disorders of 46.1% in male teachers and 61% in female teachers. One has to keep in mind that the prevalence of voice disorders in teachers ranges widely according to use of point, career, or lifetime prevalence.

Career prevalence of voice disorders was also shown to be significantly higher for female teachers compared to their male colleagues (38% versus 13.2%). This has been consistently reported in previous studies [1,3,4,19,20]. It has been hypothesized that these differences between genders are due to physiological reasons. Women have shorter vocal folds and produce voice at a higher fundamental frequency. Consequently, there is less tissue mass to dampen a larger amount of vibrations. At the molecular level, women have less hyaluronic acid (HA) in the superficial layer of the lamina propria. Hyaluronic acid plays an important role in wound repair. A lower amount of HA indicates that there is less protective tissue dampening and, therefore, a reduced wound-healing response [3,21 – 23].

A family history of voice disorders was also positively correlated with voice disorders in teachers. The probability of developing a voice disorder was increased by a factor of two when a positive family history of voice disorders was present. This was in concordance with the study of Roy et al. [3]. These studies indicate that genetics may predispose certain individuals to voice disorders when combined with a vocally demanding occupation such as teaching. This also suggests that questions about a family history of voice disorders should be included in voice screening protocols in the future. Familial voice characteristics are most likely a combination of genetic and environmental influences [3]. Results from the Simberg et al. study [24] showed that dysphonia was explained in 35% by genetic factors and in 65% by environmental factors. The relation between family history and voice disorders is an enticing finding worthy of further study.

The number of pupils per classroom was a significant risk factor (OR 2.01) for both male and female teachers in this study, which was consistent with the results of Kooijman et al. [13]. The probability of developing a voice disorder when teaching a larger group of pupils is increased by a factor of two. This is in accordance with the assumption that teaching of a larger group requires more vocal effort. Larger groups of pupils often generate higher levels of background noise. Therefore more vocal effort is demanded to overcome the background noise and to maintain the attention of the larger group. Intensive voice use increases mechanical load on the mucous membranes [25].

Teachers working in classrooms with frequent temperature changes were at significantly higher risk of developing a voice disorder. Temperature changes may induce a change in the relative humidity of the inhaled air. Hemler et al. [26] showed that the human voice is very sensitive to decreases in humidity of the air and that, even after a short exposure to dry air, a significant increase in perturbation measures was found. Water content of tissue and mucus of the vocal folds changes with variations in humidity of inhaled air, and consequently changes in viscosity will occur. Thus, variation in the humidity of inhaled air due to temperature changes in the classroom may affect the vibratory pattern through changes in viscosity and mucus conditions [26]. Another risk factor for voice disorders was subjectively rated noise within the classroom (caused by students, ventilation, and technical equipment). This finding is in concordance with results from the studies of Åhlander et al. [27] and Pekkarinen [28]. Abundant background noise may lead to a decrease in intelligibility of the speech. This decrease may result in repetitions and also in increased voice intensity by the speaker to facilitate the understanding of the message [15]. Moreover, in the classroom the students are at a distance of 1–7 meters from the teacher, so a teacher needs to speak more loudly to bridge the distance between the students and himself. As teachers often sit or stand several meters away from the students, background noise may set too high demands on their voices. It is not possible to conclude from these results that abundant background noise and frequent temperature changes may cause voice disorders, but they suggest that teachers with voice disorders may be more sensitive to these factors.

Factors not significantly associated with voice disorders in teachers

The analysis of this study showed that alcohol and caffeine consumption and daily fluid intake were not significantly correlated with voice disorders in teachers (Table IV). This study also showed an unexpected result. Smoking was inversely proportional to voice disorders. This could be due to the fact that only current smoking was taken into account. A substantial number of women could have recently quit smoking, which could have skewed the result of the effect of smoking. It is also plausible that women with voice disorders were more reluctant to admit that they were smokers or that smokers could not distinguish voice-related problems from those that might be related to the smoking (i.e. irritation of the upper airway). Note, however, that previous research on this topic also demonstrated that smoking does not seem to be a vocal risk factor [20,28–30].

It is generally accepted that GERD can play an important role in the development of voice disorders [31]. In the current study, GERD was not identified as a risk factor for voice disorders. This is in contrast to the study of Van Houtte et al. [32], which documented that GERD was the third most common diagnosis among professional voice users with voice disorders. However, the results in the current study were based on a subjective perception of GERD and not on videostroboscopy. Teachers with allergy were not more prone to develop voice disorders. The negative result in this study could be due to the fact that it was clearly stated in the questionnaire that it had to be a proven allergy and thereby excluding subjects with an allergy who had not been tested (yet). However, allergies have been considered to be a risk factor contributing to voice disorders in previous studies [3,33].

This study also investigated whether or not a voice-demanding hobby and age and number of children at home could be identified as vocal risk factors. These factors could contribute to an additional voice load for the teacher after school-hours. None of these factors proved to be of any impact. Further analysis with multivariate logistic regression could not confirm any correlation between the years of teaching, grade level taught, or number of lecture hours per week as a risk factor for voice disorders. This was in concordance with previous research [6,12,13,29].

PSYCHO-EMOTIONAL FACTORS

Previous research showed that stress and psychological factors may play a contributing role in voice disorders [13,20,30]. In this study, teachers with voice disorders presented higher levels of psychological distress in all surveyed items. However, note that cross-sectional data does not allow distinction between causes and consequences. The results of the current study support the hypothesis of the multifactorial nature of voice disorders and stress the importance of a thorough approach to address voice disorders in professional voice users. The higher stress levels reported by teachers with voice disorders suggest that a situation may exist that is more complex than purely the mechanical failure of extrinsic and intrinsic laryngeal muscles. Internal factors such as general condition, psychological factors, and personality traits may influence the ability of the voice to withstand the demands of the profession [17]. Early research [34] connected stress with objective parameters of strained vibratory features such as raised fundamental frequency (F_0) and sound level. The phonation pattern is changed by increases in stress with a subsequent increase in voice load [17]. Clinical studies have also proven that voice disorders may become chronic or resistant to treatment if certain psychological factors are present [7,35]. Further longitudinal research is needed to clarify the co-morbidity of voice and psychological disorders in teachers.

LIMITATIONS OF THE STUDY

The response rate of this survey was 46.6%. This is similar to the studies of Nerrière et al. [20] and Chen et al. [30], and higher than the studies of Kooijman et al. [13] and de Jong et al. [19] with, respectively, a response rate of 31% and 34.3%. However, more than half of the teachers did not complete the questionnaire, and this may have introduced a bias. One could also argue that teachers with vocal problems are more interested in completing the survey. On the other hand, it is also plausible that teachers with vocal problems are more reluctant to complete the questionnaire because they do not want to draw any more attention to their voice disorder. Non-response bias is more accurately seen as a function of both the non-response rate and the magnitude of the difference between respondents and non-respondents on the key variable of interest [36]. The presence of a voice disorder was the key variable of this investigation, and the results of this study were consistent with previously conducted research [3,14,35], suggesting that the questioned sample of teachers was representative of the entire population of teachers.

Secondly, a questionnaire was chosen as the method of investigation. This means that the data were obtained from self-reporting and retrospective recall of the teachers. As addressed by Russell et al. [1], this study design may introduce subjective elements. It should be stated that this research investigated the subjective problem perception of the teachers. It is possible that the subjective perception does not correspond to the physical correlate of the investigated item. In order to focus further research, it is however very important to know what kind of influences a teacher with voice disorders experiences.

Thirdly, the key question in this study was: 'Have you ever had a voice disorder during your profession as a teacher?' This question reflects the profession prevalence of a voice disorder, but it does not indicate whether the voice disorder was currently present or had been experienced in the past. This question also does not allow differentiating between acute versus chronic voice disorders, or single versus multiple episodes of voice disorders. It is important to acknowledge that vocal risk factors and psycho-emotional factors may differ between these different categories.

Finally, cross-sectional studies cannot comment on the cause and effect. An association between psycho-emotional factors and voice disorders was documented in this study. However, it is not possible to say whether the stress caused the voice disorders or whether the voice disorders lead to stress. More detailed research is needed to evaluate the direction of this association.

Conclusion

The results of this study confirm that teaching is a high-risk occupation for the development of voice disorders. The career prevalence was 51.2% among teachers. Female teachers were at significantly higher risk of developing a voice disorder in comparison with their male colleagues. After correcting for age and gender, vocal risk factors for teachers were a family history of voice disorders, number of pupils per classroom, frequent temperature changes in the classroom, and noise (caused by students, ventilation, and technical equipment) in the classroom. Furthermore, teachers with voice disorders presented with significantly higher levels of psychological distress. The results of this study identify job-related and personal risk factors for the development of voice disorders in teachers and imply that a reduction of these factors may reduce voice disorders in teachers.

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APPENDIX 1

QUESTIONNAIRE

Dear participant,

This questionnaire was composed to conduct the study ‘Voice disorders in teachers’. This study is conducted because a higher prevalence of voice disorders in professional voice users such as teachers is assumed. With this questionnaire, we want to investigate which factors (personal, environmental and psycho-emotional factors) may have an influence on the prevalence of voice disorders.

Thank you for your time to complete this questionnaire.

Remark:

The VAS (visual analogue scale) is used for some questions. This 10 cm horizontal line represents a continuum ranging from one extreme to the other extreme. For example: the line may represent the degree of pain/distress caused by factor ranging from ‘no complaints’ (on the left side) to extreme complaints (on the right side). We ask you to mark the degree of pain/distress with one vertical line on the VAS.

GENERAL:

Age: |__|__| year

Gender: ( ) M ( ) F

1) How do you score your general condition?

excellent |____| extremely bad

2) How do you score your general physical condition?

excellent |____| extremely bad

3) Do you practice sport? ( ) Yes ( ) No

When yes: which sport?

Hours/week: |__|__| hours

4) Do you smoke: ( ) Yes ( ) No

When yes: number of cigarettes per day: |__|__|

For how many years: ( ) <10 years

( ) 11-30 years

( ) > 30 years

When no: have you smoked? ( ) Yes ( ) No

When yes: when did you stop? ( ) less than 1 year ago

( ) between 1-5 year ago

( ) between 5-10 years ago

( ) more than 10 years

How many cigarettes did you smoke: |__|__|

5) How many glasses of alcohol do you drink: ( ) 1-6/week

( ) 1-2/day

( ) > 2/day

6) How many glasses of caffeine do you drink (coffee, coke): ( ) 1-2/day

( ) 2-4/day

( ) > 4/day

7) How much do you drink daily? (all kinds of liquids: water, soft drinks, soup,…)?

( ) < 0.5 liter: 0-2 glasses

( ) 0.5-1liter: 3-5 glasses

( ) 1- 1.5 liter: 6-8 glasses

( ) >1.5 liter: >8 glasses

8) Do you have a voice-demanding hobby? ( ) Yes ( ) No

When yes: which hobby?

Number of hours per week: |__|__|

9) How do you estimate your voice? ( ) very bad ( ) bad ( ) average ( ) good ( ) excellent

10) Family situation: do you have children? ( ) Yes ( ) No

When yes: number: |__|__|

Age of the children: |__|__| - |__|__| - |__|__| - |__|__|

11) Are there people in your family with voice problems? ( ) Yes ( ) No

When yes: who?:

Which voice problems? . . . .

12) Did you ever had or do you have problems with:

<u>The thyroid gland?</u> ( ) Yes ( ) No

Do you need to take medication for this condition? . . . .

<u>Diabetes?</u> ( ) Yes ( ) No

Do you need to take medication for this condition? . . . .

<u>Hypertension?</u> ( ) Yes ( ) No

Do you need to take medication for this condition?. . . . .

13) Which home medication do you take? . . . .

<u>14) asthma:</u>

No complaints |————————————————————| extreme complaints

<u>15) reflux:</u>

No complaints |————————————————————| extreme complaints

16) Do you have allergies? (proven by an allergy test): ( ) Yes ( ) No

TEACHING RELATED FACTORS:

17) Teacher in: ( ) kindergarten ( ) primary school ( ) secondary school

18) Courses taught: ……………………………………………………………….

19) Years of teaching: ( ) 1 to 5 years ( ) 6 to 10 years ( ) 11 to 15 years ( ) 16 to 20 years
( ) 21 to 25 years ( ) 26 to 30 years

20) Number of lecture hours per week: ( ) less than 15 hours ( ) 16 to 20 hours
( ) 21 to 25 hours ( ) > 25 hours

21) Number of pupils per classroom: ( ) less than 15 ( ) between 15 and 20 ( ) between 20 and 25

22) Did you ever had a voice problem during your career as a teacher: ( ) yes ( ) no

23) Do you shout?

never |————————————————| always

24) Do you whisper?

never |————————————————| always

25) Do you sing?

never |————————————————| always

ENVIRONMENTAL FACTORS:

Score the amount of background during teaching:

26) Noise from outside the classroom (traffic, other classrooms, etc,...) :

No noise |————————————————| extremely noisy

27) Noise from inside the classroom (students, ventilation, technical equipment):

No noise |————————————————| extremely noisy

28) Score the acoustics in the classroom:

Very good |————————————————————| extremely bad acoustics

29) How big is the classroom? |__|__|__| m^3

30) Do you use chalk? ( ) Yes ( ) No

31) Score the amount of dust in the classroom:

No dust |————————————————————| extremely dusty

32) Is there carpet in the classroom? ( ) Yes ( ) No

33) Is there air-conditioning? ( ) Yes ( ) No

34) Are there curtains in the classroom? ( ) Yes ( ) No

35) Are there frequent temperature changes in the classroom? ( ) Yes ( ) No

PSYCHO-EMOTIONAL FACTORS

Please, encircle the number 0, 1, 2 or 3, according to the frequency that the statement was applicable to you during the last week.

0: did not apply to me at all

1: applied to me to some degree or some of the time

2: applied to me to a considerable degree or a good part of time

3: applied to me very much or most of the time

36) I was upset about small things

0 1 2 3

37) I found it difficult to relax

0 1 2 3

38) I was quite nervous

0 1 2 3

39) I was impatient when there was a delay (for example: elevators, traffic lights, …)

0 1 2 3

40) I found it difficult to calm down when something had upset me

0 1 2 3

41) I found it difficult to be tolerant when I got disturbed

0 1 2 3

42) I was very tense

0 1 2 3

43) I was very rushed

0 1 2 3

THE IMPACT OF VOICE DISORDERS AMONG TEACHERS: TREATMENT-SEEKING BEHAVIOR, KNOWLEDGE OF VOCAL CARE AND VOICE-RELATED ABSENTEEISM

The Impact of Voice Disorders Among Teachers: Vocal Complaints, Treatment-Seeking Behavior, Knowledge of Vocal Care, and Voice-Related Absenteeism

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Abstract

Objectives. Teachers are at increased risk for developing voice disorders. Occupational risk factors have been extensively examined; however, little attention has been paid to the consequences of the vocal complaints. The objective of this study was to investigate the knowledge that teachers have about vocal care, treatment-seeking behavior, and voice-related absenteeism.

Methods. The study group comprised 994 teachers and 290 controls whose jobs did not involve vocal effort. All participants completed a questionnaire inquiring about vocal complaints, treatment-seeking behavior, voice-related absenteeism, and knowledge about vocal care. Comparisons were made between teachers with and without vocal complaints and with the control group.

Results. Teachers reported significantly more voice disorders than the control population (51.2% vs 27.4%)(χ^2= 50.45, df = 1, $P < 0.001$). Female teachers reported significantly higher levels of voice disorders than their male colleagues (38% vs 13.2%, χ^2= 22.34, df = 1, $P < 0.001$). Teachers (25.4%) sought medical care and eventually 20.6% had missed at least 1 day of work because of voice disorders. Female teachers were significantly more likely to seek medical help (χ^2= 7.24, df = 1, P= 0.007) and to stay at home (χ^2=7.10, df = 1, P= 0.008) in comparison with their male colleagues. Only 13.5% of all teachers received information during their education.

Conclusions. Voice disorders have an impact on teachers' personal and professional life and imply a major financial burden for society. A substantial number of teachers needed medical help and was obligated to stay at home because of voice disorders. This study strongly recommends the implementation of vocal education during the training of teacher students to prepare the vocal professional user.

Key Words: Teachers – Voice disorders – Voice-related occupational disease.

INTRODUCTION

Professional voice users, especially teachers, have been found to be at increased risk for voice disorders.[1–3] A number of studies have focused on the teaching population and showed that the prevalence of vocal dysfunction was significantly higher in teachers (ranging from 11% to 81.0%) compared with nonteachers (ranging from 1.0% to 36.1%).[1,4–11] This high prevalence is because of intense and prolonged occupational voice use, speaking in a noisy environment, and inefficient phonation techniques. Teachers are more susceptible to aphonia, edema, polyps, and nodules than nonvocal professionals.[5–7,12] Vocal dysfunction leads to a lesser quality of teaching, an increased absenteeism, and a major financial burden. Serious personal and emotional consequences may also result for the individual teacher. Teachers feel limited in their current job performances and in their future job or career options because of their voice problems.[6]

Therefore, a large number of studies have focused on occupational vocal risk factors. Years of teaching have been identified as a risk factor because of cumulative voice use.[13,14] The number of pupils in the classroom also showed to be important since teaching a larger group requires more vocal effort.[13] Abundant background noise or classrooms with bad acoustics forces the teacher to speak more loudly, which also increases the risk.[9] Other unfavorable working conditions, for example, dry air, dust, smoke, temperature changes, may irritate the mucosa and negatively influence the voice.[15]
Psycho-emotional factors and stress have been consistently shown to be related to voice disorders.[5,8,13] Emotions can influence voice production negatively, especially in sensitive persons. Increase in stress changes the phonation pattern with a subsequent increase in voice load.[8,16]

In contrast to the elaborate literature describing the vocal risk factors, little attention has been paid to the consequences of these voice disorders. Vocal dysfunction may lead to extensive periods of sick leave and vocal rehabilitation, whether or not combined with surgical intervention, which involves great financial costs. Few studies have investigated the treatment-seeking behavior of the teachers or voice-related absenteeism. Moreover, there is a lack of research examining whether teachers received information during their training or during their career about the physiology of their voice, vocal techniques, and the use of vocal hygiene.

The purpose of this study was to provide an in-depth analysis of different aspects regarding the impact of voice disorders in professional voice users: (1) the knowledge of teachers concerning vocal care; (2) their treatment-seeking behavior; and (3) the duration of the voice-related absenteeism. This study contributes to the knowledge of the development of voice disorders in teachers and helps to further develop preventive programs to reduce the impact and severity of voice disorders in teachers.

METHODS

DESCRIPTION OF THE QUESTIONNAIRE

The questionnaire of this study was based on existing questionnaires in the literature,[4–6,8–10,13,15] the investigators' clinical experience, and suggestions from teachers. The outcome variable was ''Have you ever had a voice disorder during your professional career?'' Voice disorder was defined as any time the voice did not work, perform, or sound as it usually does and interfered with communication. The survey addressed four main categories: (1) Ear, nose and throat (ENT), vocal and corporal complaints; (2) treatment-seeking behavior; (3) voice-related absenteeism; and (4) knowledge concerning vocal care. Specific questions elicited information regarding (1) ENT symptoms: nasal obstruction, dry nose, rhinorrhea, postnasal drip; (2) vocal complaints: hoarseness, a tired voice, loss of voice, loss of voice control, loss of voice range, pain after speaking, globus sensation, dry mouth at day, dry mouth at night, dry mouth when speaking; (3) corporal complaints: headache, sore throat, neck pain; (4) the frequency and type of consulted physician; (5) the need and duration of voice therapy; (6) the prevalence of voice-related absenteeism; (7) the specific duration of the sick leave; (8) source of information regarding vocal care; and (9) use of vocal hygiene rules. Demographic variables considered in this study were age and gender. The questionnaire was accompanied by a description of the background and the aim of the study. Teachers were asked to score their ENT symptoms, vocal complaints, and physical discomfort using a visual analog scale (VAS).[17] This scale measures 10 cm and ranged from ''0 as no complaints'' in one end to ''10 as extremely severe'' at the other end. Teachers were asked to mark the line where they experienced their problems. Treatment-seeking behavior and knowledge of vocal care were interrogated with yes/no questions.

SAMPLING PROCEDURES

The questionnaires were distributed between October 2008 and June 2009. Randomly selected schools in the provinces of the Flanders (the Northern Flemish part of Belgium) were chosen from a list provided by the Web site of the State Office of Education. Every educational level and type was included: kindergarten schools, elementary schools, and high schools. An equal number of schools in the cities as in the suburbs were selected. The teachers aged between 21 and 65 years (mean age= 38.9 years). The initial contact was made by telephone to the principal of the school. The purpose of the study was briefly explained, and the school was asked to participate. If the principal agreed, a questionnaire for every teacher was passed to the school and distributed by the principal. It was the teachers' own choice to complete the survey or not. The questionnaires were again collected by the investigators of the study. When a school would not participate, the main reason was that the teachers were already overloaded with questionnaires and the workload was too heavy. In total, 2133 questionnaires were delivered at the schools and 994 were available for analysis. The response rate for the teacher group was 46.6% (994/2133).

