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EFFECT OF VOICE TRAINING & THERAPY

CONTENT AND DOSAGE

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Effect of voice training and voice therapy: content and dosage

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The human voice is the instrument we all play.
It is the most powerful sound in the world.
- Julian Treasure -

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List of publications

This thesis is based on the following articles published in or submitted to international peer reviewed journals:

1. Meerschman, I., D'haeseleer, E., De Cock, E., Neyens, H., Claeys, S., & Van Lierde, K. (2016). Effectiveness of chewing technique on the phonation of female speech-language pathology students: a pilot study. *Journal of Voice,* 30(5), 574-578. IF: 1.381, Q3.
2. Meerschman, I., Bettens, K., Dejagere, S., Tetaert, L., D'haeseleer, E., Claeys, S., & Van Lierde, K. (2016). Effect of two isolated vocal facilitating techniques chant talk and pitch inflections on the phonation of female speech-language pathology students: a pilot study. *Journal of Voice,* 30(6), 771.e17-771.e25. IF: 1.381, Q3.
3. Meerschman, I., D'haeseleer, E., Catry, T., Ruigrok, B., Claeys, S., & Van Lierde, K. (2017). Effect of two isolated vocal facilitating techniques glottal fry and yawn-sigh on the phonation of female speech-language pathology students: a pilot study. *Journal of Communication Disorders,* 66, 40-50. IF: 1.348, Q1.
4. Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. (2017). Short-term effect of two semi-occluded vocal tract training programs on the vocal quality of future occupational voice users: "resonant voice training using nasal consonants" versus "straw phonation". *Journal of Speech, Language, and Hearing Research,* 60(9), 2519-2536. IF: 1.771, Q1.
5. Meerschman, I., Van Lierde, K., Ketels, J., Coppieters, C. Claeys, S., & D'haeseleer, E. Effect of three semi-occluded vocal tract therapy programs on the phonation of patients with dysphonia: lip trill, water-resistance therapy or straw phonation. *Submitted to International Journal of Language & Communication Disorder*s. IF: 2.195, Q1.
6. Meerschman, I., Van Lierde, K., Van Puyvelde, C., Bostyn, A., Claeys, S., & D'haeseleer, E. (2018). Massed versus spaced practice in vocology: Effect of short-term intensive voice training versus a longer-term traditional voice training. *International Journal of Language & Communication Disorders,* 53(2), 393-404. IF: 2.195, Q1.
7. Meerschman, I., Claeys, S., Bettens, K., Bruneel, L., D'haeseleer, E., & Van Lierde, K. Massed versus spaced practice in vocology: Effect of a short-term intensive voice therapy versus a long-term traditional voice therapy. *Submitted to Journal of Speech, Language, and Hearing Research.* IF: 1.771, Q1.

List of abbreviations

A	asthenia
AVQI	Acoustic Voice Quality Index
B	breathiness
C	control group
CI	confidence interval
CPPS	smoothed cepstral peak prominence
CSL	Computerized Speech Lab
CT	chant talk
dB	decibels
DSI	Dysphonia Severity Index
EBP	evidence-based practice
EM	estimated mean
F-high	highest frequency
F-low	lowest frequency
f_o	fundamental frequency
F-range	frequency range
G	grade
GF	glottal fry
h	hour(s)
HNR	harmonics-to-noice ratio
Hz	hertz
I	instability
ICF	International Classification of Functioning, Disability and Health
I-low	lowest intensity
I-high	highest intensity
IQR	interquartile range
I-range	intensity range
IVT	intensive voice training/therapy
IVT-I	individual intensive voice therapy
IVT-G	group intensive voice therapy

LT	lip trill
LTAS	long-term average spectrum
mo.	month
M	mean
MDVP	Multi Dimensional Voice Program
min	minutes
MPT	maximum phonation time
N/A	not applicable
NHR	noise-to-harmonic ratio
PI	pitch inflections
PQ	phonation quotient
R	roughness
S	strain
s	seconds
SLP	speech-language pathology/pathologist
SPL	sound pressure level
R	resonant voice training
SD	standard deviation
SOVT	semi-occluded vocal tract
SP	straw phonation
VC	vital capacity
vf_o	variation in fundamental frequency
VHI	Voice Handicap Index
VRP	Voice Range Profile
VTDS	Vocal Tract Discomfort Scale
wk	week
WRT	water-resistance therapy
yr.	year
yrs.	years
YS	yawn-sigh

Summary

The high prevalence and psychosocial impact of voice disorders highlight the need for evidence-based practice. Research should focus on finding the most effective and efficient voice training and therapy models. To date, efficacy or effectiveness studies of voice training and therapy are limited and the research methodology is usually poor (Speyer, 2008; Ruotsalainen et al., 2008; Ruotsalainen et al., 2010; Hazlett et al., 2011; Bos-Clark & Carding, 2011). Therefore, the main objective of this doctoral thesis was to investigate the effect of voice training and voice therapy, both on the content and dosage level.

Content - This thesis focused on two main groups of vocal techniques: the vocal facilitating techniques and the semi-occluded vocal tract (SOVT) exercises. The vocal facilitating techniques were first listed by Boone in 1971. Although used for more than 40 years in clinical practice, efficacy and effectiveness studies are rare. Therefore, this thesis aimed to investigate the effect of voice training programs including the vocal facilitating techniques "chewing", "chant talk", "pitch inflections", "glottal fry" or "yawn-sigh" on the phonation of vocally healthy future occupational voice users. Chewing showed the most promising results as both acoustic perturbation and noise measures, the voice range profile and the Dysphonia Severity Index (DSI, a multiparametric vocal quality index) improved. Yawn-sigh had a positive impact on both acoustic perturbation and noise measures, and the voice range parameter highest intensity. Chant talk and pitch inflections led to less noise in the acoustic signal. Glottal fry, on the other hand, is less suitable for optimizing the voice of vocally healthy future occupational voice users.

SOVT exercises are characterized by a reduction in the cross-sectional area of the vocal tract while phonating (Andrade et al., 2014; Dargin & Searl, 2015; Fantini et al., 2017). Although the physics behind an SOVT seem promising, it is not yet confirmed whether an SOVT training or therapy program leads to enhanced phonation and improved vocal quality on the short or long term (Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015). Therefore, this thesis aimed to investigate the effect of the SOVT training programs "resonant voice training using nasal consonants" and "straw phonation" on the phonation of vocally healthy future occupational voice users. Resonant voice training showed a positive impact on the DSI, and straw

phonation expanded the subjects' intensity range. In a second study, the effect of the SOVT therapy programs "lip trill", "water-resistance therapy" and "straw phonation" was investigated in patients with dysphonia. Straw phonation was most effective and led to improvements in both acoustic parameters, auditory-perceptual vocal quality and DSI. Lip trill also seems a promising SOVT exercise as the lowest intensity and the DSI improved, and the psychosocial impact associated with dysphonia decreased. At last, water-resistance therapy led to a decrease in psychosocial impact and a better self-perceived vocal quality, although objective and auditory-perceptual outcomes did not improve.

Dosage - Unlike most medical and pharmaceutical therapies, the optimal "dosage" for voice training or therapy is unknown (Roy, 2012; De Bodt et al., 2015). A practice schedule with one or two weekly sessions spread over several weeks, months or years seems to be the standard (Carding et al., 1999; Chen et al., 2007; Fischer et al., 2009; Bergan, 2010; Demmink-Geertman & Dejonckere, 2010; Patel et al., 2011; Behlau et al., 2014; Wenke et al., 2014). However, based on motor learning principles, high-intensity practice is possibly the most optimal condition to obtain a behavioral change (Patel et al., 2011).

Therefore, this thesis aimed to compare the effect of a short-term intensive voice training/therapy (IVT) with a long-term traditional voice training/therapy (TVT). Results showed that IVT is a promising service delivery model to optimize the healthy voice and rehabilitate the disordered voice. An equal progress was made in only 2 weeks (12h) of IVT compared with 6 months (24h) of TVT. Advantages of this new model are obtaining a higher time efficiency, motivation, adherence, focus and cost-effectiveness. Besides, it is a "greener" (ecological) method. A potential drawback might be an insufficient psychosocial progress. The golden mean between IVT and TVT can therefore be an achievable, effective and efficient possibility for everyday clinical practice. Group treatment might be a solution for the complexity of scheduling an IVT.

Samenvatting

Gezien de hoge prevalentie en de psychosociale impact van stemstoornissen, is er nood aan evidence-based practice. Daarbij is het belangrijk om op zoek te gaan naar de meest effectieve en efficiënte trainings- en therapieprogramma's. Het aantal effectiviteitsstudies is heden beperkt en de gebruikte methodologie kent vaak tekortkomingen (Speyer, 2008; Ruotsalainen et al., 2008; Ruotsalainen et al., 2010; Hazlett, Duffy & Moorhead, 2011; Bos-Clark & Carding, 2011). De hoofddoelstelling van dit doctoraat was daarom het effect nagaan van stemtraining en stemtherapie, zowel qua inhoud als dosering.

Inhoud - In dit proefschrift werden twee groepen stemtechnieken onderzocht: de facilitatietechnieken en de semi-occluded vocal tract (SOVT) oefeningen. De facilitatietechnieken werden voor het eerst beschreven door Boone in 1971 en worden dus al langer dan 40 jaar gebruikt in de klinische praktijk. De effectiviteit van deze technieken werd tot op heden echter onvoldoende aangetoond. Een eerste doelstelling van dit proefschrift was daarom het effect van trainingsprogramma's bestaande uit de facilitiatietechnieken "chewing", "chant talk", "pitch inflections", "glottal fry" of "yawn-sigh" te onderzoeken op de stemgeving van gezonde toekomstige professionele stemgebruikers. Chewing bleek de meest effectieve techniek te zijn aangezien zowel akoestische perturbatie- en ruismetingen, het stembereik en de Dysphonia Severity Index (DSI, een objectieve stemkwaliteitsindex) verbeterden. Yawn-sigh had een positieve impact op zowel akoestische perturbatie- en ruismetingen als de hoogste intensiteit. Chant talk en pitch inflections leidden beiden tot een daling van de ruis in het akoestisch signaal. Glottal fry bleek daarentegen geen doeltreffende facilitatietechniek voor het optimaliseren van de stem van toekomstige professionele stemgebruikers.

SOVT-oefeningen worden gekenmerkt door een vernauwing van het aanzetstuk tijdens stemgeving (Andrade et al., 2014; Dargin & Searl, 2015; Fantini et al., 2017). Hoewel de onderliggende fysica van een SOVT gunstig blijkt, werd tot op heden niet bevestigd of SOVT-trainings- en therapieprogramma's een positief effect hebben op korte of lange termijn (Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015). Daarom werd in dit proefschrift nagegaan wat het effect is van de SOVT-trainingsprogramma's "resonantietraining met gebruik van nasale consonanten” en “straw phonation” op de stemgeving van gezonde toekomstige professionele stemgebruikers. Resonantietraining had een positieve impact op de DSI en straw phonation breidde het intensiteitsbereik van de proefpersonen uit. In een tweede studie werden de SOVT-therapieprogramma’s “liptril”, “water-resistance therapy” en “straw phonation” onderzocht bij patiënten met dysfonie. Straw phonation bleek het meest effectief en had een positieve impact op zowel akoestische metingen, auditief-perceptuele stemkwaliteit en de DSI. Liptril bleek eveneens een veelbelovende techniek aangezien de stilste intensiteit en de DSI verbeterden, alsook de psychosociale impact geassocieerd aan dysfonie afnam. Water-resistance therapy gaf ook aanleiding tot een afname in psychosociale impact en leidde daarnaast tot een betere zelfgepercipieerde stemkwaliteit. De objectieve en auditief-perceptuele parameters verbeterden echter niet.

Dosering - In tegenstelling tot de meeste medische en farmaceutische behandelingen, is de optimale “dosering” van stemtraining of –therapie niet gekend (Roy, 2012; De Bodt et al., 2015). Traditioneel worden een of twee wekelijkse sessies georganiseerd gedurende weken, maanden of jaren (Carding et al., 1999; Chen et al., 2007; Fischer et al., 2009; Bergan, 2010; Demmink-Geertman & Dejonckere, 2010; Patel et al., 2011; Behlau et al., 2014; Wenke et al., 2014). De principes van motorisch leren geven echter een voorkeur aan kortdurend en intensief oefenen om een gedragsverandering te bekomen (Patel et al., 2011).