The control population was sampled by a mailing list of all employees of the University of Ghent. This sample consisted of working individuals in occupations with low vocal loading (administrators, secretaries, research workers, information and communication technology (ICT) personnel, technicians, social workers, nurse/health aides, etc) of the same geographic area and age criteria (21–65 years, mean 36.5 years). None of the controls had ever participated in any form of teaching. The questionnaires were emailed to all employees and, once completed, emailed back to the investigators. A total number of 290 questionnaires were returned.

Statistical methods

All data were evaluated using the statistical program SPSS version 18 (SPSS Inc., Chicago, IL). The relationships between voice disorders that occurred at any time and various factors were assessed. Nonparametric data were treated with the Mann-Whitney U test for comparison between groups. Logistic regression and multiple linear regression methods were used to predict outcome based on a combination of multiple factors. Logistic regression models were simultaneously adjusted for gender. Chi-square tests were used to investigate association between groups for the occurrence of one or more characteristics. In all statistical tests, two-tailed tests of significance and confidence intervals were based on the level of $P < 0.05$. Comparisons were made between teachers with and without voice complaints and between the teacher group and the control population.

Results

Profile of the participants

In total, 994 teachers completed the questionnaire. The overall response rate was 46.6% (994/2133). The teacher group consisted of 67.4% (n = 670/994) females and 32.6% (n = 324/994) males. The mean age of the teachers was 38.9 years (range 21–65 years). The greatest number of the teachers worked at the secondary school level (69.6%, 690/994). Teachers working in primary schools accounted for 23.5% (233/994) and in kindergarten for 6.9% (68/994). The largest group (25.6%, 254/994) had been teaching for 1 to 5 years. The

second largest group (19.8%, 197/994) had been teaching for 25 to 30 years. In the group of teachers, more than half of them (n = 509/994, 51.2%) had suffered from vocal complaints at some point during their career as a teacher. Female teachers suffered significantly more often than their male colleagues as depicted in Figure 1 (38% [378/994] vs 13.2% [131/994], χ^2= 22.34, df = 1, P < 0.001). In male teachers, the prevalence of reporting a voice disorder was significantly related with age (χ^2=11.24, df = 3, P= 0.010), whereas in women no age-related significance was found (χ^2= 3.31, df = 3, P = 0.347).
The control population consisted of 71% (n = 206/290) women and 29% (n = 84/290) men. The mean age was 36.5 years (range 18–68 years). Voice disorders occurred in 27.6% (80/290) in the control population. The prevalence was not significantly higher for females (21.4%, 62/290) than males (6.2%, 18/290) (χ^2= 2.25, df = 1, P= 0.134). The prevalence of voice disorders reported by teachers was significantly higher than in the control population (χ^2= 50.45, df = 1, P < 0.001).

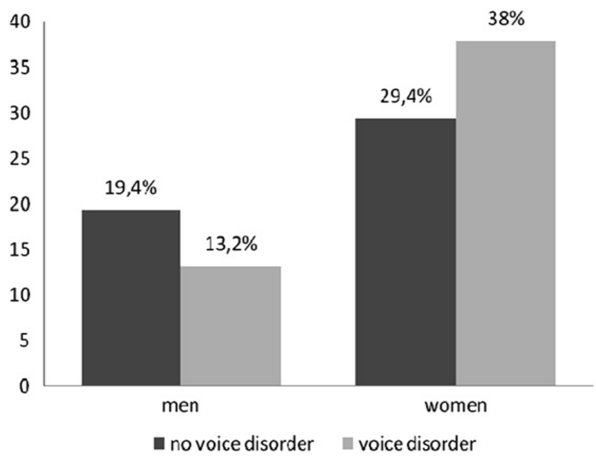

Fig. 1: Percentages of voice disorders in the teachers group that consisted of 67.4% females and 32.6% males. Female teachers suffered significantly more of voice disorders compared to their male colleagues: 38% vs 13.2%

VOICE-RELATED COMPLAINTS

By means of a forward logistic regression, we were able to estimate the relative importance of different VAS characteristics that were necessary to discriminate healthy from dysphonic subjects. The following VAS characteristics were used as independent variables: (1) ENT symptoms: nasal obstruction, dry nose, rhinorrhea, postnasal drip; (2) vocal complaints: hoarseness, a tired voice, loss of voice, loss of voice control, loss of voice range, pain after speaking, globus sensation, dry mouth at day, dry mouth at night, dry mouth when speaking; (3) corporal complaints: headache, sore throat, neck pain; and (4) gender. Finally, using a linear combination of the VAS characteristics (hoarseness, a tired voice, loss of voice, loss of voice range, and gender), a correct classification of teachers with voice disorders could be achieved in total 73% (726/994) of all subjects, with specificity of 81% and sensitivity of 66%. By itself, this is not the aim of the analysis, but this method provides a tool to assess the relative importance of each individual variable as essential for the status dysphonic or healthy. As such, the most determining symptoms were (1) hoarseness; (2) loss of voice; and (3) diminished pitch and intensity with Exp(B) of 1.26, 1.23, and 1.19, respectively. Also, gender was part of the finally determining factors, with the result that men had less problems with their voice than women. These values correspond to the change in odds of having dysphonia in case of an increase with 1 cm on the VAS of the different characteristics (Table 1).

Table I: Exp(B) of the most relevant vocal complaints and gender as determined by a forward logistic regression

TABLE 1.
Exp(B) of the Most Relevant Vocal Complaints and Gender as Determined by a Forward Logistic Regression

			95% Confidence Interval for Exp(B)	
Vocal Complaint	Significance	Exp(B)	Lower	Upper
Hoarseness	0.000	1.262	1.137	1.400
Tired voice	0.004	1.162	1.049	1.286
Loss of voice	0.002	1.231	1.081	1.402
Loss of voice range	0.002	1.190	1.066	1.328
Gender	0.003	0.626	0.458	0.855

TREATMENT-SEEKING BEHAVIOR

Table 2 illustrates the treatment-seeking behavior of the teachers. Of the 994 teachers, 253 (25.4%, n= 253/994) sought medical help. Of the teachers with voice disorders (n = 509), this accounted for 49.7% (253/509). This was not significantly higher than the control group, which consulted a doctor in 43.7% (35/80) (χ^2=0.98, df = 1, P= 0.322) in case of vocal dysfunction. Among the teachers, the general practitioner (26.2%, 135/509) was the most frequented physician followed by the otolaryngologist (23%, 117/509). Table 2 shows that 28 teachers directly consulted an ENT specialist, whereas 86 were referred to a specialist after consulting the family doctor. The school physician was only frequented by two teachers. The treatment-seeking behavior among teachers was strongly related to (1) gender: women consulted significantly more (49.5% vs 35.9%, χ^2=7.24, df = 1, P = 0.007) than their male colleagues; (2) the years of teaching (χ^2= 4.38, df = 1, P = 0.036 for men and χ^2= 14.62, df = 1, P < 0.001 for women); (3) the age of the teacher (χ^2= 3.85, df = 1, P = 0.05 for men and χ^2= 8.52, df = 1, P = 0.004 for women); and (4) type of school. Kindergarten and primary school teachers consulted significantly more than the teachers of secondary school (χ^2= 8.56, df = 2, P = 0.014). Gender was not a determinant in the choice of the physician (general practitioner vs ENT specialist). Teachers who reported a greater severity of vocal complaints (hoarseness, vocal fatigue, loss of voice and voice range, diminished voice range, and pain in the throat after speaking) were significantly more likely to consult a doctor (all Mann-Whitney U tests were significant at P < 0.001).

Table 2: Treatment-seeking behavior of the teachers

TABLE 2.
Treatment-Seeking Behavior of the Teachers

Type of Medical Care	Frequency (n)	Percent (%)
No medical care	739	74.3
SD	1	0.1
GP	135	13.6
ENT specialist	28	2.8
SD + ENT	1	0.1
GP + ENT	86	8.7
GP + SD + ENT	2	0.2
Total	992	99.8
Missing	2	0.2
Total	994	100.0

Abbreviations: SD, school doctor; GP, general practitioner; ENT, ear, nose and throat.

VOICE-RELATED ABSENTEEISM

Teachers experienced a significant higher number of days in their career in which they missed work because of their voice in comparison with the control population (χ^2=24.97, df=1, P < 0.001). More precisely, one out of five (19.2%, 191/994) teachers reported missing at least 1 day of work because of voice-related dysfunction. In the general population, significantly fewer participants (7.6%, 22/290) were absent from work because of voice disorders. In the group of teachers with voice disorders, this accounted for 37.6% (191/509). Figure 2 shows the duration of the absenteeism in teachers with voice disorders at any point during their career: 34.6% (66/191) missed 1 day at work, 20.4% (39/191) missed several times 1 day, and 29.3% (56/191) missed 1 week. A substantial part of the teachers (15.7%, 30/509) had to stay home for a longer period: 4.7% (9/191) missed 2 weeks, 6.8% (13/191) missed more than 2 weeks' work, and 4.3% (8/191) were not able to work repeatedly 1 week. Female teachers stayed significantly more often at home (38.9% vs 26%, χ^2=7.10, df=1, P= 0.008) than male teachers.

VOICE THERAPY

During their career, 51 (5.1%, 51/994) teachers received voice therapy in comparison with 2.1% (6/290) in the general population (P=0.316). For the majority (n= 28/51), a therapy of maximum 6 months was sufficient. Thirteen of the 51 teachers needed a treatment of 6 months to 1 year and 10 teachers need treatment for more than 1 year. Statistical analysis showed that teachers who had a voice disorder as a child or young adult and received voice therapy for this problem were not at an increased risk of developing a voice disorder further on in their career (χ^2=2.64, df=2, P=0.267).

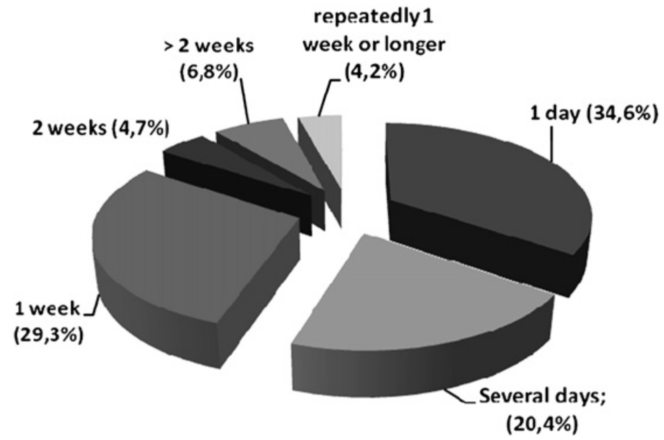

Fig. 2: Duration of voice-related absenteeism in teachers with voice disorders at any point during their career

KNOWLEDGE ABOUT VOCAL CARE AMONG TEACHERS

Only 27.8% (276/994) of the teachers received information about vocal hygiene and vocal techniques. For 13.5% (134/994) of the teachers, this was during their education to be a teacher. An even smaller number of teachers received information about vocal care during extra training or collected information at own initiative (Table 3). No gender-related differences were found among the teachers who collected information at own initiative. Unfortunately, the association between receiving information during the education and the prevention of voice disorders later on in the career was not significant (χ^2=1.00, df=1, P=0.317). When teachers were confronted with a voice disorder, there was a need for information and significantly more teachers gathered information themselves (χ^2=15.78, df=1, $P < 0.001$) in comparison with their colleagues without voice disorders.

The survey examined whether teachers used their knowledge of vocal care in their everyday teaching. The aspects of vocal use and vocal hygiene teachers are most familiar with (1) increasing fluid intake; (2) trying to shout less; and (3) trying to avoid speaking in a noisy environment. Only a very small fraction (0.6%, 9/994) of the teachers had ever used voice amplification.

Table 3. Knowledge of teachers about vocal care and vocal hygiene during education, extra training, or at own initiative

TABLE 3.
Knowledge of Teachers About Vocal Care and Vocal Hygiene During Education, Extra Training, or at Own Initiative

Information Received by the Teacher	Frequency (n)	Percent (%)
No information	717	72.1
Information during education	87	8.8
Information during extra training	31	3.1
Information during education and extra training	10	1.0
Information at own initiative	85	8.6
Information during education and at own initiative	26	2.6
Information during extra training and at own initiative	26	2.6
Information during education, extra training, and at own initiative	11	1.1
Missing	1	0.1
Total	994	100.0

DISCUSSION

This study provides descriptive data on voice-related absenteeism, treatment-seeking behavior, and knowledge of vocal care in teachers in comparison with the general population. This survey intended to give an overview of the consequences of occupational voice disorders. The results indicated that more than half of the teachers (51.2%, 509/994) experienced a voice disorder during their career. This finding was significantly greater than the control population (27.6%, 80/290). This confirms that teaching is a profession with very high vocal demands.[15,16,18] This outcome was consistent with those of Roy et al,[4] Thibeault et al,[14] and de Jong et al.[11] Female teachers reported significantly more voice disorders than their male colleagues (38% vs 13.2%). This has been consistently reported in previous studies [5,11,12,16] and has mainly been ascribed to physiological reasons. Women have shorter vocal folds and produce voice at a higher fundamental frequency. Consequently, there is less tissue mass to dampen a larger amount of vibrations. At the molecular level, women have less hyaluronic acid in the superficial layer of the lamina propria. Hyaluronic acid plays an important role in wound repair. Lower amounts of hyaluronic acid indicate that there is less protective tissue dampening and, therefore, a reduced wound-healing response.[19]

Vocal risk factors in teachers have been the subject of elaborate research. Unfortunately, these findings are often inconsistent. Moreover, many risk factors (gender, age, type of school, years of teaching, etc) are often very difficult or even impossible to change.

Therefore, attention should be focused on prevention by use of efficient vocal techniques and vocal hygiene training (such as avoid chalk, increase daily fluid intake, decrease alcohol and caffeine consumption, stop smoking, avoid yelling, etc). An inefficient phonation technique is one of the most important factors in the pathogenesis of occupational dysphonia.[10] Previous studies documented that teachers are at greater risk of developing hyperfunctional voice disorders.[10,20,21] Inefficient voicing in heavy vocal users leads to rapid voice deterioration, development of functional and, later on, organic disorders adversely affecting their ability to work.[22,23] In this study, a cluster of voice-related symptoms (hoarseness, loss of voice, and loss of voice range) were consistently reported by dysphonic teachers and will presumably have implications for both the quality of teaching and the students' learning experience.

Half of the affected teachers sought medical help. This outcome was in high contrast with the finding of Roy et al[4] and Russell et al[5] who reported that 14.3% of the American and 32.7% of the Australian teacher consulted a doctor, respectively. Roy et al[4] assumed that teachers were reluctant to take time off from work for medical appointments, or that they fear physician advice to reduce voice use or change occupations. Russell et al[5] documented that 32.7% visited a doctor and stated that teachers view voice disorders as occupational hazards and may not be aware of the help available to them. The higher prevalence in the present study could be explained by the growing awareness of vocal care or by the organization of the health system in Belgium. Consulting a physician is almost fully reimbursed in Belgium, and there is a low threshold for consulting a specialist (practically no extra fee and no referring is necessary from the general practitioner). The physician plays an important role in supporting the teacher. Voice disorders have a major psycho-emotional impact[13,16,24] because they can threaten, shorten, or even end a teacher's career. Moreover, voice disorders have not been recognized as a professional disease, which makes it more stressful for the teacher to justify his/her sick leave. In cases of distress, the family doctor is often the first aid. This was confirmed by the results of our survey because the general practitioner was the most frequented physician. It was striking that only a very limited fraction consulted the school doctor. In the future, physicians could play a crucial role in supporting the teachers, reducing the psychoemotional impact, and thereby decreasing the voice-related absenteeism. This survey also showed a strong relation between voice disorders and sick leave, 20.6% of the teachers with voice disorders had missed 1 or more days at work, which was significantly more than the general population. These results were similar to the results of Smith et al[6] and Titze et al.[2] In the vast majority, sick leave was limited to 1 week or less, but 16% of the teachers were absent for more than a week. Because teachers are a significant portion of the working population (6.7% of the working population in Belgium[25]), these data stress the important economic consequences because of sick leave, voice therapy, and/or surgical management.

Teachers were inquired about their knowledge of vocal care. It appeared that only 27.4% of the teachers had received any kind of information. Only a small percentage (13.5%) was informed during training. Because it is very difficult to identify or eliminate vocal risk factors, a good knowledge of vocal care could decrease the number of voice disorders in teachers. Unfortunately, vocal care has not been taken up in the educational program. Based on this study, we argue for the implementation of a course about the physiology of the voice and vocal care in all teacher programs. The effectiveness of preventative strategies (such as vocal hygiene training and vocal function exercises) has already been documented by previous research.[26–28] In this study, there was no association between receiving information during the education and the prevention of voice disorders. Courses should be devoted to presentation skills and public speaking. Issues related to the anatomy and physiology of the voice, reflux, medical management of the voice, and how these contribute to or detract from efficient voice use needs to be addressed. Moreover, maintaining and updating this knowledge through prevention programs in extra trainings during the teachers' career should be promoted. Focus should be on sensitizing professionals to voice disorders so they can recognize the symptoms early. When teachers are informed about their voice, early detection and treatment could reduce voice-related absenteeism and decrease the impact on the personal and social life of the teacher.

CONCLUSION

This study argues for the implementation of prevention programs. First, more than half of the teachers had to cope with a voice disorder at a certain point during their career. Second, one out of four teachers sought medical help for a voice disorder. Third, one out of five teachers will eventually stay at home for 1 or more days because of a voice disorder. Female teachers scored significantly higher on all three parameters in comparison with their male colleagues. In addition, women compile the largest group of the teachers, which represents a non-negligible portion of the working population. These three factors are responsible for a major financial burden that could partially diminish if the teaching about the physiology of the voice and vocal hygiene was introduced in the educational program. Personal characteristics, work-related voice load, and environmental risk factors have been extensively investigated but are difficult to identify and change frequently according to the conducted study. Therefore, attention should also be paid to efficient vocal techniques, vocal hygiene, and awareness of vocal care early in the education. The findings of this survey have important implications for the public health and strongly recommend the implementation of vocal education during the training of teacher students. In the future, there is a need for research focusing on the benefit of early prevention and intervention programs for teachers.

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MUSCLE TENSION DYSPHONIA

PATHOPHYSIOLOGY AND TREATMENT OF MUSCLE TENSION DYSPHONIA:

A REVIEW OF THE CURRENT KNOWLEDGE

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ABSTRACT

Objectives. Muscle tension dysphonia (MTD) is a clinical and diagnostic term describing a spectrum of disturbed vocal fold behavior caused by increased tension of the (para)laryngeal musculature. Recent knowledge introduced MTD as a bridge between functional and organic disorders. This review addresses the causal and contributing factors of MTD and evaluates the different treatment options.

Methods. We searched MEDLINE (Pubmed, 1950–2009) and CENTRAL (The Cochrane Library, Issue 2, 2009). Studies were included if they reviewed the classification of functional dysphonia or the pathophysiology of MTD. Etiology and pathophysiology of MTD and circumlaryngeal manual therapy (CMT) were obligatory based on reviews and prospective cohort studies because randomized controlled trials (RCTs) are nonexisting. Concerning the treatment options of voice therapy and vocal hygiene, selection was based on RCTs and systematic reviews.

Results. Etiological factors can be categorized into three new subgroups: (1) psychological and/or personality factors, (2) vocal misuse and abuse, and (3) compensation for underlying disease. The effective treatment options for MTD are (1) indirect therapy: vocal hygiene and patient education; (2) direct therapy: voice therapy and CMT; (3) medical treatment; and (4) surgery for secondary organic lesions.

Conclusions. MTD is the pathological condition in which an excessive tension of the (para)laryngeal musculature, caused by a diverse number of etiological factors, leads to a disturbed voice. Etiological factors range from psychological/personality disorders and vocal misuse/abuse to compensatory vocal habits in case of laryngopharyngeal reflux, upper airway infections, and organic lesions. MTD needs to be approached in a multidisciplinary setting where close cooperation between a laryngologist and a speech language pathologist is possible.

Key Words: Functional voice disorder – Functional dysphonia – Muscle tension dysphonia – Muscle misuse voice disorders – Circumlaryngeal manual therapy – Videostroboscopy.

BACKGROUND

Voice disorders in the absence of organic lesions of the vocal folds were previously cataloged as functional voice disorders.[1–3] In these patients, a psychological background was often assumed. Because of the higher vocal demands, especially in professional voice users, a better understanding of the pathophysiology was needed to overrule diagnoses such as psychogenic dysphonia.[4] The development of new diagnostic tools (videostroboscopy, laryngeal electromyography (EMG), electroglottography, and subglottal pressure measurements) supported the quest for the identification of anatomical disorders in patients with dysphonia in cases of vocal misuse and abuse (vocal ''stress'').