De tweede doelstelling van dit doctoraat was het effect van een kortdurende intensieve stemtraining/-therapie (IVT) vergelijken met een langdurende traditionele stemtraining/-therapie (TVT). Uit de resultaten bleek dat IVT een gunstig nieuw model is voor trainings- en therapiedoeleinden. Na 2 weken (12u) IVT werd een even grote progressie bereikt als na 6 maanden (24u) TVT. Voordelen van dit intensief model zijn het vergroten van de tijdsefficiëntie, motivatie, therapietrouwheid, aandacht en kosteneffectiviteit. Daarenboven is het ook een “groene” (ecologische) methode. Een mogelijk nadeel is een beperkte psychosociale vooruitgang. De gulden middenweg tussen IVT en TVT kan daarom een haalbare, effectieve en efficiënte mogelijkheid bieden voor de dagelijkse klinische praktijk. Groepssessies kunnen de complexe planning geassocieerd aan IVT eventueel vergemakkelijken.

General introduction

CHAPTER 1

Optimization of the healthy voice and rehabilitation of the disordered voice: voice training and voice therapy

Voice, produced by vibrations of the vocal folds in the larynx, is the sound source of speech production and the main instrument of human communication. It fulfills the basic needs of sharing information, experiences, emotions, and moods (Ramig & Verdolini, 1998; Ruotsalainen et al., 2008; Rodero et al., 2017). The ability to comfortably produce an audible and clear sounding voice is fundamental and will facilitate these needs. It is even crucial for occupational voice users (e.g. teachers, lawyers, speech-language pathologists), and elite vocal performers (e.g. singers, actors), who need their voice to earn a living (Behlau & Oliveira, 2009; Marques da Rocha et al., 2015; D'haeseleer et al., 2017a; D'haeseleer et al., 2017b). High vocal demands coupled with inadequate knowledge and use of the vocal instrument can eventually lead to the development of voice disorders or dysphonia (Roy et al., 2000; Rantala et al., 2002; Rangarathnam et al., 2017).

At the simplest level, a voice disorder can be defined as a persistent abnormality in the sound of the voice (Ramig & Verdolini, 1998; Titze & Verdolini Abbott, 2012). However, recent definitions, based on the *International Classification of Functioning, Disability and Health* (ICF, World Health Organization), stress the multidimensionality of dysphonia. These definitions do not only focus on the impairment itself, but also consider the associated limitations and disabilities (Ruotsalainen et al., 2008; Titze & Verdolini Abbott, 2012). For example, a lesion on the vocal folds (i.e. *impairment*) may *limit* strong and clear voice production, and, consequently, *disable* the patient to make phone calls or participate in group conversations. Communicative problems associated with dysphonia are as disruptive to quality of life as other chronic disorders, such as heart failure, angina, and chronic sinusitis. They can lead to social isolation, depression, and occupational difficulties (Smith et al., 1996; American Speech-Language-Hearing Association, 2005; Cohen et al., 2006; Desjardins et al., 2017).

Traditionally, two major classes of voice disorders have been distinguished related to the etiology: *organic* and *functional*. Organic voice disorders are characterized by the presence of a specific lesion, such as a cyst or a vocal fold nodule. Functional voice disorders are those for which there is no identifiable lesion, but yet the sound produced is abnormal (Titze, 2000a; Roy et al., 2003a; Ruotsalainen et al., 2008). However, the boundary between these two classes is often vague. Lesions can occur as a consequence of improper use, and improper use may in turn be the result of undetected lesions. In a broader sense, voice disorders can be described as structural and/or functional responses of the vocal mechanism to environmental, systematic, or traumatic conditions (Titze, 2000a; American Speech-Language-Hearing Association, 2005).

Voice disorders appear to be the most common communication disorder across the lifespan (Branski et al., 2006). The prevalence has been estimated between 3% and 9%, with a lifetime prevalence of nearly 30% (Ramig & Verdolini, 1998; Roy et al., 2005). Higher percentages were found for occupational voice users, especially teachers, with a point and lifetime prevalence up to 11% and 80%, respectively (Angelilli et al., 1990; Roy et al., 2004; Van Houtte et al., 2011a; Cantor Cutiva et al., 2013).

The high prevalence and the psychosocial impact of voice disorders highlight the need for prevention initiatives, especially for at-risk populations (Behlau & Oliveira, 2009; Nanjundeswaran et al., 2012). A first essential part of prevention is vocal hygiene, in which people are encouraged to adjust lifestyle habits that may irritate the vocal fold mucosa, such as smoking, alcohol or caffeine use, and exposure to dry or dusty air. They also learn to eliminate unhealthy vocal behaviors and excessive vocal load, such as throat clearing, screaming, and speaking for a long time without vocal rest (Behlau & Oliveria, 2009; Titze & Verdolini Abbott, 2012; Moreti et al., 2016; Rangarathnam et al., 2017). The second element of prevention includes optimization and strengthening of the voice by means of **voice training**. In voice training, vocal techniques are learnt that aim to optimize phonation (i.e. voice production) and maximize vocal control. It encompasses vocal warm-up and cool-down exercises, efficient projection or focus of voice, resonant voice production, etc. (Sundberg, 1987; Roy et al., 2000; Behlau & Oliveira, 2009; Pabon et al., 2014; Rangarathnam et al., 2017). The overall aim of vocal hygiene and voice training is to “conserve” the voice and stimulate the longevity of phonation, which lowers the risk of laryngeal hyperfunction, vocal fatigue, tissue damage and, consequently, the development of voice disorders (Titze & verdolini, 2012; Rangarathnam et al., 2017).

Once a person developed a voice disorder, behavioral **voice therapy** guided by a voice therapist is the treatment of choice in the majority of cases (Carding et al., 1999; Roy et al., 2003a; Desjardins et al., 2017). The overall goal of voice therapy is to return the patient's voice to normal or to achieve the most optimal voice within their anatomic and physiologic capacities and to satisfy the patient's occupational, social, and emotional needs (Aronson & Bless, 2009). Unfortunately, traditional voice therapy has not always proven successful. Treatment success immediately after therapy ranges from 41% to 91% (Patel et al., 2011). Long-term outcome suggests a high rate of chronic and recurrent dysphonia in about 50% of the individuals (Van Lierde et al., 2007). Furthermore, frequent cancellations of therapy sessions (up to 25%) and high drop-out rates (up to 65%) have been reported (Hapner et al., 2009; Wenke et al., 2014). These factors eventually exact a large burden on the health care system (Ramig & Verdolini, 1998; Patel et al., 2011; Wenke et al., 2014).

CHAPTER 2

Effect of voice training and voice therapy: content and dosage

The high prevalence and the psychosocial impact of voice disorders, together with the limited success rates of traditional voice therapy, highlight the need for evidence-based practice. Evidence-based practice integrates the *clinician's* expertise, the *patient's* preference and the best available *research* evidence (Figure 2.1). A successful triad will lead to a clinical decision that helps the patient, satisfies the clinician and reduces the healthcare costs (Sackett et al., 1996; McKibbon, 1998; De Bodt et al., 2008a).

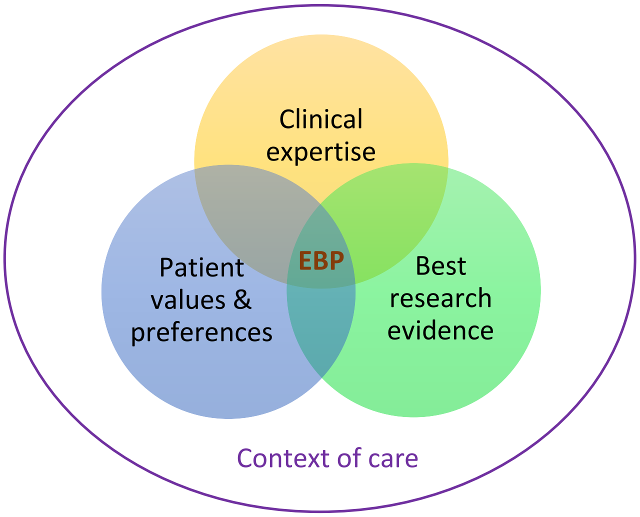


Figure 2.1 Evidence-based practice (EBP).

To date, **research evidence in voice training and therapy is limited** and the **methodology is usually poor** (Speyer, 2008; Ruotsalainen et al., 2008; Ruotsalainen et al., 2010; Hazlett et al., 2011; Bos-Clark & Carding, 2011). There is a need for larger sample sizes, randomized controlled study designs, complete and well-described training or therapy programs, standardized and multidimensional voice assessments including both objective and subjective outcomes, assessors blinded to group allocation and study evolution, and long-term follow-up data.

Effect of voice training and voice therapy can be explored on two domains:

Content: which vocal techniques are effective? (2.1)

Dosage: what is the most optimal frequency and duration of practice? (2.2)

2.1 Effect of vocal techniques (content)

The main aim of voice training and therapy is to obtain an economic and efficient phonation. *Vocal economy* is defined as the ratio of vocal output to effort (Mills et al., 2017). The intent is to produce a normal vocal intensity and power with less mechanical stress to laryngeal tissues and less laryngeal muscle effort. These factors will decrease the risk of vocal fatigue and vocal injury (Titze, 2006; Gaskill & Quinney, 2012; Croake et al., 2017; Mills et al., 2017). *Vocal efficiency* is closely related to vocal economy and can be defined as the ratio of useful energy output to required energy input. Aerodynamic energy derived from the pulmonary system is converted into acoustic energy when the vocal folds vibrate. This vibration modulates the airstream and produces sound that propagates in the vocal tract (i.e. the upper part of the airway, located between the top of the vocal folds and the edge of the lips; Figure 2.2). This conversion is often referred to as the *linear* source-vocal tract interaction (Titze, 2006; Titze & Verdolini Abbott, 2012; Titze et al., 2016).

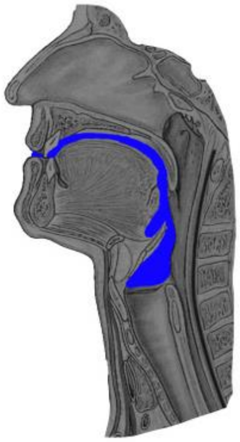


Figure 2.2 The vocal tract (From: Sobotta, Atlas van de menselijke anatomie, by Sobotta, J., 2006, p. 119).

Economic and efficient voice production leads to what is called a *resonant voice*. It is a vocal quality that is neither *pressed*, nor *breathy* (Peterson et al., 1994; Verdolini et al., 1998). Pressed voice is characterized by an excessive squeezing together of the vocal folds for voice initiation, usually with lots of lung pressure (Titze & Verdolini Abbott, 2012). Many voice users have a tendency to press their voice after prolonged speaking. It seems an unwanted compensation for increasing loudness when respiratory muscles become "lazy" and vocal fatigue occurs. A pressed voice is typically seen in voice disorders characterized by excessive laryngeal musculoskeletal tension, which are called *hyperfunctional* voice disorders or *muscle tension dysphonia* (Roy, 2008; Van Houtte et al., 2011b). If pressed phonation is continual over long periods of time, a risk of developing lesions exists because of excessive mechanical stress imposed on laryngeal tissues (Titze & Verdolini Abbott, 2012). A breathy voice, on the other hand, is characterized by insufficient vocal fold closure and a voice that lacks power (Titze & Verdolini Abbott, 2012). These types of voice disorders are often called *hypofunctional* voice disorders. Resonant voice is the ideal mix of both extremes; it is easily producible with vocal folds that are just touching. This laryngeal configuration is often referred to as vocal folds that are barely adducted (i.e. closed) or barely abducted (i.e. open) and it is the target for voice training and therapy (Verdolini et al., 1998; Berry et al., 2001; Titze & Verdolini Abbott, 2012; Guzman et al., 2015). Sensory perception of a resonant voice involves vibrations in the facial tissues, which indicates an efficient conversion of aerodynamic energy to acoustic energy and a sound that propagates along the entire airway system (Verdolini-Marston et al., 1995; Lessac, 1997; Roy et al., 2003b; Chen et al., 2007).

Several vocal techniques that aim to achieve an economic, efficient and resonant voice production have been described in the literature and are widely used in clinical practice. Given the common goal, these techniques can be used for both training and therapy purposes. This thesis will discuss two main groups of vocal techniques: the **vocal facilitating techniques** (2.1.1) and the **semi-occluded vocal tract exercises** (2.1.2).

2.1.1 Vocal facilitating techniques

Boone & McFarlane (1988, 2010) listed 25 vocal techniques, which they called "the facilitating techniques": (1) auditory feedback, (2) change of loudness, (3) chant-talk, (4) chewing, (5) confidential voice, (6) counseling, (7) digital manipulation, (8) elimination of abuses, (9) establishing a new pitch, (10) focus, (11) glottal fry, (12) head positioning, (13) hierarchy analysis, (14) inhalation phonation, (15) laryngeal massage, (16) masking, (17) nasal/glide stimulation, (18) open-mouth approach, (19) pitch inflections, (20) redirected phonation, (21) relaxation, (22) respiration training, (23) tongue protrusion /i/, (24) visual feedback, and (25) yawn sigh.

Some of these techniques are overarching and indispensable in voice training and therapy. They are used by as good as any voice coach or therapist (henceforth referred to as *vocologist*) for as good as any client or patient (henceforth referred to as *vocalist*). Examples of those general approaches are counseling, elimination of abuses, feedback, relaxation and respiration training. Other techniques are more specific, such as chewing, chant talk, pitch inflections, glottal fry and yawn-sigh. They can be selected depending on the type of voice user, disorder, and the preferences of the vocalist or vocologist. According to Boone et al. (2010), these techniques are particularly beneficial for patients with hyperfunctional dysphonia who use a pressed voice. Nevertheless, a broader application can be found in the literature, such as training the voice of occupational voice users or elite vocal performers (Weiss & Beebe, 1950; McCabe & Titze, 2002a; Bovo et al., 2007).

The vocal facilitating technique *chewing* was first described by Froeschels in 1943. He based the technique on the observation that someone can chew and speak at the same time. Because voiced chewing is an inborn and intuitive behavior, authors assumed that it might facilitate a more natural voice production (Froeschels, 1943; Froeschels, 1952; Beebe, 1956). The technique is supposed to reduce muscle tension in the vocal tract (Boone et al., 2010). A regulation of the fundamental frequency and a better coordination between respiration and phonation have also been described throughout the years (Weiss & Beebe, 1950; Brodnitz, 1966; Thomas & Stemple, 2007).

Chant talk is produced by reciting syllables in one continuous tone, creating a "singing monotone". It is characterized by an elevation of pitch, prolongation of vowels and a lack of syllable stress. The *pitch inflections* technique, on the contrary, is used to stimulate pitch variability during phonation. Potential positive results associated with these techniques have been described as "relaxed" voicing and elimination of hard glottal attacks (Bovo et al., 2007; Boone et al., 2010).

Glottal fry is the lowest vocal register (20-80 Hz) characterized by a pulse-like vibratory pattern, whereby relatively short and low-amplitude glottal pulses are followed by longer phases of vocal fold adduction (Titze, 2000a; Chen et al., 2002; Slifka, 2006; Titze & Verdolini Abbott, 2012; Parker & Borrie, 2017). This pattern results in a vocal quality accompanied by creaking, cracking and popping noises (Abdelli-Beruh et al., 2014). The vocal folds are assumed to be short, thick, compressed and lax during glottal fry (Chen et al., 2002; Oliveira et al; 2012; Titze & Verdolini Abbott, 2012). According to Boone et al. (2010), this type of phonation has therapeutic indications due to its production with minimal airflow and subglottic pressure, relaxed vocal folds and reduced friction between the folds. Remarkably, other authors considered glottal fry a perceptual, and often diagnostic, vocal parameter instead of a therapeutic technique (Ross et al., 1998; Hartelius et al., 2003; Chen et al., 2007; Gottliebson et al., 2007; Vertigan et al., 2008; Gibson & Vertigan, 2009; Nguyen et al., 2009; Iwarsson & Petersen, 2012;). *Yawn-sigh*, on the other hand, has been cited frequently as an efficient facilitating technique. The technique is supposed to reduce muscle tension in the vocal tract by lowering the larynx and widening the pharynx (Brodnitz, 1968; Moncur & Brackett, 1974; Wilson, 1979; Pershall & Boone, 1985; Boone & McFarlane, 1988; Casper et al., 1990; Colton & Casper, 1990; Boone, 1991; Moore, 1990; Boone & McFarlane, 1993; Dworkin et al., 2000; Shrivastav et al., 2000; Holmberg et al., 2001; Roy, 2003a; Schneider & Sataloff, 2007; Boone et al., 2010; Duan et al., 2010).

Although used for more than 40 years in voice training and therapy (Boone, 1971), efficacy and effectiveness studies of the vocal facilitating techniques are rare. The existing literature is mostly limited to defining the techniques or describing their potential benefit based on clinical experience. Studies that did investigate an effect, focused on a one-time performance of a technique, or investigated a technique as part of a broader therapy program rather than in isolation (Carding & Horsley, 1992; Carding et al., 1999; Holmberg et al., 2001; McCrory, 2001; Mashima et al., 2003; Rattenbury et al., 2004; Van Lierde et al., 2004; Amir et al., 2005; Bovo et al., 2007; Oliveira et al., 2009; Teczaner et al., 2009; Duan et al., 2010; Vashani et al., 2010; Rodriguez-Parra et al., 2011; Park et al., 2012).

2.1.2 Semi-occluded vocal tract exercises

A promising way to obtain economic, efficient and resonant voice production is by semi-occluding the vocal tract (Titze, 2006; Gaskill & Quinney, 2012; Croake et al., 2017; Mills et al., 2017). *Semi-occluded vocal tract (SOVT)* exercises are characterized by a reduction in the cross-sectional area of the vocal tract while phonating (Andrade et al., 2014; Dargin & Searl, 2015; Fantini et al., 2017). These reductions can be formed by the articulators (lips and/or tongue) or by an assistive device, such as a straw or tube inserted between the lips (Figure 2.3) (Titze, 2006; Maxfield et al., 2015). In the latter case, an additional and artificial lengthening of the vocal tract is achieved (Conroy et al., 2014).

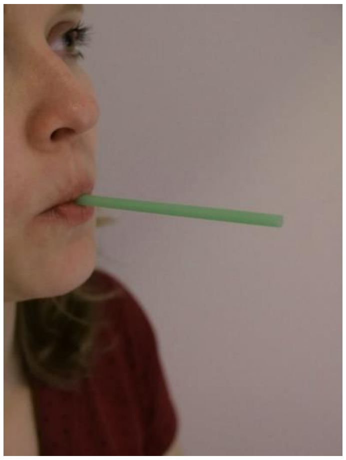


Figure 2.3 Semi-occluding the vocal tract by inserting a straw between the lips.

Examples of SOVT exercises are the use of voiced fricatives ([v], [z], [ʒ]), lip-rounded vowels ([o], [u]), nasal consonants ([m], [n], [ŋ]), lip and tongue trills, raspberries (lingo-labial trill), y-buzz (sustained [j]), phonation while covering the mouth by hand (hand-over-mouth), finger (finger kazoo) or cup (cup phonation), and phonation into straws or tubes with the outer end in the air (straw phonation) or immersed in water (water-resistance therapy, e.g. resonance tubes or Lax Vox) (Titze, 2006; Sihvo, 2006; Guzman et al., 2013; Andrade et al., 2014; Dargin & Searl, 2015; Kapsner-Smith et al., 2015; Maxfield et al., 2015; Guzman et al., 2016; Fantini et al., 2017; Tyrmi et al., 2017).

The air column in a semi-occluded vocal tract enhances the vocal fold vibration (i.e. source) by feeding acoustic energy back to the source in a non-linear way. This mechanism, which is referred to as the *non-linear* source-vocal tract interaction, is based on acoustic impedance (Titze, 2006; Gaskill & Quinney, 2012; Titze & Verdolini Abbott, 2012; Guzman et al., 2013; Andrade et al., 2014; Conroy et al., 2014; Croake et al., 2017; Fantini et al., 2017; Mills et al., 2017). In general, *impedance* can be defined as a measure of lack of response to an applied stimulus (Titze & Verdolini Abbott, 2012). It is a term used in several domains including mechanics, electrics and acoustics. The stimulus is then respectively a force, voltage or pressure, and the response is a motion, electric current or flow. If the impedance imposes a time delay to the response, it is said to have *inertive reactance.* For example, the door of a house can be considered as an imput impedance to traffic flow of people into the house. If a doorbell has to be rung, there will be inertia (delay) in the response of letting people into the house (Titze & Verdolini Abbott, 2012). This concept of impedance and inertive reactance also applies for vocal tract acoustics. If air particles move back and forth in a narrowed vocal tract, inertia will be high and supraglottal pressure will increase. If the vocal tract is also artificially lengthened (e.g. by a small straw), inertive reactance and supraglottal pressure will increase even more (Titze, 2006; Gaskill & Quinney, 2012; Titze & Verdolini Abbott, 2012; Maxfield et al., 2015). When performing SOVT exercises, the impedance at the vocal tract will better match the impedance at the source, which heightens their interaction and enhances vocal fold vibration (Titze, 2008). Using a swing metaphor, the increased pressure in the vocal tract gives the vocal folds a “push” at the exact right time, wherefore the vocal folds do not have to “pump” so hard.

To date, most authors have been interested in the immediate, physical or physiological, effects of a single SOVT performance as described above (Conroy et al., 2014; Dargin & Searl, 2015; Dargin et al., 2016). Whether a training or therapy program using SOVT exercises leads to enhanced phonation and an improved vocal quality on the short or long term is not yet confirmed (Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015).

2.2 Effect of frequency and duration of practice (dosage)

Unlike most medical and pharmaceutical therapies, the optimal “dosage” for voice training or therapy is unknown (Roy, 2012; De Bodt et al., 2015). The frequency and duration used today depends on several factors, such as the medical prescription, rules of reimbursement, the specific vocal pathology and its severity, the type of training or therapy, the vocalist’s limitations and expectations, the vocologist’s preferences, and upcoming vocal performances (Mueller & Larson, 1992; Van Lierde et al., 2007; De Bodt et al., 2008a; Van Lierde et al., 2010a). Despite these influencing factors, a practice schedule with one or two weekly sessions spread over several weeks, months or years seems to be the standard (Carding et al., 1999; Chen et al., 2007; Fischer et al., 2009; Bergan, 2010; Demmink-Geertman & Dejonckere, 2010; Patel et al., 2011; Behlau et al., 2014; Wenke et al., 2014; De Bodt et al., 2015).

Given the limited success of traditional voice therapy, the current practice schedule might be questioned (Patel et al., 2011). Basically, voice training and therapy are processes of behavioral change (Behrman, 2006; Van Leer et al., 2008; McIlwaine et al., 2010; Patel et al., 2011; Vinney & Turkstra, 2013; Wenke et al., 2014; Behlau et al., 2015; Iwarsson, 2015; Fu et al., 2015a; Fu et al., 2015b). They involve the acquisition, optimization and maintenance of economic and efficient vocal behaviors through (re)learning cognitive and motor skills (McIlwaine et al., 2010; Patel et al., 2011; Fu et al., 2015a). Therefore, the most optimal conditions to obtain these behavioral changes (i.e. learning) should be explored.

Such research is still in its infancy in our field, but received considerable attention in neurobiology, exercise physiology, motor learning, psychology and language therapy (McIlwaine et al., 2010; Patel et al., 2011; Wenke et al., 2014). One of the learning principles investigated in these fields is the principle *distribution of practice*, with *massed* and *spaced* practice as two ends of a continuum. In massed practice, sessions are organized very closely together with little or no rest time between sessions, whereas in spaced practice, the time interval between practice sessions is larger (Bergan, 2010). As literature suggests a preference for high-intensity training (i.e. massed practice) to obtain desirable learning and behavioral changes, the traditional spaced practice schedule in our field may need to be revised (Bergan, 2010; Patel et al., 2011).