In 1982, the label ''vocal abuse/misuse syndrome'' was introduced by Koufman and Blalock[5] to delineate voice disorders in nonprofessional voice users. In professional voice users, these authors used the term ''Bogart-Bacall syndrome'' when vocal complaints occurred in association with increased muscle tension. This term was introduced because men sounded like Humphrey Bogart and women like Lauren Bacall.[5] These labels identified the increased muscle tension as underlying cause of these functional voice disorders. However, these terms could only be used when a vocal abuse/misuse was at the base of the vocal complaints and did not leave any consideration for other etiological factors.

In 1983, the term ''muscle tension dysphonia'' (MTD) was introduced by Morrison and colleagues to describe clinical features of young- to middle-aged individuals with extensive voice use in stressful situations.[6–8] MTD can be described as the pathological condition in which an excessive tension of the (para)laryngeal musculature, caused by a diverse number of etiological factors, leads to a disturbed voice. This label gained international acceptance as it was not limited to one probable cause, but it describes the clinical diagnosis in which several etiological factors could play a role. MTD can be evaluated on videostroboscopy and has finally enabled functional dysphonia to lose its ''subjective'' character. MTD is not a synonym for functional voice disorders but specifically defines those patients with dysphonia caused by an excessive tension of the (para)laryngeal muscles. A number of nonorganic voice disorders (such as hypokinetic dysphonia, mutation dysphonia, and conversion aphonia) do not fall under this category and still need specific labeling. Two forms of MTD were introduced. Primary MTD involves a dysphonia in the absence of concurrent organic vocal fold pathology and is associated with excessive, atypical, or abnormal laryngeal movements during phonation, without obvious psychogenic or neurologic etiology.[2,9] Primary MTD occurs primarily in women and accounts for 10–40% of the clinical caseloads at a voice center.[2,10,11] Secondary MTD indicates a dysphonia in the presence of an underlying organic condition.[12] Till now, a division of MTD into these two categories remains necessary because it has not been elucidated whether MTD leads to organic pathology or whether MTD is the result of organic lesions.

In 1993, the term muscle misuse dysphonia was briefly used instead of MTD. Diagnosis implied abnormal laryngeal posture (ie, hyperlordosis of the cervical spine), which may have slowly changed into a persistently tense resting tone of laryngeal muscles. This may lead to a distortion of the laryngeal structures and narrowing of the thyrohyoid and cricothyroid spaces eventually.[13] But after using this new classification, some patients with muscle misuse disorders did not fit into any category and so the term MTD remained the preferred label.

In general, the term MTD is the preferred label because it (1) allows different etiological factors to be part of the equation, (2) encloses information about the pathophysiology, (3) gives the opportunity to describe a clinical diagnosis seen on videostroboscopy, and (4) allows to focus treatment. Both types of MTD (primary and secondary) can ultimately result in a ‘‘decompensating’’ voice with severe hoarseness or even complete loss of voice. To our knowledge, previous labels have been too restrictive.

PATHOPHYSIOLOGY OF MTD

Phonation demands a fluent and synchronized movement of the vocal folds. Small intrinsic laryngeal muscles are responsible for the movement of arytenoid cartilages and thus for vocal fold adduction, abduction and tension. The larger extrinsic musculature (suprahyoid and infrahyoid muscles) maintain the larynx in a stable and natural position in which the intrinsic laryngeal musculature can contract freely and undisturbed. In patients with MTD, an altered tension of the extrinsic musculature results in a changed position of the larynx in the neck (a mostly higher position) and a disturbed inclination of the cartilaginous structures of the larynx (thyroid, cricoid, and arytenoid) that immediately affects the intrinsic musculature.[14] Tension of the vocal folds is altered and the voice becomes disturbed.

Muscle tension dysphonia is used when the excessive muscle tension leads to a decompensation of the voice and the patient becomes dysphonic. It is quite possible that the MTD patterns can also exist in healthy subjects without any complaints; however, the term MTD is only used when the situation becomes symptomatic. A few studies have shown that there is a measurable difference in the tension (e.g., an increased tension) of the (para)laryngeal musculature between patients with MTD and healthy subjects.[15,16] These studies used surface electromyography (sEMG) to measure the tension of the supra- and infrahyoidal muscles. Hočevar-Boltežar et al[15] evaluated 11 patients with MTD and five normal speakers, and their results showed a six- to eightfold increase of EMG activity and/or an alternation of the EMG activity in the perioral and supralaryngeal muscles before and during phonation in most of the patients with MTD. Redenbaugh and Reich[16] examined seven normal and seven vocally hyperfunctional speakers with surface EMG and concluded that the hyperfunctional speakers showed significantly higher EMG values during rest and vowel phonation than the normal speakers. However, in both studies the number of patients and controls were limited. Further research has yet to establish why certain individuals with an increased tension of the laryngeal muscles become dysphonic, whereas others with the same videostroboscopic features remain asymptomatic.

Diagnosis of MTD is based on several key features. The history of vocal misuse/abuse, psychological influences, and stressful situations have to be evaluated. Clinical examination includes visible and palpable tension around the larynx, which is evaluated by palpation. Tightness of the (para)laryngeal musculature, laryngeal rise, decreased thyrohyoid space, and site of focal tenderness should be evaluated during rest and phonation.[13] Subsequently, the patient should be evaluated with laryngoscopy and videostroboscopy.[7] In the past, terms such as plica ventricularis and ventricular dysphonia have also been used to distinguish the image on videostroboscopy. However, the underlying pathological processes are often very different. For example, some authors used the latter terms to designate an adduction of ventricular folds with simultaneous adduction of the true vocal folds, whereas other authors used this term to describe adduction of the vocal folds in the absence of the true vocal folds phonation.[17] Therefore, these terms are confusing and it is more adequate to describe the image seen on videostroboscopy with strict patterns. Although there is no internationally accepted classification system, the following patterns are most frequently used: MTD 1—laryngeal isometric contraction with posterior open chink because of a hypertonic state of the posterior cricoarytenoid muscle, MTD 2—supraglottic contraction in which the ventricular folds are adducted to the midline, MTD 3—anteriorposterior contraction that results in a reduced space between the epiglottis and the arytenoids prominences, and MTD 4—extreme anterior-posterior contraction or squeeze.[18] It is important to note that these videostroboscopic features of MTD have also been described in normal speakers [11]. There, the label MTD is only to be used when there is a distinct voice disorder. The diagnosis of MTD can be complex and is not only made on visual examination.

The excessive muscle activity that gives rise to MTD has been attributed to many factors that can be cataloged into three distinct categories.

The first category is the psychological and/or personality factors. On the basis of the psychometric evidence, certain personality traits have been found to characterize at least a subset of patients with MTD. A general trend has been noted toward elevated levels of introversion,[2,19] neurotism,[19] (social) anxiety,[17,20,21] constraint,[17,19] stress reactivity,[17,19] and depression.[21] Researchers point out that although personality tendencies may exist in patients with MTD, personalities are generally complex and unique. Other factors must be considered, such as the nature and the degree of stress experienced, life experience, and support and coping strategies.

Secondly, vocal abuse/misuse has been indisputably acknowledged as a cause of MTD.[1,3,22] Misuse of the voluntary muscles used in phonation, including muscles of the larynx, pharynx, jaw, tongue, neck, and respiratory system can contribute to incorrect vocal techniques. Furthermore, disturbed respiratory and phonatory gestures lead to improper resonance focus, loss of control of pitch and loudness, and eventually to decompensation of the voice. This is mainly seen in professional voice users (such as teachers, lawyers, salesmen, and singers) with higher vocal demands. They do not only have daily prolonged voice use but they also rely on their voice to control, entertain, or convince their audience.

Thirdly, MTD can result because of the compensation of an underlying disease such as organic fold lesions, laryngopharyngeal reflux (LPR),[23] altered hormonal status,[24–26] aging of the larynx,[27] and upper respiratory tract infection.[3] This type of MTD is referred to as secondary MTD, which is the result of a patient's overcompensation to an underlying organic cause. In an attempt to maintain normal pitch and volume in a structurally altered larynx, vocal fold tension and stiffness are increased.[28,29] LPR can lead to MTD because gastric acid regurgitates through the esophagus into the larynx and pharynx. Airway protective mechanisms are triggered that result in the closure of the glottis, coughing or choking, and tightening of laryngopharyngeal constrictor muscles. LPR is as such believed to cause tension to the intrinsic and extrinsic laryngeal musculature.[13] The hormonal status of a patient can also be a causal or aggravating factor for MTD. In postmenopausal women, laryngeal changes such as edema, muscular and mucosal dystrophy, and atrophy can be found. These changes are believed to be related to the loss of hormonal influence on the vocal fold mucosa.[24–26] In an attempt to compensate for these alternations in the larynx, MTD can occur. The same compensation mechanism occurs for the alternations because of the aging of the larynx. In the male larynx, aging includes an overall thinning of the vocal fold mucosa and the superficial layer of the lamina propria, whereas in females, the vocal folds thicken with aging. In males, the changes are referred to as the bowing of the vocal folds during adducting tasks. In the female larynx, these changes result in a flaccid irregular vibration pattern. In both genders, compensation of adduction impairment may lead to excessive false vocal fold hyperfunction and MTD.[27] Koufman also described MTD after an acute viral laryngitis, which is often referred to as ''postviral habituated hoarseness.'' In these cases, a viral infection of the larynx may lead to compensatory development of false vocal cord phonation. Even with subsequent improvement of the inflammatory condition, the compensation may have become habituated. The patient has simply made a chronic adaptation to an acute dysfunction, usually with some secondary gain.[3] In conclusion, the cause of the elevated tension in the (para)-laryngeal musculature is multifactorial. Personality factors and/or vocal misuse and abuse—the latter especially in professional voice users—may become so decisive over time that at a certain point the voice decompensates. The laryngeal musculature tries to find a new point of balance but progressively the larynx enters a state of hypertension. Furthermore, underlying organic pathology, such as reflux laryngitis, vocal nodules, polyps, cysts, and Reinke's edema, can cause, precipitate, or aggravate the muscle tension dysphonia. Whether the MTD results from the organic pathology or organic pathology results from MTD is still a subject of debate. However, we can clearly state that muscle tension dysphonia should not be considered as a distinct voice disorder but rather as a spectrum of disturbed vocal fold behavior in the complete range of voice disorders.

TREATMENT

MTD requires a multidisciplinary approach. Dysphonia is caused by a number of interacting factors, and each of them should be systematically evaluated. Sorting out the relative importance of the various factors is the first step toward planning an effective treatment program. It is important not to classify nonorganic dysphonia too rigidly. Any classification that points out one cause, tends to ignore or underevaluate the contribution of others. MTD should always be considered when evaluating a patient with a voice disorder similar to mucosal wave, amplitude, regularity of the vocal folds, etc. MTD not only provides the opportunity to describe the clinical image seen on videostroboscopy, but also to direct and follow up the choice of therapy. Several combined indirect and direct therapy approaches, medical treatments, and surgical techniques are known.

INDIRECT THERAPY: PATIENT EDUCATION AND VOCAL HYGIENE

Vocal hygiene is an educational approach that helps individuals to identify factors that may contribute to their voice disorder. The patient needs to understand that his/her voice is an aggregate of multiple factors, including potential psychological influences. Psychological or personal factors always need to be considered and if necessary it should be treated.[30,31] To alter or avoid these factors and to modify vocal behavior, vocal hygiene uses three subgroups of advice: environmental advice, vocal use, and personal behavior advice. Examples of the first category are speaking as little as possible in an environment where there is a lot of background noise and avoid speaking in rooms where the air is dry and dusty. Examples concerning vocal use are avoiding yelling, screaming, and shouting; trying not to clear the throat while speaking; not whispering; trying not to talk the whole day long; and using a good breathing technique. Limiting the use of alcohol and caffeine, not smoking, and regular eating and sleeping patterns are examples of personal factors. For professional voice users, vocal hygiene rules should be specific and job related. Teachers should reduce the hours of teaching, the number of pupils, avoid classrooms with bad acoustics, use nonverbal communication such as whistles and bells, try not to use chalk, gather students to give instructions instead of shouting, or use of a microphone while teaching.[32]

DIRECT THERAPY: VOICE THERAPY

The voice therapist can also use various direct approaches by working on posture, breathing, phonation, articulation, or by working on muscle tension using circumlaryngeal manual therapy (CMT). Voice therapy is usually the initial treatment modality for patients with nonorganic voice disorders. The general aim of voice therapy is to minimize or correct inappropriate use of the voice to restore normal phonatory function. In most cases, a voice therapy program uses a combination of indirect and direct treatment techniques. The effectiveness has been shown in randomized controlled trials (RCTs) based on standard evaluations, such as perceptual voice quality ratings, voice handicap ratings, and acoustic analysis.[33,34] Two systematic review of the literature, performed by Ruotsalainen et al,[35,36] and three randomized studies concluded that a combination of indirect and direct therapy is effective when compared with no intervention.[33,34,37] Vocal hygiene and voice therapy were always evaluated together, as these treatment options are not mutually exclusive because vocal hygiene is always, to some extent, integrated in the voice therapy. The effect of voice therapy remained significant at medium- and long-term follow-up.[33,38] Voice therapy is focused on reversing these gestures and rendering the tension of the laryngeal musculature back to a normal point. Voice therapy plays an important role in breaking the vicious circle of decompensation and overcompensation of the voice apparatus and may prevent the development of organic lesions from disturbed voice use.

The technique of CMT has gained more attention, as it is believed that chronic posturing of the larynx in an elevated position leads to cramping and stiffness of the hyoid-laryngeal musculature. During CMT, pressure is applied over different sites of the larynx. CMT may differ according to the technique proposed by Lieberman,[39] Aronson,[40] Roy and collegues,[41,42] or Greene and Mathieson.[43] Sites of focal tenderness and nodularity are given more attention. The procedure begins superficially and the depth of the massage is increased according to the degree of tension and the tolerance of the patient. During the procedure, the patient is asked to sustain vowels or to hum while the clinician and the patient notice changes in vocal quality. Improvement of vocal quality and reductions in pain and laryngeal height suggest a relief of tension. Signs of improvement should be obtained during the first session. Generally, if changes do not occur within two sessions, it is unlikely that extralaryngeal muscle tension is the primary explanation of the observed dysphonia.[27] The advantage of this treatment is in that patients who received no benefit from voice therapy can be treated. Secondly, patients are motivated to follow this type of therapy because CMT is probably the most direct approach to ameliorate their voices. Successful treatment outcomes were reported by Roy et al.[41,42,44] In two studies of Roy et al with 17 and 25 subjects, respectively, perceptual and acoustical parameters were measured in a single treatment session over a long-term trial and showed significant voice improvement. Van Lierde et al[45] treated four professional voice users with 25 sessions of CMT. The patients had already received voice treatment without success. All the patients showed improvement of their perceptual vocal quality and dysphonia severity index (DSI). Even though these are promising results, the study groups were small and no RCTs were conducted. Further research is necessary to compare this treatment to voice therapy to delineate the patient group that would benefit from this therapy, establish the number of session of CMT that are necessary to maintain the improved voice quality.

MEDICAL TREATMENT

There are numerous medical conditions that adversely affect the voice and require medical treatment such as upper respiratory tract infection, sinusitis, allergy, and LPR. Some of them may cause MTD (such as LPR) and need appropriate medical treatment. Treatment of LPR involves dietary and lifestyle modifications (eg, reducing body weight, avoiding heavy meals, smoking, and excessive alcohol) plus antiacid medications (proton pump inhibitors).[46] Treatment duration varies between 2 and 6 months. There is still no standardization but a single dose of proton pump inhibitors (PPI) together with lifestyle modifications for 8 weeks has been recommended for most of the patients with LPR.[47]

SURGERY

Surgery plays a minor role when it comes to MTD. However, it can be the right treatment option when organic lesions occur in patients with MTD (eg, secondary MTD) in combination with indirect or direct voice therapy. A close cooperation and efficient exchange of information between the speech language pathologist and the otolaryngologist is crucial. The physician needs to step in when surgery might be needed to interrupt the vicious circle of increased muscle tension in patients with secondary MTD. In this condition, the choice of treatment is substantially influenced by the primary organic pathology rather than the disordered muscle tension.

CONCLUSION

Muscle Tension Dysphonia describes voice disorders in which an increased tension of the (para)laryngeal muscles are the common denominator. Two subgroups are defined: primary MTD and secondary MTD. Primary MTD involves a dysphonia in the absence of organic vocal fold pathology. It is regarded as a functional decompensation due to certain predisposing personality traits and longstanding vocal misuse or abuse, especially in professional voice users. Treatment should be focused on restoring the normal use of the laryngeal musculature. In most of the patients, vocal hygiene and voice therapy with especially the use of circumlaryngeal manipulation are the cornerstone in the treatment of MTD. Secondary MTD indicates a dysphonia in the presence of an underlying organic condition such as LPR, upper respiratory infection, and organic fold lesion. At current point is it not clear whether longstanding MTD leads the development of organic vocal fold pathology or whether organic vocal fold pathology leads to MTD as an overcompensation in an attempt to close the vocal folds. Medical treatment or surgery is in this case the best treatment option in combination with voice therapy. The cause of MTD is thus multifactorial and the treatment demands a multidisciplinary approach. A close cooperation between the speech-language pathologist and the otolaryngologist is necessary. As MTD is not a strictly defined entity, there is no strict protocol in which order treatment options should be offered to the patient. One should also keep in mind that the treatment options are not mutually exclusive but rather complementary. Moreover, adaptations of treatment may be necessary over time and is subject to further research.

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CLINICAL STUDIES

AN EXAMINATION OF SURFACE EMG FOR THE ASSESSMENT OF MUSCLE TENSION DYSPHONIA

AN EXAMINATION OF SURFACE EMG FOR THE ASSESSMENT OF MUSCLE TENSION DYSPHONIA

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ABSTRACT

Objectives. Muscle tension dysphonia (MTD) is the pathological condition in which an excessive tension of the (para)laryngeal musculature leads to a disturbed voice. Surface electromyography (sEMG) was used to investigate differences in extralaryngeal muscle tension in patients with MTD compared with normal speakers. sEMG was examined as a diagnostic tool to differentiate between patients with MTD and controls.

Methods. Eighteen patients with MTD and 44 normal speakers were included in the study. All subjects were evaluated with videostroboscopy, voice assessment protocol, and sEMG. sEMG was performed on three locations of the anterior neck. Measurements were taken during rest, phonation tasks, and while reading, with comparisons made between both study groups.

Results. Patients with MTD did not express higher levels of sEMG during rest, phonation, or reading compared with normal speakers. There were no significant differences in sEMG values between males and females in both study groups.

Conclusion. sEMG was not able to detect an increase in muscle tension in patients with MTD. The results of this study do not support the use of sEMG as a diagnostic tool for distinguishing patients with and without MTD. Clinical examination with laryngeal palpation, videostroboscopy, and dysphonia severity index remain the key investigations.

Key Words: Surface electromyography – Muscle tension dysphonia – Voice disorders.

INTRODUCTION

Muscle Tension Dysphonia (MTD) is one of the most prevalent diagnoses in patients frequenting the ear, nose, and throat (ENT) department for voice disorders[1–3]. MTD is the pathological condition in which an excessive tension of the (para)laryngeal musculature, caused by a diverse number of etiological factors, leads to a disturbed voice[4–6]. Several causes such as (1) technical misuses of the vocal mechanism in the context of extraordinary voice demands, (2) learned adaptations after upper respiratory tract infections, (3) laryngopharyngeal reflux, and (4) certain psychological and/or personality traits, have been cited as contributing factors to the imbalanced muscle activity[7]. However, the underlying etiology of the increased muscular tension of the extralaryngeal muscles in patients with MTD is still poorly understood. It has been hypothesized that the altered tension of the extrinsic musculature in patients with MTD results in a changed position of the larynx in the neck. Because of this altered position, the inclination of the cartilaginous structures of the larynx (thyroid, cricoid, and arytenoid) is disturbed, which affects the intrinsic musculature[8]. Tension of the vocal folds is altered and the voice becomes disturbed.

MTD can be divided into two categories. Primary MTD involves a dysphonia in the absence of concurrent organic vocal fold pathology and is associated with excessive or abnormal laryngeal movements during phonation, without obvious psychogenic or neurologic etiology[9]. Primary MTD occurs primarily in women and accounts for 10–40% of the clinical caseloads at a voice center[7,10,11]. Secondary MTD indicates a dysphonia in the presence of an underlying organic condition[9]. This study focuses on primary MTD.