Although the preference for massed practice has not yet broken through our field, it does have its history and was proven effective in specific programs, such as the Lee Silverman Voice Treatment (LSVT®, Ramig et al., 1994) and Vocal Function Exercises (VFE, Stemple et al., 1994). Recently, Patel et al. (2011) highlighted the massed practice approach with their development of a "boot camp" voice therapy, performed in a time frame of 1-4 consecutive days with 4-7 hours of therapy a day. Boot camp is designed for people who have pressing needs to improve their voice (e.g. upcoming vocal performances), who failed traditional voice therapy (e.g. recalcitrant dysphonia), and/or have an inability to schedule weekly appointments (e.g. living at geographical distances far from a voice center). A few years later, Behlau et al. (2014) shared their experience with a similar intensive short-term voice therapy used for a variety of cases, including iatrogenic dysphonia and elite vocal performers suffering from acute dysphonia. Their therapy schedule lasts 3 days to 2 weeks in which 3 to 4 sessions are provided per day.

Clinical trials that actually compare the effect of massed and spaced practice in voice therapy are limited and show some methodological shortcomings. Fu et al. (2015a) investigated the effect of both models (eight 45-minute sessions over 3 weeks versus eight 45-minute sessions over 8 weeks) in 53 women with vocal nodules and found comparable positive perceptual, physiological, and acoustic outcomes. Shortcomings of this study were the lack of long-term follow-up and self-rating questionnaires. Furthermore, subjects were not randomly assigned to the two treatment groups, but according to their availability. Wenke et al. (2014) compared the two models (four 1-hour treatment sessions a week for 8 weeks versus one 1-hour treatment session a week for 8 weeks) in voice therapy for patients with functional dysphonia (n = 16) and found high satisfaction and a significantly reduced Voice Handicap Index (VHI) after the intensive treatment. Moreover, significantly higher attendance rates were found in the intensive group compared with the traditional group. A major limitation of this study is that the therapy program was not standardized, which means that subjects received different treatment techniques depending on the individual's profile. Therefore, treatment success cannot surely be related to the distribution of practice. Besides, auditory-perceptual and objective vocal measures were lacking.

CHAPTER 3

Research objectives

The main objective of this thesis was to investigate the effect of **voice training** and **voice therapy**, both on the **content** and **dosage** level.

3.1 Effect of vocal techniques (content)

Whether a training or therapy program using vocal facilitating techniques or SOVT exercises leads to enhanced phonation and improved vocal quality on the short or long time is not yet sufficiently confirmed (Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015). Therefore, the first objectives of this thesis were:

- to investigate the effect of five training programs including the vocal facilitating techniques “chewing”, “chant talk”, “pitch inflections”, “glottal fry” or “yawn-sigh” on the phonation of vocally healthy future occupational voice users. Results of this study can be found in **chapter 4**.
- to investigate the effect of two SOVT training programs “resonant voice training using nasal consonants” or “straw phonation” on the phonation of vocally healthy future occupational voice users. Results of this study are presented in
- to investigate the effect of three SOVT therapy programs “lip trill”, “water-resistance therapy” or “straw phonation” on the phonation of patients with dysphonia. Results of this study are presented in **chapter 5.2**.

3.2 Effect of frequency and duration of practice (dosage)

Having standardized guidelines in terms of the ideal frequency and duration of voice training and therapy would be a merit for both the vocalist, the vocologist and the health care system (Patel et al., 2011; Wenke et al., 2014; De Bodt et al., 2015). Therefore, the second objective of this thesis was to compare the effect of “massed” (i.e. short-term intensive) with “spaced” (i.e. long-term traditional) practice in voice training **(chapter 6.1)** and therapy **(chapter 6.2)**. As treating patients intensively and individually may lead to quickly filled week schedules for the clinician, an additional comparison was made between an individual (IVT-I) and a group IVT (IVT-G) in chapter 6.2.

Publications

CHAPTER 4

Effect of the vocal facilitating techniques (content)

4.1 Effect of the vocal facilitating technique chewing on the phonation of future occupational voice users

Based on: Meerschman, I., D'haeseleer, E., De Cock, E., Neyens, H., Claeys, S., & Van Lierde, K. (2016). Effectiveness of chewing technique on the phonation of female speech-language pathology students: a pilot study. *Journal of Voice,* 30(5), 574-578.

ABSTRACT

Objective. The purpose of this study was to determine how use of the vocal facilitating technique, chewing, affected the phonation of vocally healthy female speech-language pathology (SLP) students.

Methods. A pretest-posttest randomized control group design was used. Twenty-seven vocally healthy female SLP students with a mean age of 18 years were randomly assigned to either an experimental group (*n* = 14) or a control group (*n* = 13). The experimental group practiced chewing exercises across 18 weeks, whereas the control group received no vocal facilitating techniques. Both groups completed a pre- and post- objective voice assessment (maximum performance task, acoustic analysis, voice range profile, and Dysphonia Severity Index). Differences between pre- and post-data were compared between the experimental and control group using an independent sample *t* test.

Results. Compared to the control group, chewing resulted in a significant decrease in jitter and noise-to-harmonic ratio, a significant increase in fundamental frequency, a significant expansion of the voice range profile, and a significant increase in Dysphonia Severity Index. Evolution in shimmer and maximum phonation time was not significantly different between groups.

Conclusions. The results of this pilot study suggest that the vocal facilitating technique, chewing, may improve objective vocal measures in vocally healthy female SLP students.

INTRODUCTION

The vocal facilitating technique, chewing, was first described by Froeschels (1943). He based the technique on the observation that someone can chew and speak at the same time. According to the author, chewing and speaking must be somewhat identical because both functions require the same muscles and nerves (Froeschels, 1952). Beebe (1956) confirmed Froeschels observations and described voiced chewing as an inborn and intuitive behavior. Voiced chewing refers to the ‘‘raw material’’ used instinctively by the aboriginal human inhabitants of the earth (Froeschels, 1952). It serves the dual purpose of supporting life (eating) and oral communication (speech) (Beebe, 1956). Because of etiquette, the voice has not been used in conjunction with chewing food for thousands of years. Despite this, voicing while chewing can still be easily accomplished by individuals (Froeschels, 1952).

The most convincing support of voiced chewing as an inborn and intuitive behavior is found in clinical experience. A natural behavior such as chewing may facilitate improved vocal production through relaxation of the vocal tract and regulation of the fundamental frequency (Brodnitz, 1966; Thomas & Stemple, 2007; Boone et al., 2010). According to Weiss and Beebe (1950), chewing also improves coordination between respiration and phonation. Froeschels (1943) described improved vocal quality during chewing aloud in individuals with vocal fold paresis, cyst, and papilloma as well as in those suffering from hypo- or hyperfunctional voice disorders, mutational disorders, and hearing impairment. Furthermore, Brodnitz and Froeschels (1954) facilitated the resolution of vocal nodules after the using of chewing in five of the six subjects under study. Boone et al (2010) recommend the technique for patients with muscle tension dysphonia who speak with tension, hard glottal attacks, and restricted mandibular movements. According to Weiss and Beebe (1950), chewing might also be useful in treating speech disorders such as stuttering and dysarthria. However, to our knowledge, no studies confirm this finding. Weiss and Beebe (1950) further described the application of chewing to train the healthy speaking and singing voice.

The use of the chewing technique in improving vocal production has mainly been supported by the results of case studies that cannot be easily generalized. Additionally, conclusions are based on observations and anecdotal clinical experience. Furthermore, a detailed description of the method is lacking and much of the published literature is outdated (Froeschels, 1943; Weiss & Beebe, 1950; Froeschels, 1952; Brodnitz & Froeschels, 1954; Beebe, 1965; Brodnitz, 1966). More recently, larger efficacy studies became available but those have examined chewing as part of a broader therapy program, rather than in isolation (Carding & Horsley, 1992; Carding et al., 1999; McCrory, 2001; Rattenbury et al., 2004; Bovo et al., 2007; Teczaner et al., 2009; Vashani et al., 2010; Rodriguez-Parra et al., 2011). Therefore, experimental studies that specifically examine the effect of chewing on voice production are required. Our pilot study aimed to make a first contribution to this research gap. We wanted to investigate if the outdated and unproven assertions about the effect of chewing may be correct. Therefore, in this first-stage investigation, we chose to focus on chewing as a technique that could facilitate and train the healthy voice (Weiss & Beebe, 2007).

The purpose of this study was to determine how use of the vocal facilitating technique, chewing, affected the phonation of vocally healthy women enrolled in a speech-language pathology (SLP) program. A positive effect on the SLP students' vocal quality and capacities was hypothesized because, according to the literature, chewing may facilitate a more natural voice production through relaxation of the vocal tract, regulation of the fundamental frequency, and better coordination between respiration and phonation (Froeschels, 1943; Weiss & Beebe, 1950; Froeschels, 1952; Brodnitz & Froeschels, 1954; Beebe, 1956; Brodnitz, 1966; Thomas & Stemple, 2007; Boone et al., 2010).

MATERIAL AND METHODS

This study was approved by the Ethics Committee of Ghent University Hospital.

Participants

Twenty-nine female students enrolled in the first year of the bachelor program Logopaedic and Audiological Sciences at Ghent University were randomly selected to participate in this study. Exclusion criteria included diagnoses of mental health conditions, voice disorders, nasal and ear diseases, and physically limiting diseases that might interfere with study completion. Additionally, individuals who had previously participated in voice therapy or training were excluded from participation. To determine that participants were not currently suffering from a voice disorder or nasal or ear disease, each subject was assessed by an otorhinolaryngologist and audiologist performing a nasopharyngeal and laryngeal evaluation, videolaryngostroboscopy, otoscopy, and audiometry. On the basis of these results, two students were excluded because of vocal fold edema and vocal fold nodules.

The remaining participants included a homogeneous group of twenty-seven vocally healthy female students with a mean age of 18 years (SD, 0.8 years; range, 17-21 years). They were randomly assigned to either an experimental group (*n* = 14) or a control group (*n* = 13). The experimental group practiced chewing exercises across 18 weeks, whereas the control group received no vocal facilitating techniques. Randomization was based on the first letter of the students' last name (A–M, control group; N–Z, experimental group). There were no differences between the two groups in mean age (Mann–Whitney *U* test; *p* = 0.239).

Voice assessment

Voice questionnaire

At the beginning of the study, each subject filled in a questionnaire based on the voice assessment protocol of the European Study Group on Voice Disorders (De Bodt et al., 1996) to describe vocal complaints and risk factors.

Objective voice assessment

Both groups completed a pre- and post- objective voice assessment. Data were collected by two experimenters (E.D.C. and H.N.) in a sound-treated room at Ghent University Hospital.

Maximum performance task. To measure the maximum phonation time (MPT), the participants were asked to sustain the vowel /a/ at their habitual pitch and loudness in free field while seated. The MPT was modeled by the experimenters, and the participants received visual and verbal encouragement to produce the longest possible sample. The length of the sustained vowel was measured in seconds. The best trial of three attempts was retained for further analysis.

Acoustic analysis. The fundamental frequency (f_o), jitter (%), shimmer (%), and noise-to-harmonic ratio (NHR) were obtained by the Multi Dimensional Voice Program of the

Computerized Speech Lab (CSL, model 4500, KayPENTAX, Montvale, NY). The subjects were instructed to produce the vowel /a/ at their habitual pitch and loudness. A midvowel segment of 3 seconds registered with a sampling rate of 50 kHz was used.

Voice range profile. The voice range assessment was performed with the CSL following the procedure outlined by Heylen et al. (1998). This assessment includes determination of the highest and lowest fundamental frequency and intensity. The participants were instructed to produce the vowel /a/ for at least 2 seconds using, respectively, a habitual pitch and loudness, a minimal pitch, a minimal intensity, a maximal pitch, and a maximal intensity. Each production was modeled by the experimenters, and the participants received visual and verbal encouragement.

Dysphonia Severity Index. The Dysphonia Severity Index (DSI) is a multiparameter approach designed to establish an objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000). The DSI is based on a weighted combination of the following parameters: MPT (in seconds), highest frequency (F-high, in Hz), lowest intensity (I-low, in dB), and jitter (in %). The DSI is constructed as 0.13 MPT + 0.0053 F-high - 0.26 I-low - 1.18 jitter + 12.4. The index ranges from -5 to +5 for severely dysphonic to normal voices. A more negative index indicates a worse vocal quality. A DSI of 1.6 is the threshold separating normal voices from dysphonic voices (Raes et al., 2002). The DSI can be calculated as a percentage by increasing the value with five points and then multiplying it by 10. A higher percentage indicates a better vocal quality (Raes et al., 2002).

Facilitating technique chewing

The experimental group practiced the facilitating technique chewing across 18 weeks. In the first 8 weeks, the group participated in weekly 1-hour training sessions organized by the experimenters. The experimenters provided verbal information, examples, and corrective feedback. Incorrect posture or poor respiratory technique were corrected. The content of the training sessions, based on the procedure outlined by Boone et al. (2010) can be found in Table 4.1. In addition to the exercises during training, the subjects were instructed to practice the chewing technique at home twice a day during 10 minutes.

Table 4.1 Content of the chewing training sessions based on Boone et al. (2010).

Session	Content
1	Education and counseling
	Creating awareness of the student's mandibular movements while speaking (visual feedback: mirror)
	Demonstration of the facilitating technique chewing by the experimenters
	Imitation and familiarization by the subjects (visual feedback: mirror)
2	Open-mouth chewing without phonation
	Chewing with phonation of the sound "njamnjam"
	Chewing with phonation of nonsense words (e.g. "ah-la-met-erah", "wan-da-pan-da")
3, 4	Chewing with phonation of automatic sequences: counting, days of the week
	Chewing with phonation of words: monosyllabic, polysyllabic
5, 6	Chewing with phonation of phrases
	Chewing with phonation of sentences
	Chewing while reading texts
7, 8	Phonation of sentences and texts with reduced chewing
	Spontaneous speech with adequate oral openness and mandibular movements

From week 9-17, the subjects repeated the technique independently at home with a frequency of two times 10 minutes a day. Meanwhile, they had the opportunity to contact the experimenters for feedback or questions. In week 18, an interactive rehearsal session was organized under the guidance of the experimenters. In this session, subgroups (two or three subjects) of the experimental group presented one of the steps learned in training. The other subjects followed their instructions.

Statistical analysis

SPSS Version 22 (SPSS Corporation, Chicago, IL) was used for the statistical analysis of the data. All analyses were conducted at $\alpha = 0.05$.

Voice questionnaire

A chi-square test of independence was used to verify if there were differences between the experimental and control group regarding vocal complaints and risk factors.

Objective voice assessment

The differences between pre- and post-data were measured for each subject. Normality of these differences was verified using a QQ-plot and a Shapiro-Wilk test. Because all data were normally distributed, an independent sample t test was used to compare the results of the experimental and control group.

RESULTS

Voice questionnaire

The results of the questionnaire regarding vocal complaints and risk factors are presented in Table 4.2. Occurrence of the vocal complaints “vocal fatigue”, “decreased vocal quality in the morning”, “laryngeal irritations”, and “decreased breath support” was not significantly different between the experimental and control group. Significantly higher percentages of “hoarseness” (40.6%; $\chi^2(1) = 4.464$; $p = 0.035$) and “decreased vocal range” (30.8%; $\chi^2(1) = 5.057$; $p = 0.025$) were found in the control group versus the experimental group. Occurrence of the vocal risk factors “vocal abuse”, “nasal airway obstructions”, “smoking”, “reflux”, and “allergy” was not significantly different between the experimental and control group. A significantly higher percentage of “stress” (40.6%; $\chi^2(1) = 4.464$; $p = 0.035$) was found in the control group versus the experimental group.

Table 4.2 Baseline vocal complaints and risk factors in the experimental group and the control group.

	Experimental group		**Control group**			
Vocal complaints and risk factors	*%*	*n*	*%*	*n*	χ^2	*p*-value
Vocal complaints						
Vocal fatigue	35.7	5/14	53.8	7/13	0.898	0.343
Hoarseness	28.6	4/14	69.2	9/13	4.464	0.035*
Decreased vocal quality in the morning	28.6	4/14	38.5	5/13	0.297	0.586
Decreased vocal range	0	0/14	30.8	4/13	5.057	0.025*
Laryngeal irritations	14.3	2/14	46.2	6/13	3.283	0.070
Decreased breath support	14.3	2/14	46.2	6/13	3.283	0.070
Risk factors						
Vocal abuse	71.4	10/14	92.3	12/13	1.947	0.163
Shouting	35.7	5/14	69.2	9/13	3.033	0.082
Overpassing noise	50.0	7/14	69.2	9/13	1.033	0.310
Member youth organization	57.1	8/14	30.8	4/13	1.899	0.168
Throat clearing	42.9	6/14	51.5	8/13	0.942	0.332
Nasal airway obstructions	35.7	5/14	46.2	6/13	0.304	0.581
Smoking	0	0/14	0	0/13	-	-
Reflux	7.1	1/14	23.1	3/13	1.356	0.244
Allergy	42.9	6/14	30.8	4/13	0.422	0.516
Stress	28.6	4/14	69.2	9/13	4.464	0.035*

Note: * indicates a significant difference between the experimental group and the control group ($p < 0.05$).

Objective voice assessment

Table 4.3 summarizes the results of the objective voice assessment at pre- and post-condition. Compared to the control group, chewing resulted in a significant decrease in the acoustic measures jitter ($p = 0.007$) and NHR ($p = 0.048$), a significant increase in the acoustic measure f_o ($p = 0.049$), a significant expansion of the voice range profile (I-low [$p = 0.044$], I-high [$p = 0.033$], F-low [$p = 0.048$], F-high [$p = 0.018$]), and a significant increase in DSI score ($p = 0.002$). No differences were found between the experimental and control group for the aerodynamic measure MPT ($p = 0.791$) and the acoustic measure shimmer ($p = 0.202$).

DISCUSSION

The purpose of this pilot study was to determine how use of the vocal facilitating technique, chewing, affected the phonation of vocally healthy female SLP students. A positive effect on the SLP students' vocal quality and capacities was hypothesized because, according to the literature, chewing may facilitate a more natural voice production through relaxation of the vocal tract, regulation of the fundamental frequency and better coordination between respiration and phonation (Froeschels, 1943; Weiss & Beebe, 1950; Froeschels, 1952; Brodnitz & Froeschels, 1954; Beebe, 1956; Brodnitz, 1966; Thomas & Stemple, 2007; Boone et al., 2010). The hypothesis that vocal function would improve via the chewing facilitating technique has been supported by the significantly decreased acoustic voice measures jitter and NHR, the expanded voice range profile (I-low, I-high, F-low, F-high), and the increased objective vocal quality index (DSI) in the experimental group compared with the control group. The DSI increased from -0.6 (44%) before chewing to +1.7 (67%) after chewing, which indicates a 23% improvement as measured by the index. Similarly, f_o significantly increased in the experimental group relative to controls. A possible explanation for this increase may be that chewing facilitated subjects to speak at their more natural pitch (Brodnitz, 1966). However, the frequency change was relatively small and a similar magnitude of decline, observed in the control group, must be taken into account. Moreover, after chewing, the f_o (226.2 Hz) was situated further from the mean norm for female adults (212 Hz), but within the normal range of 167–258 Hz (De Bodt et al., 2008a).

Table 4.3 Comparison of the differences in pre- and post- objective vocal measures between the experimental group and the control group.

	Experimental group						Control group						
					Difference						Difference		
	Pre		Post		Pre-Post		Pre		Post		Pre-Post		
Parameters	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*p*-value
Maximum performance task													
MPT (s)	17.6	5.6	17.0	4.1	-0.6	4.0	22.5	8.1	21.5	5.7	-1.0	4.2	0.791
Acoustic analysis													
f_o (Hz)	217.8	18.1	226.2	14.1	+8.4	15.3	218.7	28.4	209.7	13.1	-9.0	27.4	0.049*
Jitter (%)	2.0	1.1	1.2	0.6	-0.8	0.9	1.6	0.7	2.0	0.9	+0.4	1.2	0.007*
Shimmer (%)	4.8	1.2	4.6	1.2	-0.2	1.7	4.6	1.1	5.2	1.5	+0.6	1.5	0.202
NHR	0.13	0.02	0.12	0.02	-0.01	0.02	0.13	0.02	0.14	0.02	+0.01	0.03	0.048*
Voice Range Profile													
I-low (dB)	63.1	3.1	60.1	2.5	-3.0	3.6	60.6	3.5	60.3	1.9	-0.3	3.0	0.044*
I-high (dB)	99.7	6.8	107.6	3.9	+7.9	6.4	103.4	6.6	106.3	3.9	+2.9	5.0	0.033*
F-low (Hz)	173.9	24.9	159.5	24.9	-14.4	13.2	173.5	15.3	170.9	7.5	-2.6	16.4	0.048*
F-high (Hz)	661.1	173.5	777.6	168.5	+116.5	145.5	644.5	145.1	638.8	172.4	-5.7	97.3	0.018*
DSI	-0.6	2.3	1.7	1.5	+2.3	2.3	1.1	2.1	0.5	2.0	-0.6	2.1	0.002*

Note: SD, standard deviation; MPT, maximum phonation time; f_o, fundamental frequency; NHR, noise-to-harmonic ratio; I-low, lowest intensity; I-high, highest intensity; F-low, lowest frequency; F-high, highest frequency; DSI, dysphonia severity index. * indicates a significant difference.

The assumption that chewing improves coordination between respiration and phonation (Weiss & Beebe, 2007) could not be supported because the MPT did not improve in the experimental group. Furthermore, no improvement could be observed for the acoustic measure shimmer.

Limitations of the study should be recognized and taken into account for further research. A first limitation is that subjects and experimenters were not blinded to the purpose of the study, and no sham training was provided for the control group. A second limitation is that, despite randomization, significant differences were found between the experimental and control group in symptoms of “hoarseness” and “decreased vocal range”, and in the risk factor “stress” before the initiation of the 18-week training period. Those differences suggest that the study groups were too small to obtain perfectly homogeneous groups and that larger sample sized would improve future work. Furthermore, no voice data were obtained on participants during the 18-week time span. Follow-up assessment during these weeks, including both the voice questionnaire and the objective voice assessment, would have provided valuable information. Follow-up assessment could also have been extended to examine the long-term outcome of the technique. Besides, evaluation of vocal quality and capacities was limited to objective measures, excluding subjective auditory-perceptual evaluations of the voice (e.g., GRBASI scale; Hirano, 1981) and a patient’s self-report (e.g., Voice Handicap Index; Jacobson et al., 1997). Another shortcoming of the study is the lack of information about whether home instructions were followed in week 9-17. Hence, adherence to the practice schedule for the chewing technique cannot be ensured. Finally, other factors such as clinician facilitated changes in subjects’ posture and respiratory technique and overlap of the production ”njamnjam” with resonant voice training might possibly have contributed to the improved vocal quality and capacities detected on post-measures.

Despite the previously described limitations, this pilot study provides useful first-stage results about the effect of an outdated and understudied vocal facilitating technique and its potential ability to facilitate and train the healthy voice (Weiss & Beebe, 2007). Examining the effect of chewing in patients with voice disorders is subject for further research. The present study suggests that chewing may facilitate expansion of the patients' vocal range and improvement in their vocal quality.

CONCLUSIONS

The results of this pilot study suggest that the facilitating technique chewing may improve objective vocal measures in vocally healthy female SLP students. The extent to which the chewing technique may be useful in improving voice measures in the presence of vocal pathology awaits further study.

4.2 Effect of the vocal facilitating techniques chant talk and pitch inflections on the phonation of future occupational voice users

Based on: Meerschman, I., Bettens, K., Dejagere, S., Tetaert, L., D'haeseleer, E., Claeys, S., & Van Lierde, K. (2016). Effect of two isolated vocal facilitating techniques chant talk and pitch inflections on the phonation of female speech-language pathology students: a pilot study, *Journal of Voice,* 30(6), 771.e17-771.e25.

ABSTRACT

Objective. The purpose of this study was to determine the effect of two isolated vocal facilitating techniques chant talk and pitch inflections on the phonation of vocally healthy female speech-language pathology (SLP) students.

Methods. A multigroup pretest-posttest randomized control group design was used. Forty vocally healthy female SLP students with a mean age of 18 years were randomly assigned to one of three groups: a chant talk group (practicing chant talk across 18 weeks, *n* = 13), a pitch inflections group (practicing pitch inflections across 18 weeks, *n* = 13), or a control group (practicing no facilitating techniques, *n* = 14). To compare vocal measures before and after this time span, an identical objective voice assessment protocol (maximum performance task, acoustic analysis, voice range profile, and Dysphonia Severity Index) was performed in the three groups.

Results. Both chant talk and pitch inflections groups resulted in a significant decrease of the acoustic measure noise-to-harmonics ratio compared with the control group. The chant talk group resulted in a significant increase in the acoustic measure fundamental frequency compared with the control group.