A few studies have shown that there is a measurable difference in the tension (e.g., an increased tension) of the (para)laryngeal musculature between patients with MTD and healthy subjects[12,13]. These studies used surface electromyography (sEMG), to measure the tension of the supra- and infrahyoidal muscles. Electromyographic investigation enables recording of the collective behavior of motor units lying under the surface electrode. Hočevar-Boltežar et al.[12] evaluated 11 patients with MTD and five normal speakers. Their results showed a 6- to 8-fold increase of EMG activity and an alternation of the EMG activity in the perioral and supralaryngeal muscles before and during phonation in most patients with MTD in comparison with normal speakers. Redenbaugh and Reich[13] examined seven normal and seven vocally hyperfunctional speakers with surface EMG and concluded that the hyperfunctional speakers showed significantly higher EMG values than the normal speakers during rest, vowel phonation, and reading.

The use of sEMG in a population of patients with vocal hyperfunction (e.g. MTD and vocal nodules) has also been investigated by Stepp and colleagues[14,15,16]. Stepp et al.[14] investigated the possible role of vocal hyperfunction in 10 singers with vocal fold nodules, eight nonsingers with nodules and 10 normal speakers using anterior neck sEMG. Surface

EMG during vocal tasks did not differentiate singers or nonsingers with vocal fold nodules from healthy controls. Stepp and colleagues[15] also investigated if sEMG of the anterior neck is sensitive to changes in vocal hyperfunction associated with injection laryngoplasty. Thirteen patients were examined with sEMG before and after injection laryngoplasty for glottal phonatory insufficiency. Anterior neck sEMG was not significantly reduced despite significantly reduced perceptual ratings of strain and false vocal fold compression, reflecting a decrease of vocal hyperfunction. Furthermore Stepp et al.[16] examined 16 participant with vocal hyperfunction (MTD and vocal nodules) with surface EMG and current neck tension rating systems before and after a single session of voice therapy. They concluded that correlations between palpation ratings and anterior neck sEMG were generally low.

This study was undertaken because currently there is no objective tool to evaluate patients with MTD. Surface EMG has not found its way into daily practice despite the positive results of previous research. Therefore this technique was evaluated to establish if sEMG could function as an objective diagnostic tool in the diagnosis of MTD. To date, videostroboscopy is the main technique of investigation, but this does not always allow one to differentiate between patients with and without MTD because the laryngoscopic features of MTD (such as a incomplete posterior glottic closure) may also be present in normal speakers[11]. Furthermore, interrater reliability from videostroboscopy is known to be average to poor[17]. The use of sEMG to monitor changes in neck tension and/or laryngeal position in patients with MTD could lead to more standardized diagnosis and improved information about patient progress. The purpose of this study was to compare the tension of the (para)laryngeal musculature between MTD patients and normal speakers using surface EMG to evaluate the use of sEMG as a diagnostic tool in distinguishing patients with MTD from normal subjects. However, one has to keep in mind that surface EMG only reflects the tensions of the extrinsic laryngeal muscles, and no conclusions can be made regarding the effect on the intrinsic laryngeal muscles.

METHODS

PARTICIPANTS

The patients with MTD were recruited at the ENT Department of the University Hospital in Ghent, Belgium. Eighteen patients with MTD (six men and 12 women, mean age 38.2 years, age range 22–57 years) participated in the study. All patients included in this study were newly diagnosed patients with primary MTD. None of the patients were involved in any (medical or behavioral) treatment aimed at treating MTD.

Diagnosis of MTD was based on following key features: (1) a history of vocal misuse/abuse in context of extraordinary voice demands[4,18,19] psychological influences, and stressful situations[20,21]; (2) a clinical impression of elevated extrinsic laryngeal muscle tension on palpation; (3) voice assessment protocol with a dysphonia severity index (DSI) score below +1.6[22] (Table 1); and (4) features of MTD seen on videostroboscopy (Table 2). Clinical examination included palpation of tension around the larynx. Tightness of the (para)laryngeal musculature, laryngeal rise, decreased thyrohyoid space, and site of focal tenderness were evaluated during rest and phonation[23]. Diagnosis of MTD on videostroboscopy was established when one of following features were present: (1) open posterior commissure with a reduced amplitude and asymmetry of the mucosal waves, (2) a supraglottic contraction in which the ventricular folds are adducted to the midline, (3) an anterior-posterior contraction, which results in a foreshortening of the glottal aperture obscuring the posterior half to two-thirds of the vocal folds, or (4) complete anterior-posterior contraction or squeeze of the supraglottis with approximation of the arytenoids to the petiole: ‘‘sphinteric larynx’’ [24,25](Table 3).

The control population included 44 healthy adult volunteers, including 13 men and 31 women (mean age 35.7 years, age range 20–63 years). None of the control subjects were ever diagnosed with a voice disorder (organic or functional) or received any previous treatment (eg, voice therapy, phonosurgery, or vocal hygiene). Similar to the patient group, the control group was subsequently screened with a palpation of the (para)laryngeal musculature, a videostroboscopy and a voice assessment protocol. All control subjects showed a normal laryngeal and vocal fold anatomy (Table 2) and had a minimum cutoff value of +1.6 on the voice assessment protocol[22] (Table 1).

The study was approved by the Medical Center Ethics Committee. An informed consent was provided for all participants. All participants (patients and controls) were native Dutch speakers with normal speech and language skills. None of them had any hearing defects or any neurological or velopharyngeal abnormalities. All participants were examined by an ENT physician before their participation in the study, and an audiogram was conducted to exclude any severe hearing defects. Persons with a body mass index (BMI) in the obese range based on participants’ self-reported height and weight, were excluded from the study[26]. Other exclusion criteria were (1) acute or chronic upper respiratory infection at the time of testing, (2) a history of cardiac, pulmonary, or neurological problems[27,28], (3) current psychiatric problems or treatment, including medication for treatment of a psychiatric disorder, and (4) a history of laryngeal trauma or surgery[9,29].

Table 1. VHI and voice assessment protocol in patients with MTD and normal speakers

TABLE 1.
VHI and Voice Assessment Protocol in Patients With MTD and Normal Speakers

	MTD Patient		Control	
Feature	Mean	SD	Mean	SD
Voice assessment protocol				
Voice range				
Lowest intensity (dB)	62	5.5	57.84	4.6
Highest intensity (dB)	96.75	5.2	114.14	50.94
Lowest frequency (Hz)	126.2	34.6	116.71	28.72
Highest frequency (Hz)	513.8	141.6	705.62	202.91
Functional frequency F0 (Hz) women	209	30.9	193.58	16.38
Functional frequency F0 (Hz) men	100.8	20.2	112.83	15.44
Aerodynamics				
MPT	16.4	8.4	19.08	7.29
Vital capacity (cc)	2939.9	993.8	3021.14	690.06
Acoustics				
Jitter (%)	2.46	2.00	1276	0.7
Shimmer (%)	4.7	6.3	2.85	1.31
DSI	**−1.53**	3.88	**2.41**	2.06
VHI-10				
VHI functional (five items)	8.11	5.78	1.73	1.62
VHI physical (three items)	7.06	3.42	1.23	1.23
VHI emotional (two items)	4.56	2.66	0.18	0.18
VHI total (0–40)	**19.73**	11.08	**3.14**	3.17

VHI score per question ranging from 0 to 4.

QUESTIONNAIRE, VOICE HANDICAP INDEX, AND VOICE ASSESSMENT PROTOCOL

Participants completed a questionnaire regarding their general health, medical history, sociodemographic and job-related features, ENT problems and vocal complaints. The questionnaire was based on existing questionnaires in the literature[30,31]. The psychosocial impact of the vocal quality, as perceived by the subject, was measured by means of the validated Dutch translation of the Voice Handicap Index (VHI)-10[32]. This instrument assesses a subject’s perception of disability, handicap, and distress resulting from voice difficulties. It consists of 10 questions, which cover emotional (two questions), physical (three questions), and functional (five questions) aspects of the voice. The questions are rated according to a 5-point ordinal scale: never (0), almost never (1), sometimes (2), almost always (3), and always (4). The total score ranges from 0 (no problem perceived) to 40 (Table 1).
A voice assessment protocol was performed evaluating the frequency range (F_0 low–F_0 high), the intensity range (I low–I high), aerodynamics (maximum phonation time (MPT) and vital capacity), and the acoustics (jitter and shimmer) (Table 1). The voice range was measured with the Voice Range Profile from the Computerized Speech Lab (CSL) from Kay (model 4500). The acoustic analysis was performed with the Multi Dimensional Voice Program from CSL (Kay). All measurements took place in a sound-treated room. Based on these results, a

DSI was calculated: (0.13 x MPT) + (0.0053 F_0 high) - (0.26 x I low) - (1.18 x Jitter) + 12.4 [22]. The intraclass correlation coefficient of the DSI is 0.79, and differences in measurements between observers are not significant[33].

VIDEOSTROBOSCOPY

Subject selection was also based upon videostroboscopy. A standardized evaluation protocol was used for all subjects[34] (Table 2). The following characteristics of videostroboscopy were evaluated: symmetry (symmetrical or asymmetrical), regularity (regular, irregular, or inconsistent), glottis closure (complete, incomplete, or inconsistent), type of gap (longitudinal, posterior, anterior, irregular, oval, or hour-glass), amplitude (increased, normal, reduced, or none), and mucosal wave (normal, reduced, or none)[34]. Supraglottic contraction was observed in two directions: medio-lateral (M-L) and anterior-posterior (A-P) using the SERF-protocol[17]. The SERF protocol features a laryngeal image with superimposed laryngeal concentric circles. The rater evaluates the M-L and A-P constriction separately by choosing the numbered circle, which best corresponds to the observed constriction (from 0: no constriction to 4: very severe constriction). An interobserver reliability was used. All samples were rated independently by another ENT-physician. Concordance values were 92.5%.

Table 2. Videostroboscopic features in MTD patients and normal speakers

TABLE 2.
Videostroboscopic Features in MTD Patients and Normal Speakers

Videostroboscopic Feature	Patients With MTD, n (%) n = 18	Control Subjects, n (%) n = 44
Symmetry		
Symmetrical	5 (27.8)	40 (90.9)
Asymmetrical	13 (72.2)	4 (9.1)
Regularity		
Regular	7 (38.9)	40 (90.9)
Irregular	9 (50)	3 (6.8)
Inconsistent	2 (11.1)	1 (2.3)
Glottic closure		
Complete	1 (5.5)	33 (75)
Incomplete	17 (94.5)	11 (25)
Type glottal gap		
Longitudinal	8 (44.4)	2(4.5)
Posterior	8 (44.4)	8 (18)
Anterior	0	0
Oval	0	0
Hour-glass	1 (2.3)	1 (2.3)
Amplitude		
Normal	4 (22.2)	44 (100)
Reduced	14 (77.8)	0
Increased	0	0
Mucosal wave		
Normal	4 (22.2)	44 (100)
Reduced	14 (77.8)	0
None	0	0
A-P constriction		
0	1 (5.6)	25 (56.8)
1	3 (16.7)	17 (38.6)
2	9 (50)	2 (4.6)
3	5 (27.8)	0
4	0	0
M-L constriction		
0	5 (27.8)	34 (77.3)
1	3 (16.7)	8 (18.2)
2	8 (44.4)	2 (4.5)
3	2 (11.1)	0
4	0	0

Abbreviations: A-P, anterior-posterior constriction (0 = no constriction, 4 = severe constriction); M-L, medio-lateral constriction (0 = no constriction, 4 = severe constriction).

Table 3. Frequency distributions of MTD patients compared to normal speakers according to selected characteristics.

TABLE 3.
Frequency Distributions of MTD Patients Compared to Normal Speakers According to Selected Characteristics

	MTD patient		Control		
Variable	%	N	%	N	*P*
Gender					
Male	33.3	6	29.5	13	**0.769**
Female	66.7	12	70.5	31	
Exercise					
No	38.9	7	22.7	10	**0.078**
Yes	61.1	10	77.3	34	
Smoking					
No	88.9	16	95.5	42	**0.573**
Yes	11.1	2	4.5	2	
Alcohol consumption (glasses/day)					
None	22.2	4	4.5	2	**0.130**
1–6 glasses/week	55.4	10	75	33	
1–2	22.2	4	18.2	8	
>2	0	0	2.3	1	
Caffeine consumption (glasses/day)					
None	5.6	1	6.8	3	**0.373**
1–2	50	9	52.3	23	
2–4	22.2	4	34.1	15	
>4	22.2	4	6.8	3	
Allergy					
No	55.6	10	65.9	29	**0.564**
Yes	44.4	8	34.1	15	
Hypertension					
No	94.4	17	95.5	42	**0.866**
Yes	5.6	1	4.5	2	
Voice-demanding hobby					
No	88.9	16	88.6	39	**0.977**
Yes	11.1	2	11.4	5	
Children at home					
No	38.9	7	59.1	26	**0.337**
Yes	61.1	11	40.9	18	
Family history of voice problems					
No	77.8	14	93.2	41	**0.179**
Yes	22.2	4	6.8	3	
Fluid intake per day (glasses)					
0–2	5.6	1	0	0	**0.095**
3–5	27.8	5	27.3	12	
6–8	27.8	5	52.2	23	
>8	38.9	7	20.5	9	

Electromyographic techniques

Bipolar sEMG was used to evaluate the magnitude and pattern of extralaryngeal muscle activation. Muscle activity was investigated during speech and nonspeech experimental tasks. All sEMG recordings were made using the ME 3000 (Mega Electronics Ltd, Kuopio, Finland) and pediatric surface electrodes (Immed Soft Trace 2330-003 Pedia). A four-channel computer-based EMG system with an analog differential amplifier with a preamplifier gain of 375 was used. The Megawin PC software program (MegaWin software version 1.1, Mega Electronics Ltd, Kuopio, Finland) was used to display and analyze EMG signals and data were directly loaded to the computer. Muscle activity (EMG) was quantified in microvolts. EMG signals were band-pass filtered at 10–500 Hz. Signals were sampled at 1000 Hz. The root-mean-square (RMS) voltage, which presents the effective amplitude of the EMG signal was obtained and used for further analysis[26].

Participants were seated comfortably on a chair with back support, knees and hips in 90° flexion. This position was maintained during all procedures. Three pairs of electrodes were placed symmetrically on either side of the midline of each of the subjects. The Ag/AgCl surface electrodes consisted of 10-mm bars with interelectrode distances of 10 mm. Before the placement of the electrodes, the skin was scrubbed with alcohol gauze pads to reduce electrode skin impedance [35-37]. Electrodes were placed in accordance with relevant clinical literature[12,35,38] and parallel to the direction of the muscle fibers. The three electrode sites are: (1) beneath the chin, 1 cm from the midline to capture the activity of the anterior belly of the digastric, mylohyoid, and geniohyoid muscles [37,39]; (2) over the lamina of the thyroid cartilage, next to the midline to capture the activity of the infrahyoid muscles (sternohyoid and omohyoid muscles)[40] and (3) the third pair of electrodes was placed above the sternocleidomastoid muscles [14,15,16]. For the latter pair, a line was drawn from the sternal notch to the mastoid process and divided into three equal distances. The caudal 1/3 was marked and the pair of electrodes was placed adjacent to this mark according to the recommendations of Falla et al[41]. The electrodes were respectively labeled: (1) submental muscles, (2) infrahyoidal muscles, and (3) sternocleidomastoid muscles. Correct placement of the electrodes was confirmed by asking the patients to swallow their saliva (dry swallow)[35]. A ground (reference) electrode was placed on the left clavicula.

It is acknowledged that the muscle activity of the platysma may have been recorded as well[39]. It should be emphasized that sEMG does not allow for the sampling of individual extralaryngeal muscles as it is possible for limb muscles because of small muscle sizes and the multilayered structure of extralaryngeal muscles. Instead sEMG activity from muscle groups was captured. Exact electrode positions vary depending on each participant's laryngeal anatomy. The stability of EMG signals can be affected by numerous factors, including the thickness of the skin, the amount of fatty tissue underlying the skin, the size and properties of underlying muscles, the types of electrodes, and skin preparation[29,39]. Electrodes were all placed by the same ENT physician.

PROCEDURE

The first recording was made at rest over a period of 30 seconds. Next, the participant was asked to produce the vowel /a/ in the following manners at: (1) normal pitch and loudness, (2) loud phonation with a minimum cut off level of 70 dB, (3) silent phonation, (4) high phonation, and (5) low phonation, each of these was for 4 seconds. These exercises were similar to those used in the study of Redenbaugh and Reigh[13]. Each exercise of the vowel phonations was repeated successively three times, to confirm appropriate data display and capture. Intraclass correlation coefficient for each phonation task was >0.90. The central 2-s portion of each vowel phonation was extracted, and the mean RMS values were used for further analysis. After the vowel phonations, the participant was asked to read a fragment of the Dutch translation of the Rainbow Passage. The reading exercise was conducted once and was analyzed over a period of 25 seconds. Finally, maximal sEMG signals were obtained: each subject performed a maximal resisted-force maneuver while seated with his/her chin placed on a stationary platform [13,29]. The speaker was asked to flex his/her neck by exerting a maximal downward force on the platform. Visual feedback of the maximum voluntary contraction (MVC) sEMG recordings was provided for the participants. The MVC was held for 10 seconds and was repeated three times with intermittent one-minute recovery periods to avoid muscle fatigue[42]. Intraclass correlation coefficient for the three trials was >0.90. Mean RMS values of the central 6-s portions were used for further analysis.

STATISTICAL ANALYSIS

All data were evaluated using the statistical program SPSS version 18 (SPSS Inc., Chicago, IL). The background data analysis was performed according to the study of Stepp et al. [16]. The variability associated with differences in neck-surface electrode contact and placement was minimized by normalizing the sEMG to a reference contraction at MVC so that sEMG data gathered could be compared between speakers (eg, subcutaneous fat) and time points [26,29]. All sEMG data were computed as the RMS, and then normalized via MVC using the Megawin Software version 1.1 (Mega Electronics Ltd, Kuopio, Finland). Although studies have shown that for simple, one-joint systems, submaximal contractions are more reliable for normalization[43], it has been proven that the MVC references is more reliable for anterior neck musculature[44]. Consequently, all sEMG data were analyzed in terms of % MVC. Possible baseline differences between groups were examined with chi-square test for the demographics (gender, age, smoking, alcohol, caffeine, etc). Repeated measurement design was used, to investigate significance of the EMG differences between MTD patients and control subjects. The repeated measurement design was used, where per muscle group, the different phonation tasks were compared, within each subject, and with a group effect to see if the MTD group had a different behavior with respect to the control group. Three questions were examined per muscle group: is there a group effect, an interaction effect, and a task effect. Significance level was set at $P < 0.05$.

RESULTS

CHARACTERISTICS OF THE MTD PATIENTS AND NORMAL SPEAKERS

The results reported are based on 18 patients with MTD and 44 normal speakers. The control population consisted of 13 men and 31 women; they ranged in age from 20 to 63 years (mean= 35.7, SD= 13.8). The MTD patients consisted of 12 women and six men; they ranged in age from 22 to 57 years (mean= 38.2, SD= 9.1). There were no significant differences regarding age (P= 0.209) or BMI (P= 0.185) between the patients with MTD and the control group. Women and men are equally distributed in both groups. Table 1 shows that there is no statistical difference in prevalence of demographic features, allergy, hypertension, voice-demanding hobbies, family history, and daily fluid intake between MTD patients and controls.

sEMG VALUES

Figure 1 shows the group medians and interquartile ranges (IQR Q1–Q3) for the EMG ratios for the patients with MTD and the normal speakers during rest, phonation exercises, and reading. Repeated measurement design was used for analysis to fully investigate group effects and muscle interactions. Analysis of each phonation task per muscle group did not show higher EMG levels in the MTD patients compared with the normal speakers. The sEMG rest level was approximately the same for both study groups. None of the phonation exercises or the reading task showed an increased magnitude of the EMG signals in the patient population compared with those in the normal speakers. Gender was taken into the equation but sEMG values did not significantly differ between the sexes. sEMG values were compared between left and right side but did not show significant differences in sEMG values in either the patient group or the control group. Special attention was paid to the reading task. During the reading task, muscle tension was recorded during 25 seconds. The first 5 s were compared with the last 5 s to detect vocal effort or vocal fatigue, however no significant differences could be detected.

The sEMG values of the patients were individually compared with the sEMG values of the control population to delineate subpopulations that could be identifiable with sEMG. Only one patient could be identified with sEMG. This patient exceeded the 95th percentile during the different phonation exercises, both at rest and during reading, indicating that only the most extreme patients would be identifiable with sEMG. This woman was the most dysphonic patient of the study with a DSI of -12.9 and presented with a profound tension of the (para)laryngeal musculature lasting for several months.