Conclusions. The results of this pilot study suggest that the facilitating techniques chant talk and pitch inflections might have a positive effect on the phonation of vocally healthy female SLP students. Decreased noise levels in the acoustic voice signal were found after training.

INTRODUCTION

Chant talk and pitch inflections are listed by Boone and McFarlane (1994) as techniques that may facilitate a more optimal vocal response in patients with dysphonia. Chant talk is produced by reciting syllables in one continuous tone, creating a “singing monotone” (similar to legato in singing; Boone et al., 2010). It is characterized by an elevation of pitch, prolongation of vowels, lack of syllable stress, and an obvious softening of glottal attack. The pitch inflections technique is used to stimulate pitch variability during phonation. Both facilitating techniques were described by Boone et al. (2010) as being particularly beneficial for patients with hyperfunctional dysphonia. Nevertheless, a broader application can be found in the literature, more specifically in treating organic dysphonia and training professional voices (McCabe & Titze, 2002a; Mashima et al., 2003; Van Lierde et al., 2004; Amir et al., 2005; Bovo et al., 2007; Oliveira et al., 2009; Vashani et al., 2010; De Bodt et al., 2012; Park et al., 2012).

The existing literature is limited to defining the techniques and describing their potential benefit. Studies that investigate the underlying mechanisms and the exact reason for a possible effect are missing. Boone et al. (2010) and Bovo et al. (2007) mentioned obtaining relaxed voicing and elimination of hard glottal attacks, although these findings were based on clinical experience rather than evidence-based practice. Moreover, the techniques have been used for more than 20 years (Boone et al., 1994) and yet effectiveness studies are rare. A summary of these studies can be found in Table 4.4. A first observation of the table indicates that almost all studies had a positive outcome. A less favorable result was found by De Bodt et al. (2012), who used fiberoptic laryngovideoendoscopy to assess the impact of vocal techniques on vocal-fold closure in young females with normal vocal quality. Remarkably, chant talk resulted in significantly decreased vocal-fold closure. However, an unexpected laryngeal tension or breath holding during phonation due to the use of a flexible videoendoscopic system could possibly have influenced the results (De Bodt et al., 2012). A second observation of the table indicates that chant talk and/or pitch inflections have nearly always been investigated as part of a broader therapy program (Mashima et al., 2003; Van Lierde et al., 2004; Amir et al., 2005; Bovo et al., 2007; Oliveira et al., 2009; Vashani et al., 2010; De Bodt et al., 2012; Park et al., 2012), wherefore the results cannot be attributed solely to the techniques. One exception is a study of McCabe and Titze (2002), which examined the exclusive effect of chant talk on self-reported symptoms of vocal fatigue in four public school teachers. Group data on one particular vocal technique are difficult to gather because voice therapy is individualized and usually includes several techniques (Boone et al., 2010). Nevertheless, the need for effectiveness studies that exclusively investigate the facilitating techniques chant talk and pitch inflections becomes clear.

This pilot study aimed to make a first contribution to the research gap and focused on chant talk and pitch inflections as techniques that could facilitate and train the healthy voice. Previous studies investigating healthy subjects show conflicting results. Bovo et al. (2007) and Oliveira et al. (2009) both investigated the effect of a training program including chant talk and pitch inflections in healthy occupational voice users. Bovo et al. (2007) found a positive effect, whereas Oliveira et al. (2009) found no effect. These conflicting results are probably due to various reasons such as variations in assessment methods and training frequency, although the main reason probably remains a difference in therapy content: the techniques were never investigated in isolation and were always presented in different combinations.

The purpose of this study was to determine the effect of the isolated vocal facilitating techniques chant talk and pitch inflections on the phonation of vocally healthy female speech-language pathology (SLP) students. A positive effect on the SLP students' vocal quality and capacities was hypothesized because chant talk and pitch inflections may facilitate relaxed voicing with elimination of hard glottal attacks (Bovo et al., 2007; Boone et al., 2010), and most studies that investigated the techniques as part of a broader training or therapy program were promising (Mashima et al., 2003; Van Lierde et al., 2004; Amir et al., 2005; Bovo et al., 2007; Oliveira et al., 2009; Vashani et al., 2010; De Bodt et al., 2012; Park et al., 2012).

Table 4.4 Summary of studies investigating the effect of a training or therapy program including chant talk and/or pitch inflections.

Authors	Subjects	Therapy	Methods	Results
McCabe & Titze (2002)	*n* = 4 1 Male (36 yrs.) 3 Females (40; 50; 56 yrs.) Public school teachers Vocal fatigue	Chant talk therapy (along with a placebo therapy)	Fatiguing task pre- and post-therapy, during which self-evaluation measures of vocal effort and voice quality were made by the subjects	The chant talk therapy positively affected the subjects' responses to the fatiguing task, whereas the placebo therapy did not.
Mashima et al. (2003)	*n* = 72 (18-85 yrs.) 34 Males, 38 females Vocal nodules (*n* = 18) Edema (*n* = 21) Unilateral vocal fold paralysis (*n* = 9) Vocal hyperfunction (*n* = 3)	Chant talk, pitch inflections, focus, establishing a new pitch, yawn-sigh, glottal attack changes, open-mouth approach (all pathologies) Confidential voice (vocal nodules) Vocal function exercises (unilateral vocal fold paralysis)	Perceptual evaluation Acoustic analysis Self-evaluation Fiberoptic laryngoscopy	There was significant improvement in all outcome measurements.
Van Lierde et al. (2004)	*n* = 4 2 Males (59; 60 yrs.) 2 Females (37; 39 yrs.) Professional voice users Persistent moderate-to-severe muscle tension dysphonia	Laryngeal manual therapy program Chant talk combined with the open-mouth approach	Videolaryngostroboscopy Perceptual evaluation Aerodynamic assessment Voice Range Profile Acoustic analysis Dysphonia Severity Index	All subjects showed an improvement in perceptual evaluation, F-high, jitter, shimmer and Dysphonia Severity Index, and a f_o closer to the norm.
Amir et al. (2005)	*n* = 16 (38.1 yrs., SD = 10.7) Male teachers Laryngeal pathology group: n = 7 Vocal nodules (*n* = 3) Incomplete glottal closure (*n* = 1) Vocal nodules + incomplete glottal closure (*n* = 3) Healthy larynges group: *n* = 9	Vocal hygiene Respiratory exercises Chant talk (for subjects who experienced difficulties in producing chant talk: yawn-sigh, open-mouth approach, chewing)	Acoustic analysis Perceptual evaluation	There was significant improvement of jitter, shimmer and noise-to-harmonics ratio, and no significant improvement of f_o and Voice Turbulence Index. Subjects who were diagnosed with laryngeal pathologies benefitted more from the voice course than subjects with healthy larynges.
Bovo et al. (2007)	*n* = 41 Female teachers Study group: *n* = 21 (23-57 yrs.) Control group: *n* = 20 (24-54 yrs.)	Preventive voice program: two theoretical lectures A short group voice therapy (respiratory exercises, relaxation techniques, manual circumlaryngeal therapy, resonance therapy, exercises for developing greater oral opening, chewing, yawn-sigh, chant talk and pitch inflections) Home-controlled voice exercises Vocal hygiene	Videolaryngostroboscopy Maximum phonation time Acoustic analysis Perceptual evaluation Voice Handicap Index	At 3-month evaluation, participants in the study group demonstrated an improvement in maximum phonation time, jitter, shimmer, perceptual global grading of dysphonia (G) and the Voice Handicap Index. The positive effects remained after 12 months, although they were reduced.

Table 4.4 *(Continued)*

Authors	Subjects	Therapy	Methods	Results
Oliveira et al. (2009)	*n* = 43 (18-55 yrs.) Telemarketers Study group: *n* = 14 5 Males, 9 females Control group: *n* = 29 5 Males, 24 females	Study group: vocal training program Control group: no training Vocal warm-up: facilitating sounds, body movement techniques with sound production, overarticulation exercises, pitch and loudness range exercises, hand-over-mouth, chant talk Vocal cool-down: voice sounds with descending musical scales, yawn-sigh, laryngeal manipulation	Vocal Symptoms self-evaluation questionnaire	The vocal training program was not considered effective with regard to the occurrence of vocal symptoms. However, due to a probable increase in symptoms in untrained telemarketers, it can work as a protective factor.
Vashani et al. (2010)	*n* = 32 14 Males, 18 females Gastroesophageal reflux	Study group: medical + voice therapy Control group: medical + placebo therapy Vocal hygiene Relaxation exercises, respiratory exercises Yawn-sigh, glottal fry, chewing, chant talk, humming	Reflux score Reflux Symptom Index Acoustic analysis Perceptual evaluation	The improvement in Reflux Symptom Index, jitter and normalized noise energy was greater in the study group. The perceptual evaluation of hoarseness and breathiness, and shimmer and harmonic-to-noise ratio improved only in the study group.
De Bodt et al. (2012)	*n* = 21 (17-19 yrs.) Female first-year speech therapy and audiology students with normal vocal quality	Habitual phonation High pitch Low pitch Resonance on /m/ Coblenzer's "abspannen" Chant talk	Fiberoptic laryngovideoendoscopy	Resonance on /m/ significantly improved vocal-fold closure compared with habitual phonation. All other techniques, except for low pitch, led to significant worse closure.
Park et al. (2012)	*n* = 100 Study group: *n* = 50 (53.24 yrs.) 23 Males, 27 females Control group: *n* = 50 (57.12 yrs.) 25 Males, 25 females Laryngopharyngeal reflux	Study group: medical + voice therapy Control group: medical therapy alone Vocal hygiene Relaxation, respiratory exercises Yawn-sigh, glottal fry, chewing, chant talk, humming	Reflux Symptom Index Reflux Finding Score Voice Handicap Index Acoustic analysis Perceptual evaluation	Significantly more patients in the study group showed a clinically significant change in Reflux Symptom Index, Voice Handicap Index and perceptual evaluation.

MATERIAL AND METHODS

This study was approved by the Ethics Committee of Ghent University Hospital.

Participants

A total of 42 female students enrolled in the first year of the bachelor program Logopaedic and Audiological Sciences at Ghent University were randomly selected to participate in this study. All subjects provided written informed consent at an initial briefing. Each subject was then assessed by an otorhinolaryngologist and audiologist performing a nasopharyngeal and laryngeal evaluation, videolaryngostroboscopy, otoscopy, and audiometry to exclude voice disorders and nasal and ear diseases. On the basis of these results, two students were excluded because of an incomplete glottal closure resulting in a hypofunctional voice.

Finally, a homogenous group of 40 vocally healthy female students with a mean age of 18 years (SD, 0.7 years; range, 17-21 years) were included. The participants were randomly assigned to one of three groups: a chant talk group (receiving the facilitating technique chant talk, *n* = 13), a pitch inflections group (receiving the facilitating technique pitch inflections, *n* = 13), or a control group (receiving no facilitating techniques, *n* = 14). There were no differences between the three groups in mean age (Kruskal-Wallis test, *p* = 0.156). All participants were in good physical and mental states of wellbeing and were nonsmokers. None of them followed voice therapy or training, was an occupational voice user or an elite vocal performer.

Voice assessment

Voice questionnaire

At the beginning of the study, each subject filled in a questionnaire based on the voice assessment protocol of the European Study Group on Voice Disorders (De Bodt et al., 1996) to describe vocal complaints and risk factors.

Objective voice assessment

The three groups completed a pre- and post-objective voice assessment. Data were collected by two experimenters (S.D. and L.T.) in a sound-treated room at Ghent University Hospital.

Maximum performance task. To measure the maximum phonation time (MPT), the participants were asked to sustain the vowel /a/ at their habitual pitch and loudness in free field while seated. The MPT was modeled by the experimenters, and the participants received visual and verbal encouragements to produce the longest possible sample. The length of the sustained vowel was measured in seconds. The best trial of three attempts was retained for further analysis.

Acoustic analysis. The fundamental frequency (f_o, Hz), jitter (%), shimmer (%), and noise-to-harmonics ratio (NHR) were obtained by the Multi-Dimensional Voice Program of the Computerized Speech Lab (CSL; model 4500, KayPENTAX, Montvale, NY). The subjects were instructed to produce the vowel /a/ at their habitual pitch and loudness. A midvowel segment of 3 seconds registered with a sampling rate of 50 kHz was used.