Table 4 shows the increases in muscle activity compared with the rest values during phonation (vowel/rest sEMG ratio) and reading (reading/rest sEMG ratio). During phonation at normal pitch and loudness, laryngeal muscle activity increased on average 2–3 times compared with the rest values in both groups. Silent phonation showed the lowest increase in amplitude. Reading showed the highest overall increase in muscle activity (Table 4). During reading and the phonation tasks, the augmentation in muscle activity of the submental and the sternocleidomastoid muscles was similar in both study groups. This was in contrast with infrahyoidal muscles. In the control group, the increase in muscle activity (compared with their rest levels) of the infrahyoidal muscles was significantly higher than in the MTD group (P = 0.050 and P = 0.008 for left and right infrahyoidal muscles, respectively). Thus the range of activity of the infrahyoidal muscles, from rest level to activity level was significantly larger in the control group.

Finally, submental muscle activity was plotted against the infrahyoidal muscle activity during the phonation tasks to detect shifts in laryngeal position because of the predominant muscle tension in one group versus the other group. These ratios did not differ significantly between both study groups.

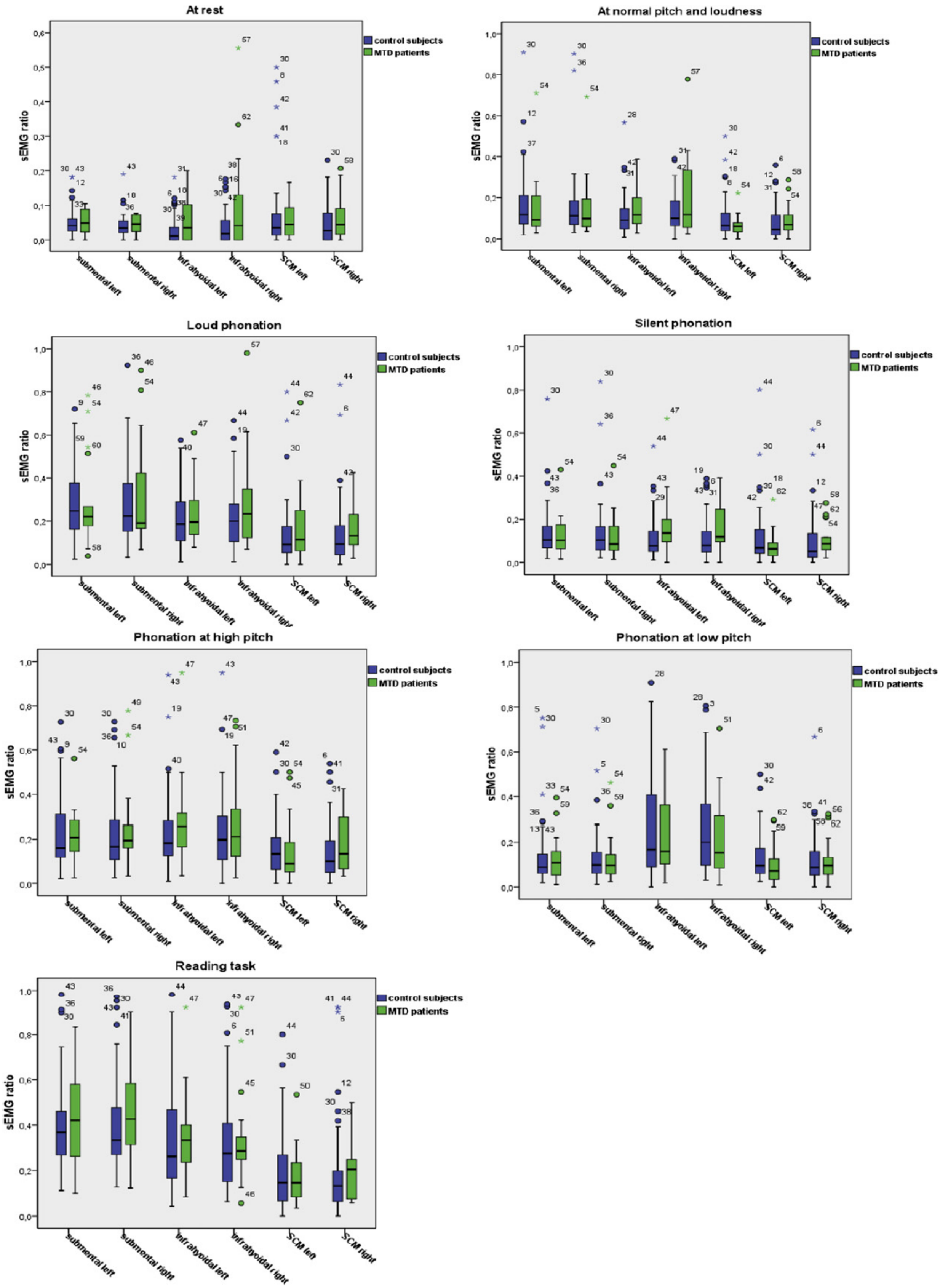

Fig. 1. Box plots of sEMG ratios (eg, sEMG values (μV) during phonation tasks or reading were normalized by the maximal voluntary contraction (μV). Ratios are dimensionless). Horizontal box lines indicate the lower (Q1) and upper quartiles (Q3), with the centerline, the data median. The lower whiskers extend to Q1 – 1.5 IQR; the higher whiskers extend to Q3 + 1.5 IQR. X-axis (from left to right): submental left, submental right, infrahyoidal left, infrahyoidal right, SCM left, SCM right

Table 4. Increase of muscle activity compared with rest values during each phonation task (normal, loud, silent, low and high phonation) and reading.

TABLE 4.
Increase of Muscle Activity Compared With Rest Values During Each Phonation Task (Normal, Loud, Silent, Low, and High Phonation) and Reading

	Submental		Infrahyoidal		SCM	
Phonation Task	Left	Right	Left	Right	Left	Right
Patients with MTD, ratio						
Normal/rest	3	3	2.5	2	2	1.5
Loud/rest	5.6	6.4	4	3	6	2.8
Silent/rest	2.6	2.6	2.8	1.6	2.7	1.8
Low/rest	2.6	2.6	4	2.1	3.3	2
High/rest	4.2	5	5.3	2.8	5	2.8
Reading/rest	8.8	8.8	6	3.5	5.7	3.3
Control subjects, ratio						
Normal/rest	3.3	3.8	3.9	3.2	1.2	1.6
Loud/rest	5.7	6.9	6.1	5.5	1.3	2.8
Silent/rest	2.8	3.6	3.4	2.9	1.1	1.8
Low/rest	2.8	3.2	10	7.1	1.5	3.5
High/rest	4.5	5.4	7.3	6	1.5	3.3
Reading/rest	8.3	10.7	10.8	7.9	1.8	4.2

Ratios are dimensionless.
Abbreviation: SCM, sternocleidomastoid muscle.

DISCUSSION

This study compared relative sEMG levels of three sites of the (para)laryngeal musculature in 18 patients with MTD with a control group of 44 normal speakers. Each subject's rest, vowel, and speech sEMG levels were normalized by using the absolute levels to derive proportions of his/her maximal EMG. Aerodynamic and acoustic measurements, DSI, VHI, and videostroboscopy were obtained, to distinguish between patients with MTD and normal speakers. An increased muscle tension of the laryngeal musculature in patients with MTD could not be demonstrated in the present study using sEMG during either the phonation tasks or the reading exercise. sEMG was not able to differentiate between patients with MTD and control subjects.

These results were in contrast with those reported by Redenbaugh and Reich[13], Hočevar-Boltežar et al.[12] and Stemple et al.[6]. In the study of Redenbaugh and Reich[13] two unipolar surface electrodes were placed ipsilaterally, overlying the thyrohyoid membrane. Patients with MTD demonstrated significantly higher rest, vowel, and speech EMG levels than the normal speakers. In the study by Hočevar-Boltežar et al.[12] nine pairs of unipolar electrodes were fixed to the face and anterior neck. The results showed a 6- to 8-fold increase of EMG activity before and during phonation, in most of the patients with MTD. The study of Hočevar-Boltežar et al.[12] was less decisive than the study of Redenbaugh and Reich[13] and concluded that there were some sEMG characteristics that appeared only in the patients with MTD. The sEMG rest level was the same for the normal speakers as for the patients with MTD. Stemple et al.[6] used sEMG electrodes for biofeedback training in patients with

MTD. The study showed significant differences in general laryngeal muscle tension while speaking and in silence between normal and pathological speakers.

There are several possible explanations for these differences in outcome between the present study and the previous studies.

First, different use of electrodes (unipolar versus bipolar), different electrode placement, and different phonation exercises makes comparison very difficult.

Second, Redenbaugh and Reich[13] was the only study that normalized the EMG data relative to the individual maximal EMG activity of the subject. Such normalization has advantages in a clinical setting where both variability between speakers and variability within a speaker (across sessions) may be considerable. Absolute EMG level comparisons between speakers are inferior because of anatomical and physiological variability[45].

Third, the present study was conducted with newly diagnosed patients with primary MTD, whereas in the studies of Stemple et al.[6] and Hočevar-Boltežar et al.[12] patients with secondary MTD were also included. In the study of Hočevar-Boltežar et al.[12] all (n = 7/7) patients were diagnosed with vocal nodules. In the study of Stemple et al.[6] two patients had a history of vocal contact ulcers, two of vocal nodules, and one of vocal-fold erythema. The inclusion of patients with primary versus secondary MTD could have influenced the results. The pathogenesis of primary versus secondary MTD is under investigation, but it is often assumed that prolonged aberrant vocal use (eg, primary MTD) may lead to the development of secondary organic lesions, such as vocal nodules (eg, secondary MTD)[4,19]. In this regard, secondary MTD can be regarded as more longstanding and more severe than primary MTD, therefore, it may be incorrect to compare results between patients with primary versus secondary MTD.

Fourth, in the studies of Redenbaugh and Reigh[13] and Hočevar-Boltežar et al.[12] all patients had a harsh voice quality, whereas some of the patients of the present study had a DSI close to the normal range (+1.6). It is possible that differences in the severity level of patients between this study and previous studies contribute to the differences in findings. In the present study, every patient who was newly diagnosed at the Voice Clinic with MTD as seen on videostroboscopy was included in the study. This study evaluated the use of sEMG as diagnostic tool for MTD in the current ENT practice, therefore, every patient with MTD was included in the study regardless of the severity of the DSI or the presence of extreme muscle tension as detected by laryngeal palpation. This makes it possible that the overall MTD in this study was less pronounced compared with previous research. In the present study, the only patient with significantly increased sEMG values had a DSI of -12.9. Because she was the only patient exceeding the 95th percentile, this implies that only the most extreme dysphonic cases are identifiable with sEMG. In daily practice, most patients do not present with such severe DSI and would consequently be missed when diagnosing MTD with sEMG.

Finally, negative reports about sEMG in patients with MTD have rarely been published. It is possible that authors neglect to send in their negative result because they contradict the pathophysiology of muscle tension dysphonia. However, negative results have been published. Stepp et al.[15] investigated vocal hyperfunction in thirteen patients who underwent injection laryngoplasty for glottal insufficiency. Anterior neck sEMG was recorded pretreatment and one week after treatment. Despite significantly reduced of perceptual ratings of strain and false vocal fold compression which reflects a decrease in tension of the (para)laryngeal muscles, sEMG values were not significantly reduced after the treatment. Their results did not support the use of anterior neck sEMG to assess muscle tension dysphonia. In another study of Stepp and colleagues[14], sEMG was used in singers with vocal fold nodules, nonsingers with nodules and a healthy control group. sEMG could not differentiate between nodule and control group.

Nonetheless, the pathogenesis of MTD is still under investigation, it is often assumed that patients with MTD have a changed position of the larynx in the neck because of an imbalance of the extralaryngeal muscles[7,18,19]. A higher position in the neck is often attributed to an increased tension of the suprahyoidal muscles[4,19]. An abnormal low position of the larynx is caused by a tight sternohyoid, sternothyroid, omohyoid, and sternocleidomastoid muscle[25]. In the present study, no overall change in muscle tension in the elevators or depressors of the larynx could be found. The results of this study do not suggest a higher or lower position of the larynx in the neck. Submental muscles were plotted to infrahyoidal muscles but ratios were similar in both study groups. These results indicate that there was no predominant muscle tension in the submental group versus the infrahyoidal group pulling the larynx out of its stabile position.

Next, the increase in activity of the different muscle groups was compared with their rest levels, to document the increase in muscle recruitment during phonation. The infrahyoidal muscles showed a significant difference in amplitude between both study groups. Because rest levels were similar in both study groups, this suggests a diminished capacity to increase muscle activity during phonation in the patient group. This could indicate a loss of flexibility of the laryngeal framework. As a result, this imbalance in infrahyoidal muscle activity is interesting and needs further research, although it is insufficient to differentiate patients with MTD from control subjects using sEMG.

The results of this study do not implicate that increased tension of the (para)laryngeal musculature was not present, but rather that sEMG is not the right diagnostic tool to differentiate between normal speakers and MTD patients. sEMG has the advantage of not being invasive, but the disadvantage that it cannot examine the behavior of individual laryngeal muscle fibers or motor units. Therefore, it is possible that individual muscles do have increased tension, but that this was not measurable because of the overlap of surrounding muscles. Sataloff et al.[46] investigated the use of inserted laryngeal EMG in the diagnosis, prognosis, and treatment of laryngeal movement disorders. They concluded that laryngeal EMG was only useful for the injection of botulinum toxin into the thyroartenoid muscle in the treatment of adductor spasmodic dysphonia. There were no evidence-based data to support its use for other laryngeal disorders. If this concern is raised for inserted EMG, then, it certainly cannot be ignored for sEMG.

The following limitations also have to be kept in mind. First, intrinsic laryngeal muscles were not investigated in the present study, therefore, no direct conclusions based on the results of the extrinsic muscles can be drawn regarding the intrinsic laryngeal muscles. Second, the maximal voluntary contraction gesture was flexion of the head against resistance, which was the appropriate gesture for the anterior belly of the digastric muscles and the sternocleidomastoid muscles, but this was not the preferred gesture for the mylohyoid, geniohyoid muscles, and infrahyoidal muscles. A dry swallow would have been more appropriate because this involves hyoid movement. Finally, this study was not blinded, which could have introduced a bias while interpreting the results.

Conclusion

The present study evaluated sEMG characteristics of patients with MTD in comparison with normal speakers, at three different sites of the anterior neck during rest, phonation, and reading tasks. This study did not show any differences in muscle tension, using sEMG between patients with MTD and the control group. Although sEMG is noninvasive and inexpensive, the results of this study do not support its use as a diagnostic tool for distinguishing patients with and without MTD. MTD remains primarily diagnosed on history, clinical examination with laryngeal palpation, videostroboscopy, and DSI.

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UES PRESSURE DURING PHONATION USING HIGH-RESOLUTION MANOMETRY AND 24-H DUAL PROBE PH-METRY IN PATIENTS WITH MUSCLE TENSION DYSPHONIA

UES PRESSURE DURING PHONATION USING HIGH-RESOLUTION MANOMETRY AND 24-H DUAL PROBE PH-METRY IN PATIENTS WITH MUSCLE TENSION DYSPHONIA

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ABSTRACT

Muscle tension dysphonia (MTD) is the pathological condition in which excessive tension of the (para)laryngeal musculature leads to a disturbed voice. This study was developed to investigate if differences in pressure in the upper esophageal sphincter (UES) were present in patients with MTD in comparison with normal speakers. Concurrently, all patients were screened for gastroesophageal reflux disease (GERD) as an associated cause or aggravating factor in MTD. The study's design was a case-control study. Fourteen patients with MTD (mean age = 40.2 years, range = 22–62 years) and 14 adult controls (mean age = 33.9 years, range = 23–58 years) were studied. A water-perfusion assembly with 22 sensors was positioned to record pressures during phonation. The mean values of the phonation pressures at the UES were measured. All patients underwent a dual-probe 24-h ambulatory pH impedance in order to measure the pH and the height of the refluxes from the lower esophageal sphincter to the hypopharynx. There were no significant differences in the UES pressures of patients with MTD compared to those of normal speakers during phonation tasks and reading. Two patients were identified with GERD. In these patients the refluxate reached the UES but this did not influence the UES pressures. We conclude that this study was not able to detect differences in phonation-induced UES pressures between patients with MTD and normal speakers using a standard water-perfusion high-resolution manometry assembly. Future investigation should be focused on developing probes with closely spaced sensors in the hypopharynx and the esophagus in order to investigate if differences in UES pressures in these study populations are present.

Keywords: Manometry - Muscle tension dysphonia - pH-metry – Reflux - Voice disorder - Deglutition - Deglutition disorders

INTRODUCTION

Muscle tension dysphonia (MTD) is a clinical and diagnostic term that describes a spectrum of disturbed vocal fold behavior caused by increased tension of the (para)laryngeal musculature. The altered tension of the extrinsic muscles results in a higher position of the larynx in the neck and a disturbed inclination of the cartilaginous structures of the larynx (thyroid, cricoid, arytenoids), which immediately affects the intrinsic musculature[1]. Tension of the vocal folds is altered and the voice becomes disturbed. MTD is diagnosed when excessive muscle tension leads to a decompensation of the vocal quality and the patient becomes dysphonic. The etiology usually includes a combination of poor vocal techniques, extensive and extraordinary voice use demands, and interacting or secondary psychological factors[2]. Diagnosis is based on a history of vocal misuse/abuse, clinical examination (palpable muscular tension around the larynx), perceptual-acoustic features, and videostroboscopy[3]. Due to increased tension in the laryngeal and suprahyoid muscles, an altered image of the glottic configuration, such as an anterior–posterior or medio-lateral contraction of the glottis, is seen on videostroboscopy. A total squeeze of the larynx is also possible[1]. However, laryngoscopic findings alone may not distinguish patients with MTD from normal subjects and are only one part of a diagnostic evaluation[4].

To the best of our knowledge no previous studies that provide objective data to diagnose MTD have been reported. Based on the pathophysiology of MTD, a persistent phonation with an abnormal laryngeal posture, due to increased (para)laryngeal muscle tension, could lead to an increase in the pressure in the hypopharynx and the upper esophageal sphincter (UES). The increased pressure in the UES could be due to a mechanical squeeze of the sphincter and the pharynx. It is hypothesized that this squeeze is caused by surrounding structures, such as posterior movement of the larynx pressing the sphincter and the hypopharynx against the spine due to increased (para)laryngeal muscle tension[5]. To what extent manometric recordings can document the diagnosis of MTD is worthwhile investigating. Previous research with manometry by Perera et al.[5] showed that phonation in normal speakers was associated with a different magnitude of increase in intraluminal pressure in the UES, esophagus, and lower esophageal sphincter (LES). This phenomenon was observed for both high and low pitch. The change in UES pressure was significantly higher compared with the esophageal body and the LES. The current study is the first to evaluate the effect of phonation on the pressure in the UES in patients with MTD in comparison with normal speakers.

Gastroesophageal reflux disease (GERD) is an important etiologic factor in many inflammatory disorders of the upper aerodigestive tract[6]. The most common otolaryngologic symptoms associated with GERD are hoarseness, dysphagia, globus pharyngeus, chronic throat clearing, cough, and excessive throat mucus[7]. Previous studies have confirmed the high prevalence of GERD in the MTD population[8,9]. In the study of Koufman et al.[8], 70% of the patients with MTD were diagnosed with reflux using 24-h dual-probe pH monitoring. Furthermore, GERD can affect UES pressure. A study by Torrico et al.[10] showed that reflux events were associated with an abrupt increase in UES pressure. Both acidic and nonacidic reflux events induce an UES contraction, but an intraluminal pH drop below 4 augments this contractile response[10].

The UES pressures were investigated because vocal fold lengthening is influenced not only by the (para)laryngeal muscles but also by the cricopharyngeus and the thyropharyngeus which constitute the UES[11]. The purpose of this study was to investigate if UES pressures in patients with MTD were significantly higher in comparison with those of normal speakers. All patients with MTD were screened for GERD.

Methods

Subjects

The patients with MTD were recruited at the ENT department of the University Hospital in Ghent, Belgium. Fourteen patients (3 men and 11 women) with MTD participated in the study. Their ages ranged from 22 to 62 years (mean = 40.2 years). Selection of the patients with MTD was based on four key features: (1) a history of vocal misuse/abuse, psychological influences, and stressful situations; (2) clinical examination; (3) voice assessment protocol; and (4) videostroboscopy. Clinical examination included palpation of tension around the larynx. Tightness of the (para)laryngeal musculature, laryngeal rise, decreased thyrohyoid space, and site of focal tenderness were evaluated during rest and phonation[12]. All patients were newly diagnosed patients with primary MTD as conducted in previous research[13, 14]. None of the patients was previously diagnosed with GERD or took proton pump inhibitors.

The control population included 14 healthy adult volunteers (3 men and 11 women). The age range was 23–58 years (mean = 33.9 years). None of the subjects was ever diagnosed with a voice disorder (organic or functional) or received any previous treatment (e.g., voice therapy, phonosurgery, vocal hygiene). Similar to the patient group, the control group was subsequently screened with a palpation of the (para)laryngeal musculature, a videostroboscopy and a voice assessment protocol. All control subjects showed normal laryngeal and vocal fold anatomy, normal mucosal wave and amplitude (cfr. infra), and had a minimum value of > 1.6 on the voice assessment protocol, which was the cutoff point to distinguish normal from abnormal voices[15].