Voice range profile. The voice range assessment was performed with the CSL following the procedure outlined by Heylen et al. (1998). This assessment includes determination of the highest and the lowest fundamental frequency and intensity. The participants were instructed to produce the vowel /a/ for at least 2 seconds using, respectively, a habitual pitch and loudness, a minimal pitch, a minimal intensity, a maximal pitch, and a maximal intensity. Each production was modeled by the experimenters, and the participants received visual and verbal encouragements.

Dysphonia Severity Index (DSI). The DSI is a multiparameter approach designed to establish an objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000). The DSI is based on a weighted combination of the following parameters: MPT (in s), highest frequency (F-high, in Hz), lowest intensity (I-low, in dB) and jitter (in %). The DSI is constructed as $0.13\ \text{MPT} + 0.0053\ \text{F-high} - 0.26\ \text{I-low} - 1.18\ \text{jitter} + 12.4$. The index ranges from −5 to +5 for severely dysphonic voices to normal voices. A more negative index indicates a worse vocal quality. A DSI of 1.6 is the threshold separating normal voices from dysphonic voices (Raes et al., 2002).

Facilitating techniques

The chant talk group practiced the facilitating technique chant talk across 18 weeks, whereas the pitch inflections group practiced the facilitating technique pitch inflections in the same time span. Both programs (chant talk or pitch inflections) consisted of six weekly training sessions organized by the experimenters. These 1-hour group sessions, given in six nonconsecutive weeks, were gradually built up in terms of difficulty. The content of the training programs, based on the procedure outlined by Boone et al. (2010) is presented in Table 4.5. The experimenters provided verbal information, examples, and corrective feedback. In addition to the exercises during training, the subjects were instructed to practice the facilitating technique individually at home twice a day for 10 minutes. At any moment, these home exercises were adapted to the level achieved in the group sessions. In week 18, an interactive rehearsal session was organized in both groups. Under the guidance of the experimenters, subgroups (two or three subjects) presented one of the steps learned in training (chant talk: automatic sequences, words, phrases/sentences, texts, spontaneous speech; pitch inflections: vowels, words, sentences, texts, spontaneous speech). The steps were covered in the same order as in the training sessions. The other subjects followed their instructions. The control group did not receive any facilitating techniques in these 18 weeks and were instructed to use their voice as in everyday life.

Statistical analysis

SPSS version 22 (SPSS Corporation, Chicago, IL) was used for the statistical analysis of the data. All analyses were conducted at $\alpha = 0.05$.

Voice questionnaire

A chi-square test of independence was used to verify if there were differences between the three groups in precondition vocal complaints and risk factors.

Objective voice assessment

One-way analysis of variance (ANOVA) was used to make a comparison between the three groups in: (a) precondition objective vocal measures, and (b) differences between pre- and post-objective vocal measures. *Post hoc* Scheffé analysis was performed when a significant group effect was found.

Table 4.5 Content of the training programs chant talk and pitch inflections based on Boone et al. (2010).

Session	Chant talk (CT)	Pitch inflections (PI)
1	Education and counseling - Explanation of CT as a method that reduces the effort in speaking - Pointing out that CT is only a temporarily way of practicing and will not become a permanent way of speaking Demonstration - Demonstrating CT by playing a recording of a religious chant - Demonstrating CT by the experimenters: reading aloud some sentences and paragraphs - Imitation and familiarization by the subjects	Education and counseling - Explanation of PI as a method that improves intonation in monotone voices - Comparing adequate intonation and vocal monotony using auditory and visual feedback obtained by the software program *Praat* (Boersma & Weeninck, Phonetic Sciences Department, University of Amsterdam, The Netherlands) Demonstration - Demonstrating PI by the experimenters: ascending, descending and alternating tones in vowels and words - Imitation and familiarization by the subjects
2	Practicing CT in automatic sequences: counting, days of the week Practicing CT in words: monosyllabic, two syllabic, polysyllabic	Practicing PI in the vowels /a/, /e/, /i/, /o/, /y/: ascending, descending, and alternating tones
3	*Repeating automatic sequences and words* Practicing CT in phrases Alternating phrases with CT and normal speech	*Repeating vowels* Practicing PI in words (monosyllabic, two syllabic, polysyllabic): ascending, descending and alternating tones
4	*Repeating automatic sequences, words and phrases* Practicing CT in sentences Alternating sentences with CT and normal speech (+ auditory feedback: contrast of the chanted voice and the normal voice: discussion pitch differences, phonatory prolongations, and soft glottal onset)	*Repeating vowels and words* Practicing an adequate intonation in sentences (+ auditory and visual feedback – *Praat*)
5	*Repeating phrases and sentences* Practicing CT in texts Alternating texts with CT and normal speech (+ auditory feedback)	*Repeating vowels and words* Practicing an adequate intonation in sentences, texts and spontaneous speech (+ auditory and visual feedback – *Praat*)
6	*Repeating phrases, sentences and texts* Practicing CT in spontaneous speech Alternating spontaneous speech with CT and normal speech	*Repeating vowels and words* Practicing an adequate intonation in sentences, texts and spontaneous speech (+ auditory and visual feedback – *Praat*)

RESULTS

Voice questionnaire

The results of the questionnaire concerning vocal complaints and vocal risk factors are presented in Table 4.6. No significant differences were found between the three groups at precondition (chi-square test, $p > 0.05$).

Table 4.6 Baseline vocal complaints and risk factors in the chant talk group, the pitch inflections group and the control group.

	Chant talk		**Pitch inflections**		**Control group**			
Vocal complaints and risk factors	%	*n*	%	*n*	%	*n*	χ^2	*p*-value
Vocal complaints								
Vocal fatigue	23.1	3/13	23.1	3/13	35.7	5/14	0.729	0.695
Hoarseness	38.5	5/13	38.5	5/13	50.0	7/14	0.496	0.780
Decreased vocal quality in the morning	69.2	9/13	38.5	5/13	42.9	6/14	2.901	0.234
Decreased vocal range	30.8	4/13	23.1	3/13	35.7	5/14	0.518	0.772
Laryngeal irritations	23.1	3/13	23.1	3/13	42.9	6/14	1.695	0.428
Decreased breath support	38.5	5/13	23.1	3/13	42.9	6/14	1.261	0.532
Risk factors								
Vocal abuse								
Shouting	53.8	7/13	69.2	9/13	64.3	9/14	0.686	0.710
Overpassing noise	76.9	10/13	76.9	10/13	57.1	8/14	1.695	0.428
Member youth organization	23.1	3/13	46.2	6/13	28.6	4/14	1.729	0.421
Throat clearing	30.8	4/13	30.8	4/13	50.0	7/14	1.436	0.488
Nasal airway obstructions	30.8	4/13	15.4	2/13	42.9	6/14	2.428	0.297
Smoking	0	0/13	0	0/13	0	0/14	-	-
Reflux	23.1	3/13	23.1	3/13	21.4	3/14	0.014	0.993
Allergy	23.1	3/13	15.4	2/13	28.6	4/14	0.676	0.713
Stress	30.8	4/13	30.8	4/13	50.0	7/14	1.867	0.393

Objective voice assessment

Comparison of the precondition objective vocal measures

The results of the precondition voice assessment are presented in Table 4.7. No significant differences in precondition vocal measures were found between the three groups (One-way ANOVA, $p > 0.05$).

Table 4.7 Comparison of baseline vocal measures between the chant talk group, the pitch inflections group and the control group.

	Chant talk		**Pitch inflections**		**Control group**		ANOVA	
Parameters	Mean	SD	Mean	SD	Mean	SD	*F*-value	*p*-value
Maximum performance task								
MPT (s)	21.2	8.0	17.0	5.9	23.2	7.4	2.678	0.082
Acoustic analysis								
f_o (Hz)	213.5	17.7	210.3	21.4	212.9	39.4	0.047	0.954
Jitter (%)	1.3	0.7	1.4	0.4	1.5	0.7	0.273	0.763
Shimmer (%)	5.3	2.0	5.0	1.3	4.5	1.2	1.024	0.369
NHR	0.15	0.03	0.14	0.02	0.13	0.02	2.762	0.076
Voice Range Profile								
I-low (dB)	60.5	3.2	63.1	3.1	60.7	3.3	2.793	0.074
I-high (dB)	104.0	6.8	100.3	5.9	102.9	6.4	1.136	0.332
F-low (Hz)	169.9	15.5	163.7	20.5	167.8	26.2	0.283	0.755
F-high (Hz)	748.7	142.3	700.1	160.3	635.6	172.5	1.716	0.194
DSI	1.5	1.7	0.7	1.6	1.2	1.5	0.910	0.411

Note: SD, standard deviation; MPT, maximum phonation time; f_o, fundamental frequency; NHR, noise-to-harmonic ratio; I-low, lowest intensity; I-high, highest intensity; F-low, lowest frequency; F-high, highest frequency; DSI, dysphonia severity index.

Comparison of the differences in pre- and post-objective vocal measures

Comparison of the differences in pre- and post-objective vocal measures between the three groups is presented in Table 4.8. One-way ANOVA showed a significant group effect for the acoustic measures f_o (F[2,37] = 7.852, p = 0.001) and NHR (F[2,37] = 7.893, p = 0.001). No significant group effect was found for the maximum performance task MPT, the acoustic measures jitter and shimmer, the voice range measures (I-low, I-high, F-low, and F-high), and the DSI. *Post hoc* Scheffé analysis showed a significant increase in f_o in the chant talk group (M = +21.3, SD = 21.9) compared with the control group (M = −10.3, SD 25.1) (p = 0.002). No significant differences in f_o were found between the chant talk group and the pitch inflections group, and between the pitch inflections group and the control group. *Post hoc* Scheffé analysis showed a significant decrease in NHR in the chant talk (M = −0.014, SD = 0.026) and pitch inflections groups (M = −0.022, SD = 0.024) compared with the control group (M = +0.013, SD = 0.023) (chant talk: p = 0.023, pitch inflections: p = 0.002). No significant differences in NHR were found between the chant talk group and the pitch inflections group.

Table 4.8 Comparison of the differences in pre- and post- objective vocal measures between the chant talk group, the pitch inflections group and the control group.

	Chant talk						**Pitch inflections**						**Control group**						**ANOVA**	
					Evolution						Evolution						Evolution			
	Pre		Post		Pre-Post		Pre		Post		Pre-Post		Pre		Post		Pre-Post			
Parameters	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F-ratio	*p*-value
Maximum performance																				
MPT (s)	21.2	8.0	23.5	7.1	+2.3	4.3	17.0	5.9	18.3	5.9	+1.3	4.1	23.2	7.4	22.2	6.2	-1.0	4.1	2.260	0.119
Acoustic analysis																				
f_o (Hz)	213.5	17.7	234.8	17.3	+21.3	21.9	210.3	21.4	210.9	21.8	+0.6	13.6	212.9	39.4	202.6	30.5	-10.3	25.1	7.582	0.001*
Jitter (%)	1.3	0.7	1.1	0.6	-0.2	0.8	1.4	0.4	1.0	0.6	-0.4	0.7	1.5	0.7	1.9	0.9	+0.4	1.2	2.873	0.069
Shimmer (%)	5.3	2.0	5.0	1.8	-0.3	1.4	5.0	1.3	4.4	0.9	-0.6	1.4	4.5	1.2	5.0	1.5	+0.5	1.6	2.124	0.134
NHR	0.149	0.030	0.135	0.013	-0.014	0.026	0.140	0.023	0.118	0.019	-0.022	0.024	0.128	0.019	0.141	0.024	+0.013	0.023	7.893	0.001*
Voice Range Profile																				
I-low (dB)	60.5	3.2	61.1	3.1	+0.6	2.9	63.1	3.1	61.5	4.6	-1.6	4.1	60.7	3.3	60.9	2.7	+0.2	2.7	1.726	0.192
I-high (dB)	104.0	6.8	108.6	5.2	+4.6	3.3	100.3	5.9	107.3	4.9	+7.0	5.3	102.9	6.4	106.4	3.9	+3.5	4.6	2.140	0.132
F-low (Hz)	169.9	15.5	170.9	17.3	+1.0	14.6	163.7	20.5	152.7	19.7	-11.0	17.2	167.8	26.2	166.5	21.3	-1.3	16.7	2.023	0.147
F-high (Hz)	748.7	142.3	821.2	228.1	+72.5	230.8	700.1	160.3	732.8	248.6	+32.7	233.2	635.6	172.5	627.2	200.4	-8.4	90.8	0.585	0.562
DSI	1.5	1.7	2.6	1.9	+1.1	2.2	0.7	1.6	1.4	3.1	+0.7	2.2	1.2	1.5	0.5	1.9	-0.7	1.7	3.000	0.062

Note: M, mean; SD, standard deviation; MPT, maximum phonation time; f_o, fundamental frequency; NHR, noise-to-harmonic ratio; I-low, lowest intensity; I-high, highest intensity, F-low, lowest frequency; F-high, highest frequency, DSI, Dysphonia Severity Index. * indicates a significant effect of group on the differences in pre- and post-objective vocal measures.