The study was approved by the Medical Center Ethics Committee of the University Hospital in Ghent, Belgium (2010/075). Written informed consent was obtained from all subjects. All participants (patients and controls) were native Dutch speakers with normal speech and language skills. None had any hearing defects or any neurological or velopharyngeal abnormalities. All participants were examined by an ENT physician prior to their participation in the study and an audiogram was conducted to exclude any hearing defects. Other exclusion criteria were (1) acute or chronic upper respiratory infection at the time of testing; (2) a history of cardiac, pulmonary, or neurological problems; (3) a history or symptoms of systemic disease known to affect the nervous or endocrine systems; (4) current psychiatric problems or treatment including medication for treatment of a psychiatric disorder; and (5) a history of laryngeal trauma or surgery.

VOCAL COMPLAINTS, VOICE HANDICAP INDEX (VHI) AND REFLUX SYMPTOM INDEX (RSI)

All participants completed a questionnaire regarding their general health, medical history, sociodemographic and job-related features, and vocal complaints. The psychosocial impact of vocal quality, as perceived by the subject, was measured by means of the validated Dutch translation of the Voice Handicap Index-10 (VHI)[16]. This instrument assesses a subject's perception of disability, handicap, and distress resulting from voice difficulties. It consists of 10 questions that cover emotional (2 questions), physical (3 questions), and functional (5 questions) aspects of the voice. The questions are rated according to a 5-point ordinal scale: never (0), almost never (1), sometimes (2), almost always (3), and always (4). The total score ranges from 0 (no problem perceived) to 40.

Symptoms related to GERD were questioned using the Reflux Symptom Index (RSI)[7,1], which is a 9-item instrument that documents symptoms of patients with laryngopharyngeal reflux (LPR). The questions are rated according to an ordinal scale ranging from (0) no problem to (5) severe problem. An RSI of more than 13 is considered to indicate GERD[7].

OBJECTIVE VOICE ASSESSMENT

A voice assessment protocol was performed, evaluating the frequency range (F_0 low-F_0 high), the intensity range (I_{low}-I_{high}), aerodynamics [maximum phonation time (MTP) and vital capacity (VC)], and the acoustics (Jitter and Shimmer). The voice range was measured with the voice range profile from the Computerized Speech Lab (CSLTM) model 4500 (KayPENTAX, Lincoln Park, NJ). The acoustics analysis was performed with the Multi Dimensional Voice Program (MDVP) from the CSL. All measurements took place in a sound-treated room. Based on these results, a Dysphonia Severity Index (DSI) was calculated: $(0.13 \times MPT) + (0.0053 \times F_0 \text{ high}) - (0.26 \times I_{low}) - (1.18 \times Jitter) + 12.4$[15]. The intraclass correlation coefficient of the DSI was 0.79, and differences in measurements between observers were not significant[18].

VIDEOSTROBOSCOPY

A videostroboscopy was performed in all subjects. A standardized evaluation protocol was used[19]. The following characteristics of videostroboscopy were evaluated: symmetry (symmetrical or asymmetrical), regularity (regular, irregular, or inconsistent), glottis closure (complete, incomplete, or inconsistent), type of gap (longitudinal, posterior, anterior, irregular, oval, or hourglass), amplitude (increased, normal, reduced, or none), and mucosal wave (normal, reduced, or none)[19]. Supraglottic contraction was observed in two directions, medio-lateral (M-L) and anterior–posterior (A-P), using the SERF protocol[20]. The SERF protocol features a laryngeal image with superimposed laryngeal concentric circles. The M-L and A-P constrictions were evaluated separately by choosing the numbered circle that best corresponds to the observed constriction (0 = no constriction, 4 = very severe constriction). An interobserver reliability was used. All samples were rated independently by two ENT physicians (EVH and SC). Concordance values were 92.5%.

EXPERIMENTAL PROTOCOL: MANOMETRY

Manometric data at the UES during rest, swallow, and phonation were collected using a water-perfused assembly with a 4.2-mm outer diameter. The silicone catheter had a total of 22 recording side holes (Dentsleeve, Ontario, Canada). The catheter contained 15 microlumina to monitor the pharynx, the UES, and the esophageal body (spacing = 2 cm); six channels 1 cm apart (virtual sleeve) for the LES; and one channel for gastric recording (placed 5 cm below the LES). The assembly was perfused with degassed, distilled water by a low-compliance pneumohydraulic perfusion pump at a water perfusion rate of 0.15 ml/min (Solar GI HRM, Medical Measurements Systems, B.V., Enschede, the Netherlands). Pressure zeroing was done before each study. The data-acquisition frequency was 20 Hz for each sensor. Pressure data were acquired and shown using software especially designed for high-resolution manometry (HRM; Medical Measurements Systems ver. 8.17), which displays isobaric contour plots on three-dimensional views that resemble topographic plots of geographical elevations. The pressure measurement with high-resolution manometry consisted of two parts: the first part was focused on swallowing and the second part on phonation. The evaluation of the swallows was included solely to establish that none of the participants had a swallowing disorder. All subjects were investigated after a fasting period of at least 4 h. The nasal cavity was anaesthetized with 2% topical lidocaine. The manometric catheter was passed transnasally into the esophagus and was withdrawn stepwise until the virtual sleeve was localized in the LES. Positioning of the catheter was verified by the topographic contour display before beginning the swallowing and phonation exercises. The catheter was fixed in place by taping it to the nostril. The LES pressures were referenced to the gastric pressure and all other pressures were referenced to atmospheric pressure. For the first part of the examination, the patient was in a supine position. The patient was asked 10 times to swallow a small amount of water (5 cm^3) in order to evaluate the swallowing function. For the second part of the examination, the patient was placed in an upright sitting position. The first recordings were made at rest over 10 s in order to establish the rest pressures. Next, vocal exercises were performed. The participant was asked to produce the vowel /a/ as follows: (1) at normal pitch and loudness, (2) loud phonation with a minimum cutoff level of 70 dB, (3) silent phonation, (4) high-pitch phonation, and (4) low-pitch phonation, each for 4 s. Each vowel exercise was repeated successively three times to confirm appropriate data display and capture. After these vowel phonations, the participant was asked to read a fragment of the Dutch translation of the Rainbow Passage. The reading exercise was conducted once and was analyzed over a period of 25 s. During all recordings, a marker was placed to demarcate the beginning and end of each exercise. The pressures recorded at the UES of patients with MTD and the normal speakers during the different types of phonations were compared.

EXPERIMENTAL PROTOCOL: 24-H DUAL-PROBE PH IMPEDANCE

Gastroesophageal reflux was studied using ambulatory 24-h impedance-pH measurements in patients with MTD. This technique allows detection of all reflux events, regardless of acidity (acid/ weakly acid /nonacid) or composition (liquid/gas/mixed). This combined technique of impedance and pH monitoring is more accurate in detecting both acid and nonacid reflux than is pH monitoring alone. Esophageal impedance-pH monitoring was performed using an Omega multichannel intraluminal impedance ambulatory system (Medical Measurement Systems). The system includes a portable data logger with impedance-pH amplifiers and two catheters. The first catheter was placed in the esophagus, with the pH electrode 5 cm above the LES. This catheter contained one pH electrode and eight impedance rings at 2, 4, 6, 8, 10, 14, 16, and 18 cm from the tip of the catheter. The second catheter contained seven impedance electrodes. The two catheters were aligned, with 2 cm between the last electrode of the first catheter and the first electrode of the second catheter in order to establish continuity. Each pair of adjacent electrodes represents an impedance-measuring segment, 2 cm in length, corresponding to one recording channel. Impedance recordings were made from 3 to 27 cm above the LES in a total of 11 impedance channels. The impedance-pH monitoring was performed on an outpatient basis after an overnight fast. Before the start of the recordings, the pH sensor was calibrated using pH 4.0 and pH 7.0 buffer solutions. After locating the LES by esophageal manometry, the impedance-pH catheter was passed transnasally under topical anesthesia and positioned in the esophageal body to record pH at 5 cm proximal to the LES. Subsequently, the second impedance catheter was placed in alignment with the first. Both impedance electrodes were externally taped together at the nostril and fixed behind the ear. Upon discharge, subjects were encouraged to maintain normal activities and sleep schedule and eat their usual meals at their normal times. Subjects were provided with a diary chart to record with precision their food and medication intake, symptoms, and periods of lying down. Subjects were also asked to press the appropriate button on the portable device when eating, experiencing symptoms, and sleeping. The data stored on the memory card were transmitted to a computer and analyzed with the assistance of dedicated software (Virtual Instructor ProgramTM ver.8.17, Medical Measurement Systems). Analysis included identification, enumeration, and characterization of individual reflux events. Reflux episodes were characterized by pH-metry as acidic (pH<4), weakly acidic (pH 4–7) and nonacidic (pH>7). All reflux events were analyzed with the patient in both upright and supine positions. Meals were excluded for the analysis. The following parameters were used for statistical analysis:

percentage of total time that pH was lower than 4, total number of reflux episodes, and DeMeester score (a score composed of six parameters used to calculate the degree by which the patient's reflux pattern differs from the norm)[21].

Statistical Analysis

All data were evaluated using the statistical program SPSS ver. 18 (SPSS Inc., Chicago, IL). Possible baseline differences between study groups were examined using Student's t-test for the following variables: demographics (gender, age, smoking, alcohol, caffeine), Reflux Index Score (RSI), Voice Handicap Index (VHI), videostroboscopy, and voice assessment protocol. The median UES pressures were used for statistical analysis. Significance level was set at $P<0.05$. The Mann–Whitney U nonparametric test was used to investigate significance differences in median, minimum, and maximum UES pressures between MTD patients and control subjects.

Results

Subjects

The results are based on 14 patients with MTD and 14 normal speakers. Both study groups consisted of 11 women and 3 men and were comparable in age ($z = -1.842$, $P = 0.069$). Table 1 shows that there is no statistical difference in prevalence of lifestyle, allergy, family history, and daily fluid intake between MTD patients and controls.

Vocal Complaints, Voice Handicap Index, and Reflux Symptom Index

Vocal complaints (hoarseness, vocal fatigue, loss of voice, loss of vocal control, diminished voice range, pain after speaking, globus sensation, dry mouth while speaking) were all significantly more severe in patients with MTD (Mann–Whitney U test, $P<0.001$ for all complaints) than in the control group.
The psychosocial impact of vocal quality, as perceived by the subject, was measured by means of the validated Dutch translation of the Voice Handicap Index-10 (VHI)[15]. This instrument assesses a subject's perception of disability, handicap, and distress resulting from voice difficulties. Patients with MTD scored significantly higher on functional ($P<0.001$), physical ($P<0.001$), and emotional items ($P<0.001$). In total, patients scored 15.42 out of 40 compared with 0.50/40 for the normal speakers ($P<0.001$).

The Reflux Symptom Index (RSI) documents symptoms of patients with laryngopharyngeal reflux (LPR). An RSI of more than 13 is considered to indicate GERD[7]. The normal speakers scored an average of 1.79, while patients scored significantly higher on the RSI ($P<0.001$) with an average of 18.21 (see Table 2).

Table 1. Frequency distributions of MTD patients compared to normal speakers according to selected characteristics

Variable	MTD patients		Controls		*P*
	%	*N*	%	*N*	
Gender					
Male	21.4	3	21.4	3	1.000
Female	78.6	11	78.6	11	
Exercise					
No	50	7	21.4	3	0.236
Yes	50	7	78.6	11	
Smoking					
No	92.9	13	92.9	13	1.000
Yes	7.1	1	7.1	1	
Alcohol consumption					
None	42.9	6	28.6	4	0.605
1–6/week	35.7	5	57.1	8	
1–2/day	21.4	3	14.3	2	
>2/day	0	0	0	0	
Caffeine consumption (per day)					
None	7.1	1	21.4	3	0.464
1–2	42.9	6	57.1	8	
2–4	28.6	4	14.3	2	
>4	21.4	3	7.1	1	
Allergy					
No	64.3	9	57.1	8	0.699
Yes	35.7	5	42.9	6	
Hypertension					
No	92.9	13	100	14	1.000
Yes	7.1	1	0	0	
Voice-demanding hobby					
No	85.7	12	85.7	12	1.000
Yes	14.3	2	14.3	2	
Family history of voice problems					
No	92.9	13	85.7	12	1.000
Yes	7.1	1	14.3	2	
Fluid intake per day (glasses)					
0–2	0	0	7.7	1	0.537
3–5	28.6	4	15.4	2	
6–8	42.9	6	30.8	4	
>8	28.6	4	46.2	6	

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

OBJECTIVE VOICE ASSESSMENT

The voice assessment protocol separated patients with MTD from normal speakers. The voice range assessment showed that patients with MTD had a significantly decreased intensity range (I_{low}: P = 0.015 and I_{high}: P = 0.030) and a diminished capacity to reach high frequencies (P = 0.036) in comparison with normal speakers. The aerodynamics (maximum phonation time and vital capacity) and the acoustics analysis (Jitter and Shimmer) were similar for dysphonic and healthy individuals. The Dysphonia Severity Index (DSI) was significantly lower in patients with MTD compared with the control population (-0.98 in patients with MTD versus 3.20 in controls, P<0.001).

Table 2. Reflux Symptom Index, Voice Handicap Index and voice assessment protocol in patients with MTD and normal speakers

Feature	MTD patients		Controls		*P*
	Mean	SD	Mean	SD	
Reflux Symptom Index					
Hoarseness or a problem with voice	4.07	0.91	0.43	0.64	<0.001***
Clearing your throat	3.14	1.16	0.21	0.42	<0.001***
Excess throat mucus or postnasal drip	2.64	1.33	0.43	0.64	<0.001***
Difficulty swallowing food, liquids, pills	0.79	1.36	0.0	0.0	0.098
Coughing after eating or after lying down	0.79	0.97	0.07	0.26	0.041*
Breathing difficulties or choking episodes	1.07	1.20	0.07	0.26	0.039*
Troublesome or annoying cough	1.36	1.08	0.14	0.36	0.003**
Sensation of something sticking in throat or lump in throat	2.36	1.33	0.0	0.0	<0.001***
Heartburn, chest pain, indigestion or stomach acid coming up	2.0	1.51	0.43	0.93	0.040*
Total (0–45)	18.21	5.76	1.79	2.29	<0.001***
Voice Handicap Index-10					
Functional (5 items, score /20)	5.43	5.34	0.36	0.74	0.015*
Physical (3 items, score /12)	6.00	2.98	0.14	0.36	0.001***
Emotional (2 items, score /8)	4.00	2.18	0	0	<0.001***
Total (0–40)	15.42	9.64	0.50	0.94	<0.001***
Voice assessment protocol					
Voice range					
Lowest intensity (dB)	62.07	7.13	56.79	2.86	0.015*
Highest intensity (dB)	96.07	11.39	103.14	4.99	0.030*
Lowest frequency (Hz)	124.58	28.96	119.51	31.44	675
Highest frequency (Hz)	621.83	250.8	783.49	139.9	0.036*
Functional frequency (Hz), women	192.90	18.7	193.55	23.68	0.761
Functional frequency (Hz), men	95.84	9.7	95.26	6.61	0.827
Aerodynamics					
Maximum phonation time (MPT) (s)	16.6	9.09	21.17	9.15	0.241
Vital capacity (cm^3)	2776.92	774.76	2779.08	1158.5	0.605
Acoustics					
Jitter (%)	2.18	2.20	1.21	0.70	0.201
Shimmer (%)	4.78	6.70	3.05	1.71	571
Dysphonia severity index (DSI)	−0.98	4.31	3.20	1.27	<0.001***

An RSI of more than 13 is considered to indicate LPR

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Videostroboscopy

All participants were examined with videostroboscopy using standard protocols[19,20]. Results are given in Table 3. Amplitude and mucosal wave of the vocal folds were significantly decreased in the MTD patients versus the control group (χ^2 = 9.33, df = 1, P = 0.006 and χ^2 = 9.33, df = 1, P = 0.006, respectively). Supraglottic contraction was observed in two directions: medio-lateral (M-L) and anterior–posterior (A-P). A more pronounced anterior–posterior contraction was observed (χ^2 = 20.31, df = 3, P<0.001) in patients with MTD. The medio-lateral contraction was also significantly increased in the MTD patients compared with the normal speakers (χ^2 = 15.05, df = 3, P<0.001). Among the 14 normal speakers, 13 presented with complete closure and 1 presented with a posterior gap. In the 14 patients with MTD, 2 patients presented with complete closure, 6 presented with a longitudinal gap, 4 with a posterior gap, 1 with an anterior gap, and 1 with an hourglass gap.

Table 3. Videostroboscopic features in MTD patients and normal speakers

Video stroboscopic feature	MTD patients [*N* (%)]	Controls [*N* (%)]	*P*
Symmetry			
Symmetrical	5 (35.7%)	14 (100%)	<0.001***
Asymmetrical	9 (64.3%)	0	
Regularity			<0.001***
Regular	5 (35.7%)	14(100%)	
Irregular	9 (64.3%)	0	
Inconsistent	0	0	
Glottic closure			<0.001***
Complete	2 (14.2%)	13 (92.9%)	
Incomplete	12 (85.8%)	1 (7.1%)	
Type glottal gap			<0.001***
Longitudinal	6 (42.8%)	0	
Posterior	4 (28.6%)	1 (7.1%)	
Anterior	1 (7.1%)	0	
Oval	0	0	
Hourglass	1 (7.1%)	0	
Amplitude			0.006**
Normal	4 (28.6%)	12 (85.7%)	
Reduced	10 (71.4%)	2 (14.3%)	
Mucosal wave			0.006**
Normal	4 (28.6%)	12 (85.7%)	
Reduced	10 (71.4%)	2 (14.3%)	
None	0	0	
A-P constriction			<0.001***
0	1 (7.1%)	12 (85.7%)	
1	2 (14.3%)	2 (14.3%)	
2	6 (42.9%)	0	
3	5 (35.7%)	0	
4	0	0	
M-L constriction			<0.001***
0	3 (21.4%)	13 (92.9%)	
1	4 (28.6%)	1 (7.1%)	
2	3 (21.4%)	0	
3	4 (28.6%)	0	
4	0	0	

A-P anterior–posterior constriction (0 = no constriction, 4 = severe constriction), *M-L* mediolateral constriction (0 = no constriction, 4 = severe constriction)

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

24-H DUAL-PROBE IMPEDANCE-PH MONITORING

All patients with MTD were screened for GERD using 24-h impedance-pH monitoring. This technique allows identification of all reflux events regardless of acidity (acidic, weakly acidic, and nonacidic reflux). The individual results are given in Table 4. Thirteen out of fourteen patients scored positively on the Reflux Symptom Index (RSI). However, only two patients (one man and one woman) were diagnosed with GERD using impedance-pH monitoring. These two patients scored more than 14.72 on the DeMeester score which is the 95th percentile of the normal value[21]. The female patient had a DeMeester score of 22.28 and showed an anterior–posterior contraction of the glottis on videostroboscopy. In this patient, no laryngopharyngeal reflux (LPR) could be detected. None of the reflux events reached the UES (see Table 4). The male patient had a DeMeester score of 59.07 and was diagnosed with an extreme anterior–posterior and medio-lateral contraction of the glottis (i.e., squeeze). In this patient, no acidic events reached the UES but four weakly acidic events did reach the UES.

Table 4. Demographic characteristics (age, gender), Reflux Symptom Index (RSI) and individual results of 24-h Dual probe impedance-pH monitoring and number of proximal reflux events (27 cm above LES)
An RSI of more than 13 is considered to be positive[7]. A total number of < 50 reflux episodes in 24h is the cutoff normal value[21]
[a] Patient 3 had a DeMeester score of 59.07 and was diagnosed with an extreme anterior-posterior and mediolateral contraction of the glottis
[b] Patient 5 had a DeMeester score of 22.98 and showed an anterior-posterior contraction of the glottis

No.	Age (years)	Gender	RSI	DeMeester score	Total reflux time in 24 h (%)	No. of reflux episodes in 24 h	No. of impedance events	Acid reflux (%)	Acidic events 27 cm above LES (*n*)	Weakly acidic reflux (%)	Weakly acidic events 27 cm above LES (*n*)	Nonacid reflux (%)	Nonacidic events 27 cm above LES (*n*)
1	36	M	24	7.79	2.2	25.3	40	25	0	72.5	0	2.5	0
2	54	M	23	10.19	3	49.2	123	54.5	1	43	0	2.5	0
3	46	M	17	59.07[a]	14.5	76.3	315	15.9	0	83.5	4	0.6	0
4	39	F	27	13.72	5	11.7	19	21	0	79	0	0	0
5	41	F	14	22.28[b]	8.3	46.9	74	54	0	46	0	0	0
6	41	F	14	4.68	1.4	9.2	21	42.9	0	47.6	0	9.5	0
7	28	F	16	3.66	1.3	20.7	59	35.6	0	64.4	0	0	0
8	41	F	21	1.26	0.2	9.3	45	17.8	1	55.5	0	26.7	0
9	22	F	18	8.81	1.8	20	48	57.1	0	42.9	0	0	0
10	62	F	27	7.37	2.7	16.6	24	50	0	50	0	0	0
11	33	F	18	3.28	0.9	19.4	37	27	0	70.3	2	2.7	0
12	36	F	8	1.37	0.2	10	118	5.9	0	84.7	0	9.4	0
13	32	F	18	1.53	0.3	8.1	43	11.6	0	37.2	0	51.2	0
14	33	F	10	1.42	0.2	11	58	3	0	90	0	7	0

PRESSURES IN THE UES

The group medians and interquartile ranges (IQR Q1–Q3) for the median, minimum, and maximum UES pressures for patients with MTD and normal speakers during rest, vocal exercises, and reading are given in Table 5. The Mann–Whitney U test was used for analysis and could not demonstrate significant differences in UES pressure between the study groups. None of the vocal exercises nor the reading task showed an increase in UES pressure in the patient population versus the control group (Fig. 1). Subsequently, the UES pressures of the genders were compared but did not differ significantly between the patient population and the control group.

Table 5. Phonation-induced UES pressures during vocal exercises and reading between MTD patients and control population

UES pressure	MTD patients		Controls		*P*
	Median (mmHg)	IQR (Q1–Q3) (mmHg)	Median (mmHg)	IQR (Q1–Q3) (mmHg)	
At rest					
Mean	62.5	45.7–111.2	73.0	54.0–94.5	0.455
Max	95.0	65.7–128.0	98.0	75.0–153.0	0.565
Min	43.0	31.2–87.7	45.0	32.5–74.5	0.639
At normal pitch					
Mean	82.5	60.9–122.2	73.3	55.6–97.3	0.375
Max	108.7	79.6–162.7	115.7	69.3–135.6	0.641
Min	64.8	53.5–101.1	64.3	55.5–83.5	0.972
Loud pitch (>70 dB)					
Mean	80.8	55.2–143.1	74.0	61.5–97.5	0.641
Max	94.8	69.2–185.7	96.3	77.6–128.0	0.766
Min	66.3	51.0–89.7	61.7	50.5–85.5	0.729
Silent pitch					
Mean	79.3	61.5–135.1	74.7	60.5–140.5	0.981
Max	92.6	68.1–168.4	105.0	78.5–178.7	0.830
Min	67.5		61.7	47.7–94.1	0.952
Low pitch					
Mean	93.3	73.8–131.9	90.3	60.6–122.5	0.650
Max	134.5	98.4–181.1	114.3	77.0–147.6	0.343
Min	67.0	46.5–90.2	81.3	46.8–103.0	0.793
High pitch					
Mean	106.3	74.1–163.3	67.0	51.8–146.0	0.264
Max	120.3	105.5–211.1	76.7	60.3–192	0.186
Min	79.3	46.8–96.1	53.3	44.5–88.1	0.441
Reading					
Mean	79.0	61.5–104.0	78.0	58.0–102.5	0.722
Max	132.0	119.5–176.0	126.0	84.5–180.5	0.579
Min	35.0	26.0–48.5	35.0	21.5–56.5	0.850

IQR interquartile range

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Table 6 shows the increases/decreases in UES pressure compared to the rest UES pressure during phonation tasks (vowel/rest UES pressure ratio) and reading (reading/rest UES pressure ratio). Patients with MTD had an overall higher increase in UES pressure compared to their rest UES values than the normal speakers. The UES pressure in normal speakers was shown to be rather stable during the phonation task and reading, whereas in the patients with MTD there was always a considerable increase in UES pressure. However, these differences were not statistically significant, except for the high phonation task. At the high pitch, there was a significant difference (P = 0.027) between patients with MTD and control subjects. There was a significant increase in UES pressure compared to rest UES pressure in patients with MTD (high pitch/rest ratio = 1.70), whereas normal speakers had a small decrease in UES pressure compared to their rest UES pressure (high pitch/rest ratio: 0.91).

Table 6. Increase of UES pressure compared to rest values during each phonation task (normal, loud, silent and low and high phonation) and reading

Table 6 Increase of UES pressure compared to rest values during each phonation task (normal, loud, silent, and low and high phonation) and reading

UES pressure	MTD patients	Controls	*P*
Normal/rest ratio	1.32	1.00	0.252
Loud/rest ratio	1.29	1.01	0.231
Silent/rest ratio	1.26	1.02	0.274
Low/rest ratio	1.49	1.23	0.131
High/rest ratio	1.70	0.91	0.027*
Reading/rest ratio	1.26	1.06	0.252

Ratios are dimensionless

* $P < 0.05$

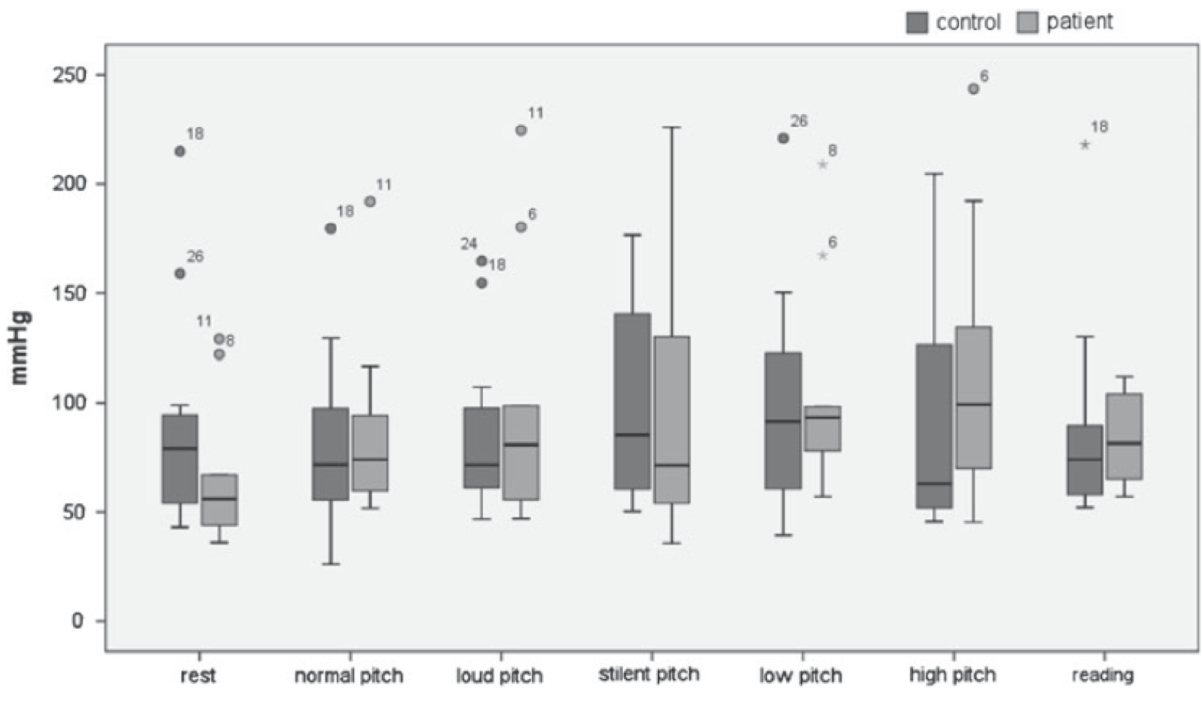

Fig 1. Median UES pressures (mmHg) between patients with MTD and normal speakers during rest phonation exercises and reading. Horizontal box lines indicate the lower (Q1) and upper quartiles (Q3), with the centerline the data median. The lower whiskers extend to Q1 – 1.5IQR; the higher whiskers extend to Q3 + 1.5IQR. The numbered dots are outliners

DISCUSSION

To our knowledge, this is the first study to use high-resolution manometry in order to establish differences in UES pressure in normal speakers versus patients with MTD. Currently, diagnosis is based on a patient's history, palpable tension during clinical examination, an objective voice assessment, and videostroboscopic features such as a posterior open chink, supraglottic medio-lateral or anterior–posterior contraction, or a squeeze of the glottis[1]. However, some of these findings are also seen in normal speakers[4]. Therefore, there is a need for an objective tool for evaluating patients with MTD. This study aimed to test the possibility of high-resolution manometry (HRM) as diagnostic tool in patients with MTD. HRM measures the pressure from the UES to the stomach and is used in patients with dysphagia to detect esophageal dysfunctions such as achalasia, esophageal spasm, and nutcracker esophagus. These disorders are caused by an imbalance in esophageal muscle activity. Since MTD is considered a dysphonia caused by an imbalance of the (para)laryngeal musculature, this study intended to detect the difference in manometric results of patients with MTD versus normal speakers.

More than 100 years of research in this area has established that the contribution of the (para)laryngeal muscles to voice production is significant[11]. The strap muscles (sternothyroid and hyothyroid) and the inferior pharyngeal muscles [cricopharyngeal (CP) and thyropharyngeal (TP)] are directly connected to the larynx. The suprahyoid muscles (digastric, mylohyoid, geniohyoid, hyoglossus, and genioglossus) as well as the infrahyoid muscles (sternohyoid and omohyoid) have an indirect effect on the larynx. As regards vocal fold biomechanics, it is important to notice that with the exception of the cricopharyngeus, the forces produced by the extrinsic laryngeal muscles act directly on the thyroid cartilage. Changes in the relationship between thyroid and cricoid cartilage require new adjustments of the neighboring muscles. The suspended mechanism must also be stabilized within the whole framework of the larynx. Vocal fold lengthening is influenced not only by the cricothyroid muscles but also by esophageal musculature and the TP muscle, which approximates the thyroid laminae and thus moves the anterior fixation point of the vocal folds forward[11]. The CP and the TP make up the UES: the CP constitutes the lower one third of the UES and the TP the upper two thirds. The CP muscle has a significant role in adjusting the length of the vocal folds[11]. The CP consists of circular and ascending fibers. The fibers encircling the esophagus are attached to the cricoid cartilage; the ascending fibers run from the cricoid cartilage cranially and are attached to the centrum tendineum of the posterior pharyngeal wall, running to the base of the skull. Considering this anatomy, it is possible that the circular fibers may contract the esophageal sphincter and that the cranially running fibers attached to the centrum tendineum may pull the cricoid cartilage posteriorly and cranially[11]. This study hypothesized that an altered position of the thyroid and cricoid cartilage due to increased tension of the (para)laryngeal musculature may alter the pressure in the UES of patients with MTD. Using high-resolution manometry, UES pressure was measured during different phonation exercises and reading and was compared with normal speakers.

This study could not detect a difference in phonation-induced UES pressure between the MTD patients and the control group. A number of explanations for these findings need to be considered.

First, the results of this preliminary study could have been influenced by the probe that was used. In this investigation, a water-perfused assembly with a regular probe was tested in order to evaluate the clinical usefulness of the standard HRM equipment as a diagnostic tool for MTD. This catheter contains 22 side holes of which one records in the stomach, 6 closely spaced side holes (1 cm apart) measure the LES, and the remaining 15 side holes cover the esophageal body and the UES at a 2-cm spacing. This study showed that traditional manometry with 2-cm-spaced unidirectional sensors cannot provide adequate information regarding anatomic variations such as those seen in patients with MTD. However, it is still possible that HRM is a reliable method for evaluating MTD if a specific closely spaced probe is developed. Based on this pioneering work, a 1-cm-spaced probe would be capable of recording pressure in asymmetric structures, offering the spatial and temporal resolution necessary to accurately capture rapidly changing pressures throughout the pharynx without anatomic variations and moving structures. Analyzing pressure across the pharyngoesophageal segment during phonation should reveal additional and perhaps subtle findings that were previously undetectable with traditional manometry.

Second, this study hypothesized that the altered inclination of the thyroid and cricoid cartilage due to increased tension of the extrinsic laryngeal musculature leads to an increased tension of the thyropharyngeus and the cricopharyngeus. However, since no previous work has been conducted using manometry in patients with MTD, it is unclear if these subtle changes in the tension in the TP and CP lead to a detectable difference in pressure in the UES. It could be possible that even with specifically developed probes, pressures differences are too small to detect using manometry.

Third, only a small number of participants was studied and a small sample size can lead to errors in interpretation of the results. In the future, larger study groups should be investigated. Since this is the first study to evaluate UES pressure during phonation in patients with MTD, comparison with previous work is not possible. Moreover, despite much research concerning water-perfused HRM, there are no normal UES resting values available. The study groups were also too small to investigate any relationship between the presence of GERD and the type of MTD. Future research is needed to investigate the relationship between the presence of GERD and the type of MTD seen on videostroboscopy.

Fourth, the lack of higher UES pressure in patients with MTD could be bound intrinsically to the restrictive phonation capacity of the patients versus the normal speakers. All participants were asked to maintain vowel phonation for 4 s. However, a substantial number of the patients were not able to sustain phonation for 4 s, whereas normal speakers all reached the time limit. Since very little is known about the physiology of the UES during phonation, it could be possible that pressure is built up during sustained phonation. Therefore, it could be possible that the patients did not reach their maximum UES pressure whereas normal speakers built up tension to reach the 4 s. Keeping this in mind, it is possible that the mean UES pressure of the MTD patients remains lower than the built up pressure of the control population.

Finally, it could be that there are simply no differences in UES pressures to be detected. The pathogenesis of MTD is still poorly understood. To what extent the increased tension in the extrinsic and intrinsic laryngeal muscles influences the CP and TP is currently unknown. It is very well possible that the altered tension remains limited to the larynx and that CP and TP do not play a role in MTD. However, before drawing any firm conclusions, further research is needed.

The UES pressures during phonation were compared to UES resting pressures (= vowel/rest UES pressure ratio) and evaluated between patients with MTD and the control group. The change in UES pressure ratio during phonation at high pitch was shown to be significantly different. Patients with MTD showed a significant increase in UES pressure ratio, whereas the control subjects had a small decrease in UES pressure ratio during high-pitch phonation. This may indicate that patients with MTD try harder (or even force themselves) to reach the high frequencies which may result in squeezing the larynx and a consequential increase in UES pressure. The difficulty in reaching the high frequencies can also been seen in the voice assessment protocol. The patients with MTD do not succeed in reaching the same highest frequencies as the control group. This is an interesting finding that needs to be researched further.

All patients underwent a dual-probe 24-h impedance-pH monitoring in order to establish the role of GERD in MTD. Intraluminal electrical impedance is a recently developed technique that allows the monitoring of the flow of acid and nonacid liquids and/or gas within the gastrointestinal tract. Dual-probe pH monitoring provides additional information about the occurrence of proximal esophageal reflux events. GERD is a known cause and aggravating factor of laryngeal and voice disorders. This is possibly due to reflux-generated increased tension in the intrinsic and extrinsic laryngeal musculature[12]. Since esophageal stimulation is shown to produce a reflex laryngeal contraction[22] and globus sensation is thought to be due to reflux-induced pharyngeal muscle tension[6], it seemed important to question whether the pharyngeal constrictor tension is higher in reflux patients. When gastric acid regurgitates through the esophagus into the laryngopharynx, airway protective mechanisms are triggered resulting in closure of the glottis, coughing and choking, and tightening of laryngopharyngeal constrictor muscles, especially the cricopharyngeus. A porcine animal study demonstrated a direct reflex relationship between stimulation of the lower esophagus and thyroarytenoid muscle activity[22]. The study of Angsuwaransee and Morrison[12] showed a strong relationship between thyrohyoid muscle tension and GERD, specifically in patients with an inappropriate anterior–posterior contraction of the supraglottis (MTD type 3). This contraction might be a protective mechanism to shield the airway from acid reflux. Angsuwaransee and Morrison[12] argued that longstanding GERD might cause MTD type 3 or, in other words, MTD type 3 might be one of the laryngeal manifestations of reflux. Morrison[2] also found an association between reflux and MTD. In the current study, all patients were tested for GERD but only two were shown to have GERD. Using dual-probe impedance, regurgitate (acid, weakly acid, and nonacid) reaching the UES can be evaluated. In the two GERD positive patients of this study, one showed to have four weakly acidic reflux event reaching the UES over a period of 24 h. A study in 40 healthy volunteers showed that at least some pharyngeal reflux events occurred in most of them, mainly when they were in the upright position[23]. The low prevalence of GERD in patients with MTD in this study contrasted with previous research. Koufman et al.[8] detected GERD in 18 of 23 (78%) patients with MTD. The high prevalence in that study can be explained by the fact that only patients with both symptoms and video stroboscopic findings of LPR (such as laryngeal edema, hypertrophy of the posterior commissure, erythema, granulation) underwent 24-h dual-probe pH monitoring. This selection of patients made it more likely that GERD would be detected. Koufman et al.[8] also noted that their center is recognized as one that is particularly experienced in the diagnosis and management of LPR and this may have biased their study population. In the study of Altman et al.[9], 49% of the patients were identified as having GERD. However, the diagnosis of GERD was based on the patients' personal complaints or laryngoscopic findings but was not objectively documented with pH-metry. Nonspecific laryngoscopic signs such as erythema and edema are the two most common findings for diagnosing laryngopharyngeal reflux, but laryngeal findings depend on the use of rigid versus flexible laryngoscopy, and the presence of erythema showed low interrater reliability[24]. In the current study, each patient with MTD was screened for GERD regardless of their symptoms or findings on videostroboscopy. The results show that when patients with MTD present with only vocal complaints and do not show any further signs of LPR on videostroboscopy, abnormal reflux testing will be less frequent. The two GERD-positive patients of this study did not have higher levels of UES pressures at rest or during phonation. One of the patients with GERD had anterior–posterior contraction of the glottis and the other patient had extreme supraglottic contraction (i.e., squeeze). However, these laryngoscopic features were also seen in the other patients who had normal impedance-pH monitoring. It has been widely recognized that MTD is a multifactorial disease[9,25]. However, based on the results of this study, GERD plays a minor role when symptoms and videostroboscopic features of GERD are absent.

CONCLUSION

This was the first study to investigate UES pressures with high-resolution manometry during phonation in patients with MTD. Differences in UES pressures between patients with MTD and normal speakers could not be obtained using a standard water-perfused HRM assembly.

Further research in a larger group and with purpose-designed closely spaced probes must be encouraged in order to measure subtle changes in pressure in the UES in patients with MTD. When complaints or laryngoscopic features of GERD are absent, a positive impedance pH-metry will be less frequent and attention should rather be paid to incorrect vocal techniques.

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GENERAL DISCUSSION

GENERAL DISCUSSION

Voice is essential for human communication and involves accurate coordination of numerous muscles for voluntary production of voice, swallowing and breathing [1]. Nearly one-third of the population has impaired voice production at some point in their lives [2, 3]. Voice disorders are more prevalent in professional voice users such as teachers, but all age groups and both genders can be affected [2-4]. Patients suffer from social isolation, depression and reduced disease-specific and general quality of life [5, 6]. In addition to the impact on health and quality of life, voice disorders have significant public health implications. Voice disorders lead to frequent health care visits and significant financial costs due to work-related absenteeism. In the general population, 7.2% of the individuals missed work for one or more days within the preceding year because of a problem with their voice [2]. Among teachers, this rate increases to 20 percent [7, 8].

Functional voice disorders account for 10-40% of the cases referred to multidisciplinary voice clinics [9, 10]. Most functional voice disorders implicate a pathological condition in which excessive tension of the laryngeal musculature leads to muscle tension dysphonia (MTD). The high prevalence, significant individual and societal implications and lack of consensus make functional dysphonia, and more specifically MTD, an important subject for an up-to-date research. Therefore, we conducted this thesis.

The first purpose of this thesis was to evaluate functional dysphonia and its distribution (occupation-gender-age) in a treatment-seeking population with dysphonia in Flanders. In the second part of the thesis we further investigated professional voice users, more specifically teachers. We evaluated occupational vocal risk factors in teachers and the consequences of the voice disorders regarding treatment-seeking behavior and voice-related absenteeism. In the third and clinical part of the thesis we evaluated the use of surface EMG and UES manometry as a diagnostic tool for MTD.

FUNCTIONAL VOICE DISORDERS IN A TREATMENT-SEEKING POPULATION WITH DYSPHONIA

The prevalence of functional voice disorders in a treatment-seeking population with dysphonia at a Voice Clinic in the Ghent University Hospital was investigated. Data of 882 patients over a period of 5 years were collected and analyzed. Laryngeal pathology was diagnosed using videostroboscopy and divided into twelve categories. Voice disorders were most frequently reported in the working population (age groups 25-44 and 45-64 years). The group mostly visiting the ENT department was the age group 45-64 years (34.3%, n=303/882). Laryngeal pathologies were significantly more common in females than in males, representing 63.8% (n=563/882) and 36.2% (n=319/882) of the population. These results support the statement that women are more vulnerable for developing voice disorders than men. It has been hypothesized that this is due to differences in their laryngeal anatomy. Women have shorter vocal folds and produce voice at a higher fundamental frequency. Consequently, there is less tissue mass to dampen a larger amount of vibrations. At the molecular level, women have less hyaluronic acid in the superficial layer of the lamina propria. Hyaluronic acid plays an important role in wound repair. Lower amount of hyaluronic acid in the female vocal cords may indicate that a reduced wound-healing response is possible [11].

In our study, functional voice disorders were most frequently diagnosed (30%), followed by vocal fold nodules (15%) and pharyngolaryngeal reflux (9%). The high number of functional voice disorders may be due to the growing awareness of the importance of vocal quality on daily functioning. The workforce population (= age groups of 25-44 and 45-64 years) was divided into three main categories: professional voice users (41%), non-professional voice users (52%) and unemployed and disabled people (7%). Professional voice users accounted for 41% of the workforce population with teachers as the main subgroup. Functional voice disorders rose up to 41 % in the group of professional voice users. Compared to the nonprofessional voice users, they suffered from approximately twice as many functional voice disorders (41% vs. 24.3%) and vocal fold nodules (15% vs. 6.2%), probably due to the cumulative effect of vocal use and misuse. We concluded that functional voice disorders were the most common diagnosis in patients with dysphonia frequenting the ENT department in all age groups (except children).

The results of this study attracted attention to two major subjects: the high prevalence of functional dysphonia and the large group of professional voice users seeking medical attention for their voice disorder. These results stress the importance of further research towards etiology, diagnostic and therapeutic management of this type of dysphonia, especially in professional voice users. The diagnosis of functional dysphonia is often subjective as objective criteria for its diagnosis are missing.

VOICE DISORDERS IN PROFESSIONAL VOICE USERS

The prevalence study conducted at the ENT department, showed that professional voice users were a substantial part of the treatment-seeking population with dysphonia. Patients were labeled as professional voice users when they depend on their voice as main working tool. Teachers accounted for more than half of the professional voice users. The abundant number of teachers frequenting the ENT department underlined the need for further investigation in this subgroup.

In chapter 4.1 we investigated vocal risk factors related to both the personal life of the teacher and their work environment. We found that 51.2% of the teachers presented a

voice disorder at some point during their career, which was consistent with previous reports [12-14]. Female teachers reported more voice disorders than male teachers. Vocal risk factors were a family history of voice disorders, temperature changes in the classroom, the number of pupils per classroom and noise level inside the classroom. It is important to identify these risk factors since voice disorders are a multifactorial disease and voice therapy alone will not be sufficient. The patient with functional dysphonia needs to be informed how he can adapt his behavior and environment in order to reduce the voice disorder. Awareness of these vocal risk factors can make early intervention possible.
We also found that teachers with voice disorders presented with higher psychological distress compared with teachers without voice disorders. An association between psycho-emotional factors and voice disorders was documented in this study. However, it is not possible to say whether the stress should be considered causal, correlational or consequential to the voice disorder. More detailed research is needed to evaluate the direction of this association. It was not the intention of this study to investigate the psychological correlates of voice disorders but merely to point out that psychological factors should not be neglected when treating a dysphonic patient. Failure to recognize psychological factors may limit long-term success of the treatment.

Analysis of the consequences of voice disorders in teachers (chapter 4.2) revealed that a substantial number of teachers sought medical help (25.4%) and were obligated to stay at home because of voice disorders (20.6%). Female teachers were significantly more likely to seek medical help and to stay at home in comparison with their male colleagues. Nonetheless teachers are professional voice users, only a small percentage (13.5%) received any kind of information of vocal use during their training to be a teacher.

The results of this epidemiologic study provide valuable information regarding the prevalence of voice disorders, risk factors contributing to voice disorders, functional impact and consequences of voice disorders in Belgian teachers. When assessing a patient with a voice disorder, vocal risk factors should be thoroughly questioned and addressed in order to improve treatment. Patients with functional dysphonia, especially professional voice users, are often referred to a speech-language pathologist which is their only treatment option. Unfortunately, duration of voice therapy is long and therapy failure is high [9]. If occupational, emotional or personality features contributing to the voice disorder remain unchanged during/after voice therapy, it would be logical that such persistent factors increase the risk of future recurrences [15]. Furthermore education and prevention programs, targeting specific populations at high risk of developing a voice disorder, should be implemented in the training for teachers. Attention should be focused on prevention by use of efficient vocal techniques and vocal hygiene (increase daily fluid intake, decrease alcohol and caffeine consumption, stop smoking, avoid yelling, etc). An inefficient phonation technique (e.g. strained phonation, decreased resonance, incorrect breathing, etc.) is one of the most important factors in the pathogenesis of occupational dysphonia [16]. Inefficient voicing in professional voice users leads to rapid voice deterioration, development of functional and, later on, organic disorders adversely affecting their ability to work [17]. The effectiveness of preventive strategies (such as vocal hygiene training and vocal function exercises) has already been documented by previous research [18].

EVALUATION OF DIAGNOSTIC TOOLS FOR PATIENTS WITH MUSCLE TENSION DYSPHONIA

Muscle tension dysphonia is a voice disorder characterized by an increased tension or dysregulation of the muscles in and around the larynx [19, 20]. The diagnosis of primary MTD is used to describe those patients with (para)laryngeal hyperfunction in absence of organic and/or neurologic disorders. It is important to remember that MTD is not a synonym for patients with a functional voice disorder but specifically defines those patients with dysphonia caused by an excessive tension of the (para)laryngeal muscles.

Diagnosis of MTD is based upon history taking, palpable laryngeal tension, a videostroboscopy and a voice assessment protocol with digital manipulation of the larynx. The characteristics of MTD often have limited diagnostic value because other voice disorders can have similar auditory-perceptual elements or videostroboscopic features. The features of MTD (especially open posterior chink) can also exist in nondysphonic subjects [21]. Furthermore, laryngeal palpation and videostroboscopy in patients with MTD both depend on the experience of the investigator. Therefore, it is important to identify objective measures that capture the core features of MTD and are not typically evidenced in people without voice disorders.

SURFACE EMG

Phonation demands a fluent and synchronized movement of the vocal folds. Small intrinsic laryngeal muscles are responsible for the movement of arytenoid cartilages and thus for vocal fold adduction, abduction, and tension. The larger extrinsic musculature (suprahyoid and infrahyoid muscles) maintain the larynx in a stable and natural position in which the intrinsic laryngeal musculature can contract freely and undisturbed. It is generally stated that an altered tension of the extrinsic laryngeal musculature may disturb the function of the intrinsic laryngeal musculature [22-24]. In patients with MTD, an altered tension of the extrinsic musculature results in a changed position of the larynx in the neck (a mostly higher position) and a disturbed inclination of the cartilaginous structures of the larynx that immediately affects the intrinsic musculature. Tension of the vocal folds is altered and the voice becomes disturbed [25]. When individuals demonstrate increased intrinsic laryngeal muscle tension, it is thought that they simultaneously contract the extrinsic laryngeal muscles in a similar hyperfunctional manner. However, current assessment methods of neck muscle tension depend on tactile measures [26], which are subjective and lack a dynamic range of measurement. Therefore, the use of sEMG as a diagnostic tool for MTD was investigated. The implementation of sEMG to monitor changes in neck tension in patients with MTD could lead to a more standardized care and improved information about patient progress.

Surface EMG was performed on three locations of the anterior neck (respectively the submental muscles, infrahyoidal muscles and the sternocleidomastoid muscles). The results of patients with MTD (n=18) were compared to subjects without MTD (n=44). Patients with MTD did not express higher levels of sEMG during rest, phonation or reading compared with normal speakers. sEMG values were compared between left and right side but did not show significant differences in either the patient group or the control group. There were no significant differences in sEMG values between males and females in both study groups. Furthermore, this study does not suggest a higher or lower position of the larynx in the neck in this specific group of patients with MTD. Submental muscles were plotted against infrahyoidal muscles but ratios were similar in both study groups. These results indicate that there was no predominant muscle tension in the submental muscle group versus the infrahyoidal muscle group pulling the larynx out of its stable position. In contrast with the non-significant results of the average sEMG values during voicing, we found a significant difference in muscle activity range (= the increase in muscle activity from rest level to phonation level). We found that the infrahyoidal muscles of patients with MTD had a significant smaller increase in muscle activity from rest level to phonation level compared to subjects without MTD. Because rest levels were similar in both study groups, this suggests a diminished capacity to increase muscle activity during phonation in the patient group. This indicates that the infrahyoidal muscles in patients with MTD are more hypertonic and that there is a loss of flexibility in the laryngeal framework in patients with MTD. Coordinated interaction among submental and infrahyoidal muscles is needed to control the position of the larynx and other laryngeal positions such as laryngeal tilt. The (para)laryngeal muscles need to be able to contract and relax in an appropriate manner so that the delicate intrinsic musculature can work effectively. In this studies we found an reduced muscle recruitment from rest level to phonation level in the infrahyoidal muscles, interfering with their normal functioning. An altered tension of the (para)laryngeal muscles may alter the tension or angle between laryngeal cartilages and thereby changing the resting lengths of the intrinsic muscles [1]. This decreased capacity to contract during phonation, especially when reaching the high frequencies, can be described as a loss of flexibility in the larynx of patients with MTD.

The results of this study do not support the use of sEMG as a diagnostic tool in the assessment of MTD. This was in contrast with the 2 previous conducted studies [27, 28]. However, these studies were limited by task, electrode location, populations and some methodological failings (e.g. single electrode placement, a lack of variety in speech tasks, a disordered population, lack of normalization of sEMG signals). The evidence of the clinical utility of EMG as an objective indicator of hypertension of the (para)laryngeal muscles is therefore not compelling. In our study, attention was paid to these shortcomings but we could not withhold their positive results. More recent studies conducted by Stepp and colleagues [29-31] also reported negative results concerning the use of sEMG as a diagnostic tool for MTD. Based on our results and recent publications[29-31], we suggest that sEMG should not be used as a diagnostic tool for MTD. However, sEMG can still play a role in the investigation of the pathophysiology of MTD. Our results showed that the infrahyoidal muscles in patients with MTD are more hypertonic. This might indicate that patients with MTD are recruiting anterior neck musculature in a different manner than normal speakers.

HIGH-RESOLUTION MANOMETRY

Since no overall increase in laryngeal tension could be detected on the outside, we investigated if altered tension could be noted internally at the level of the UES (upper esophageal sphincter). The UES pressures were investigated because vocal fold lengthening is influenced not only by the (para)laryngeal muscles but also by the cricopharyngeal muscle and the thyropharyngeal muscle which constitute the UES [32]. The cricopharyngeal muscle and thyropharyngeal muscle are attached to the cricoid and thyroid cartilage respectively. The extrinsic laryngeal muscles are responsible for the position of the larynx in the neck. A changed (mostly higher) position of the larynx in the neck and a narrowed thyrohyoid space have been considered as features of MTD [24, 25]. This study hypothesized that an altered position of the thyroid and cricoid cartilage, due to increased tension of the (para)laryngeal musculature, may alter the pressure in the UES of patients with MTD. The UES pressure was recorded using high-resolution manometry.

We investigated if differences in UES pressure were present in patients with MTD in comparison with normal speakers. Measurements were recorded during rest, phonation tasks and reading. The average UES pressures during rest and the phonation tasks were not significantly different between the patients with MTD and the control group. However, during phonation, there was an increase in UES pressure compared to the UES rest pressure (vowel/rest UES pressure ratio), which was more pronounced in patients with MTD than in the control group. In the control group, alterations in the UES pressure are rather subtle whereas in the patients with MTD there is a substantial increase in UES pressure. This increase is most pronounced when reaching the highest frequencies. This might indicate that, when there is a normal tension of the laryngeal musculature, there is a balanced interaction between pharynx and larynx during voicing. However, when the tension of the laryngeal musculature is altered (mostly increased), the flexibility between larynx and pharynx is reduced and they become to work as one segment with subsequent changes in the UES pressures. Patients with MTD try harder (or even force themselves) to reach the high frequencies which may result in squeezing the larynx and a consequential increase in

UES pressure. The UES is built up of the thyropharyngeal muscles and the cricopharyngeal muscles which are attached to the thyroid and cricoid cartilage respectively. A higher position of the larynx is considered as a feature of MTD. It could be hypothesized that this higher laryngeal position is thereby pulling on the TP and CP and thereby creating a higher tension in the UES during phonation. It might be worthwhile not only to further investigate the higher laryngeal position in patients with MTD but also a possible dorsal position of the larynx, pressing on the UES.

The hypothesis of the 'loss of flexibility of the larynx and pharynx' coincides with the results we found in the first study with sEMG. The significant lower increase in activity range of the infrahyoidal muscles might also indicate a loss of flexibility in the laryngeal framework in patients with MTD. The range of mobility of the cartilaginous structure has been limited due to an overall changed tension in the laryngeal muscles. Consequently, there is lesser space for the vocal folds to be lengthened, shortened, opened and closed. The larynx is now blocked and the voice becomes disturbed. This pilot study was the first to investigate the UES pressure during phonation in patients with MTD. Our results suggest that future research with specially designed probes can be useful in the exploration of patients with MTD. In patients with MTD, focus should not be restricted to the extrinsic and intrinsic laryngeal muscles but also to surrounding structures such as the UES.

Each patient was also investigated with a 24h impedance pH-metry. Gastro-esophageal reflux was investigated because reflux is a known cause and aggravating factor of voice disorders [33] and reflux events are associated with an increase in UES pressure. Both acidic and nonacidic reflux events can induce an UES contraction [34]. Furthermore, high prevalences of GERD in MTD patients (up to 70%) has been documented by previous research [22, 35]. In our study, two out of fourteen patients tested positive for GERD detected by impedance pH-metry. The two GERD-positive patients did not have higher levels of UES pressures at rest or during phonation. In these GERD positive patients, an anterior-posterior and an extreme anterior-posterior contraction (squeeze) of the larynx were seen on videostroboscopy. However, no conclusion can be drawn regarding the relation of the presence of reflux and the videostroboscopic image due to the small number of subjects. In the future, it is worthwhile to investigate if the presence of reflux is associated with certain videostroboscopic features. It has been suggested that reflux provokes an anterior-posterior contraction of the larynx in order to protect the larynx against reflux [26].

General Conclusion

Patients with functional voice disorders represent a large part of the treatment-seeking population with dysphonia. The task of the ENT specialist is to sort out factors that are predisposing and sustaining the dysphonia, and to apply terminology that best describes the relevant ongoing pathological process for each patient in a view to select the optimal treatment protocol. In order to do so, a framework with correct epidemiological data, identification of vocal risk factors, understanding of the impact on the patients personal life and a objective diagnostic tool for MTD needs to be present.

This thesis demonstrates that functional dysphonia is the most prevalent voice disorder in a treatment-seeking population with dysphonia, especially in professional voice users. This thesis also shows that certain risk factors (personal, occupation-related and environmental) influence the development of voice disorders in teachers. Furthermore, voice disorders in teachers are associated with higher levels of psycho-emotional distress, a significant need for medical consult and a high prevalence of voice-related absenteeism. This implies an important burden for the patient as well as for the society. Only a fraction of the teachers received information about vocal use during their training. We suggest that education and prevention programs should be implemented in the training of future professional voice users.

Notwithstanding the high prevalence and significant consequences of functional dysphonia, objective criteria for its diagnosis are missing. Within the group of functional dysphonia, we focused our research on muscle tension dysphonia. MTD is a voice disorder caused by an imbalanced/dysregulated activity of the paralaryngeal musculature. We evaluated the use of surface EMG and high-resolution manometry as a diagnostic tool for MTD. The use of sEMG in muscle tension dysphonia has been under investigation in the past decades but results remain inconclusive. Our study could not detect differences in the average laryngeal muscle tension between both study groups. Based on the results of the current study, we suggest that sEMG cannot be used as diagnostic tool for patients with MTD. However, we found that the infrahyoidal muscles of patients with MTD had a significant smaller increase in muscle activity from rest level to phonation level compared to subjects without MTD. This indicates that the infrahyoidal muscles in patients with MTD are more hypertonic, suggesting that there is a loss of flexibility in the laryngeal framework in patients with MTD. In the study of the HRM, we compared the UES pressure of patients with and without MTD. The average UES pressures were not significantly different between the patients with MTD and the control group. However, during phonation, there was an increase in UES pressure ratio (= vowel UES pressure/rest UES pressure ratio), which was more pronounced in patients with MTD than in the control group. In the control group, alterations in the UES pressure are rather subtle whereas in the patients with MTD there is a substantial increase in UES pressure. This might indicate that when the tension of the laryngeal musculature is altered, the flexibility between larynx and pharynx is lost and they become to work as one segment with subsequent changes in the UES pressures. This was the first study to investigate UES pressure using HRM during phonation in patients with MTD. Further research needs to be conducted with more adapted, specialized probes in order to evaluate HRM as a diagnostic tool for MTD (cfr. future perspectives).

We concluded that when assessing a patient with a functional voice disorder a strict voice protocol should be used. First, a thorough history taking of the patient needs to elucidate all vocal risk factors (work-related and personal) and the impact/consequences of the voice disorder on the patient's life. Secondly, a clinical ENT examination including a laryngeal palpation needs to be performed. Thirdly, a videostroboscopy is performed using a standard protocol [36]. Fourthly, a logopedic voice assessment with digital manipulation of the larynx is conducted by a speech-language pathologist. Finally, a thorough management of a voice disorder can only be accomplished by a multidisciplinary team. A close cooperation of the ENT specialist and the speech-language pathologist, psychologist, neurologist, general practitioner, pneumologist, etc. is necessary in order to obtain the best medical care for the dysphonic patient. In the future, an objective diagnostic tool to evaluate patients with MTD should be added to this protocol.

FUTURE PERSPECTIVES

High-resolution manometry is an indispensable diagnostic tool in swallowing disorders. However, research assessing its use in the evaluation of voice disorders is very rare. The pilot study of this thesis was, to our knowledge, the first to evaluate the use of HRM in patients with MTD. Results did not show a significant difference in average UES pressures in patients with MTD versus subjects without MTD. However, since this was a pilot study and the first of its kind, several limitations could have lead to the negative results. Future research should address these limitations in order to explore the diagnostic value of this technique in patients with MTD. First of all, a closely spaced probe is needed in order to record the rapid changes in the UES. The probe that is used to evaluate swallowing disorders in our University Hospital is a water-perfused system which records pressure at a spacing of 2 cm. For the pharyngeal segment and the UES, a spacing of maximum 1 cm should be used. Solid-state manometry is preferred because it can detect rapid changes in the UES and the pharynx in comparison with water-perfused systems. Furthermore, solid-state transducers can be circumferential and thereby measuring pressures from different sides and averaging the values, instead of recording from only one direction. Secondly, more attention should be paid to underlying/aggravating swallowing disorders in the population with MTD. During swallowing, the UES relaxes and opens during superior and anterior movement of the larynx (due to contraction of the suprahyoidal muscles) and closes during laryngeal descent. In patient with MTD, it is generally stated that the larynx is in a higher position with a narrowed thyrohyoid space. Consequently, it can be assumed that this higher laryngeal position interferes with UES opening and closing. In this thesis, we focused on voice disorders and we might have underevaluated swallowing disorders. In future research, more attention should be paid to (minor) swallowing problems/discomfort and globus sensation in patients with MTD. In our study, the subjective complaints (= increased reflux symptom index) do not correlate with the objective finding on the 24-h pH-impedance metry. This implicates that patients with MTD have an altered sensation in the larynx/UES that cannot be assigned to reflux. Future research investigating UES pressure during phonation tasks as well as during swallowing in patients with MTD with and without reflux needs to be conducted.

Magnetic resonance imaging (MRI) could be another interesting technique to investigate anatomical differences in patients with MTD. A recent study used MRI to analyze the vocal tract morphometry of women with vocal fold nodules compared to normal female subjects [37]. Their results showed that (1) the laryngeal vestibule was significantly smaller in the dysphonic group, (2) the distance between the right and left vocal process of the arytenoids' cartilages was smaller and (3) the distance between the anterior commissure of the glottis and the laryngeal posterior wall was significantly smaller in the dysphonic group compared to the normal subjects [37]. Results obtained from this study suggests that patients with vocal fold nodules may present a constantly increased tension of the laryngeal muscles, even at rest. Moreover, reduced anterior-posterior dimension of the larynx may be a morphological characteristic of patients with vocal fold nodules. Since vocal fold nodules are considered as a manifestation of vocal hyperfunction[20], it would be of interest to investigate if these changes seen on MRI are also present in patients with MTD.

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VOORDRACHTEN OP WETENSCHAPPELIJKE CONGRESSEN

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