DISCUSSION

The purpose of this study was to determine the effect of two isolated vocal facilitating techniques chant talk and pitch inflections on the phonation of vocally healthy females enrolled in an SLP program. A positive effect on the SLP students' vocal quality and capacities was hypothesized because chant talk and pitch inflections may facilitate relaxed voicing with elimination of hard glottal attacks (Bovo et al., 2007; Boone et al., 2010), and most studies that investigated the techniques as part of a broader training or therapy program were promising (Mashima et al., 2003; Van Lierde et al., 2004; Amir et al., 2005; Bovo et al., 2007; Oliveira et al., 2009; Vashani et al., 2010; De Bodt et al., 2012; Park et al., 2012). The experiment started with a homogeneous group of 40 female future occupational voice users (mean age: 18 years) with healthy vocal fold anatomy and physiology. No significant differences were found between the three groups regarding vocal complaints, vocal risk factors, and objective vocal measures before the use of a facilitating technique.

Chant talk resulted in a significant increase of the acoustic measure f_o compared with the control group. The f_o increased from 213.5 Hz pretraining to 234.8 Hz posttraining with the last value being less close to the mean norm defined for women (212 Hz), but within the normal range (167–258 Hz) (De Bodt et al., 2008a). This result does not corroborate the findings of Van Lierde et al. (2004) and Amir et al. (2005) (Table 4.4). Van Lierde et al. (2004) found an f_o closer to the norm in patients with muscle tension dysphonia after the laryngeal manual therapy program followed by chant talk in combination with the open-mouth approach. However, it must be taken into account that three out of four studied subjects showed increased f_o values pretherapy (when compared with the mean norm), which is hypothetically related to the increased muscle tension. Amir et al. (2005) did not find a significant difference in f_o in patients with vocal nodules and/or incomplete glottal closure after the voice course consisting of chant talk as the major direct technique. A possible explanation for the increase in f_o in the present study could be that the participants maintained the elevation of pitch necessary to create chant talk. Nevertheless, they were pointed to the fact that chanting is only a temporary behavior, and the technique was alternated with normal speech during training sessions to practice this transition (Table 4.5).

Both chant talk and pitch inflections showed a significant decrease in the acoustic measure NHR compared with the control group. The NHR decreased from 0.149 pre-chant talk to 0.135 post-chant talk and from 0.140 pre-pitch inflections to 0.118 post-pitch inflections. These post-training values were closer to the mean norm for female adults (0.121) (De Bodt et al., 2008a). Amir et al. (2005) also found a decrease in NHR after chant talk combined with vocal hygiene and respiratory exercises in male teachers with and without vocal pathology. A decrease in NHR indicates less noise in the acoustic voice signal. Noise can arise from turbulent airflow generated by inadequate closure or aperiodic vibrations of the vocal folds (Ferrand, 2002). Therefore, a decrease in NHR might indicate an improved glottal closure and a better conversion from aerodynamic energy into acoustic energy (Titze, 2000a). However, inclusion of glottal efficiency measures in future studies are needed to support this hypothesis. It should additionally be noted that the above reasoning is not supported by the decreased vocal fold closure during chant talk found by De Bodt et al (2012). Besides, glottal efficiency is dependent on f_o with a favor for high-pitched production (Titze, 2000a) which may have caused the differences in the chant talk group (increased f_o posttraining).

As hypothesized, the results indicate a positive effect of the facilitating techniques on the SLP students' vocal quality, more specifically on the NHR. The question why this decrease in NHR (together with an increase in f_o after chant talk) could be expected remains unanswered. Boone et al. (2010) assumed a relaxation of the vocal tract and an elimination of hard glottal attacks, but these findings were based on clinical experience rather than evidence-based practice. The first assumption, “relaxation of the vocal tract”, is rather vague and misses a concrete definition [e.g. less tension in the (para)laryngeal musculature, less thyrohyoid space tenderness, less supraglottic hyperfunction, or less base of tongue tightness (Nguyen et al., 2009; Van Houtte et al., 2011b; Craig et al., 2015)]. Surface electromyography (sEMG), measuring supra- and infrahyoidal muscle tension, may provide more clarity in future studies (Milutinoviæ et al., 1988; Redenbaugh & Reich, 1989; Hocevar-Boltezar et al., 1998; Stepp et al., 2011). The second assumption, “elimination of hard glottal attacks”, can be debated as well. Although hard glottal attacks may be not as harmful as previously assumed (Cottrell, 2009), Andrade et al. (2000) did measure higher frequencies in patients with voice disorders compared with controls, and several authors (Morrison et al., 1986; Andrade et al., 2000; Altman et al., 2005) reported an association with hyperfunctional dysphonia. It is not clear whether a high frequency of hard glottal attacks causes voice disorders or whether the association occurs for some other reason such as compensation (Andrade et al., 2000). However, in the context of voice disorders, we can assume that this vocal behavior (which requires excessive tension) tends to vocal abuse and needs to be eliminated (Andrade et al., 2000; Cotrell, 2009). Whether chant talk and/or pitch inflections are effectively eliminating hard glottal attacks cannot be concluded from this study and is subject for further research.

Besides the lack of evidence-based practice, another concern rises about the assumptions made by Boone et al. (2010). If both techniques are supposed to be based on identical mechanisms (relaxation of the vocal tract and elimination of hard glottal attacks) and if both techniques are supposed to be effective for the same patients (hyperfunctional dysphonia), the following contradiction is rather unexpected: a monotonic phonation is stimulated during chant talk, whereas adequate intonation is stimulated during pitch inflections (Boone et al., 2010). These ambiguities and vague assumptions highlight the need for studies that investigate the techniques' underlying mechanisms and the exact reason for a possible effect.

This pilot study focused on chant talk and pitch inflections as techniques that could facilitate and train the healthy voice. Although these techniques were originally listed as rehabilitation techniques (for patients with dysphonia), they were occasionally used in voice training (of healthy subjects) (Bovo et al., 2007; Oliveira et al., 2009). This is no surprise keeping in mind the common goal of both interventions, namely improving vocal quality and capacities (De Bodt et al., 2008a). A similar trend of using identical techniques for both rehabilitation and training can be seen in multiple studies (Timmermans et al., 2004; Timmermans et al., 2011; Van Lierde et al., 2011; D'haeseleer et al., 2013; Santos et al., 2015). Training programs including some of these techniques (such as manual circumlaryngeal therapy, the open-mouth approach, glottal fry, resonant exercises, voiced tongue and lip trills, the hand-over-mouth technique, relaxation, and respiration) appear to improve vocal capacities in healthy subjects as well, more specifically in future occupational voice users or elite vocal performers (Timmermans et al., 2004; Timmermans et al., 2011; Van Lierde et al., 2011; D'haeseleer et al., 2013; Santos et al., 2015). Based on the results of the current study, chant talk and pitch inflections may possibly be added to the list of useful training techniques, although this awaits further study. Whether similar results can be expected in patients with a variety of voice disorders can only be suggested and is also subject for further research.

The limitations of the study should be recognized and taken into account for further research. One of these limitations is that subjects and experimenters were not blinded to the purpose of the study and no sham training was provided for the control group. Besides, no voice data were obtained on participants during the 18-week time span. Follow-up assessment during those weeks, including both the voice questionnaire and the voice measures, would have provided valuable information. This follow-up assessment could also have been extended to examine the long-term outcome of the technique. Another shortcoming of the study is the lack of information about whether home instructions were followed by all students. Hence, adherence to the practice schedules for both techniques cannot be ensured. Furthermore, evaluation of vocal quality and capacities was limited to objective measures, excluding a subjective perceptual evaluation of the voice (e.g. GRBASI scale; Hirano, 1981) and a patient's self-report (e.g. Voice Handicap Index; Jacobson et al., 1997). Finally, the objective measures were only based on sustained vowel samples. Including voice assessments based on both sustained vowels and continuous speech (e.g. Acoustic Voice Quality Index; Maryn et al., 2010a) would be a merit in approximating daily speech and voice use patterns.

Despite the above-described limitations, this pilot study provides useful first-stage results about the exclusive effect of two outdated and understudied vocal facilitating techniques. As hypothesized, the results indicate a positive effect of the facilitating techniques on the SLP students' vocal quality, more specifically on the NHR. A larger scale investigation will have to confirm these preliminary results. To test the hypothesis, we focused on chant talk or pitch inflections as techniques that could facilitate and train the healthy voice. Examining the effect of the techniques in patients with voice disorders is subject for further research.

CONCLUSIONS

The results of this pilot study suggest that the facilitating techniques chant talk and pitch inflections might have a positive effect on the phonation of vocally healthy female SLP students. Decreased noise levels in the acoustic voice signal were found after training. An investigation of the underlying mechanisms together with their potential effect in subjects with vocal pathology is recommended in future.

4.3 Effect of the vocal facilitating techniques glottal fry and yawn-sigh on the phonation of future occupational voice users

Based on: Meerschman, I., D’haeseleer, E., Catry, T., Ruigrok, B., Claeys, S., & Van Lierde, K. (2017). Effect of two isolated vocal facilitating techniques glottal fry and yawn-sigh on the phonation of female speech-language pathology students: a pilot study. *Journal of Communication Disorders,* 66, 40-50.

ABSTRACT

Objective. The purpose of this study was to determine the effect of two isolated vocal facilitating techniques, glottal fry and yawn-sigh, on the phonation of vocally healthy female speech-language pathology (SLP) students.

Methods. A multigroup pretest-posttest randomized control group design was used. Thirty-six vocally healthy female SLP students with a mean age of 18 years were randomly assigned to one of three groups: a glottal fry group (practicing the facilitating technique glottal fry across 18 weeks, *n* = 12), a yawn-sigh group (practicing the facilitating technique yawn-sigh across 18 weeks, *n* = 12), or a control group (receiving no facilitating techniques, *n* = 12). To compare vocal measures before and after this training period, an identical objective voice assessment protocol (maximum performance task, acoustic analysis, voice range profile and Dysphonia Severity Index) was performed in the three groups. Groups were compared over time using linear mixed models. Within-group effects of time were determined using post-hoc pairwise comparisons.

Results. Glottal fry resulted in a significant decrease in lowest and highest intensity. Yawn-sigh resulted in a significant increase in fundamental frequency, a significant decrease in shimmer and noise-to-harmonic ratio, and a significant increase in highest intensity.

Conclusions. Yawn-sigh may have a positive effect on the phonation of female vocally healthy future SLPs, whereas results are less supportive for using glottal fry in training this population’s voice.

INTRODUCTION

Glottal fry and yawn-sigh are listed by Boone and McFarlane (1988) as techniques that may facilitate a more optimal vocal response in dysphonic patients. According to the authors, especially voice disorders characterized by vocal hyperfunction, such as muscle tension dysphonia, vocal nodules, polyps, spasmodic dysphonia and ventricular phonation, may benefit from the techniques (Boone et al., 2010).

Glottal fry (also referred to as *vocal fry*, *basal register*, *pulse register*, *glottalization*, *crackling voice*, *creaky voice or strohbass*) is the lowest vocal register characterized by frequencies ranging from 20 to 80 Hz, irregular oscillations and pulse-like vibrations with relatively long periods of glottal closure and tightly adducted vocal folds (Blomgren et al., 1998; Titze, 2000a; Chen et al., 2002; Doellinger et al., 2005; Nix et al., 2005; Slifka, 2006; De Bodt et al., 2008a; Boone et al., 2010; Yuesa, 2010; Cielo et al., 2011; Wolk et al., 2012; Abdelli-Beruh et al., 2016; Oliveira et al., 2016). This pulse-like vibratory pattern of low frequency results in a vocal quality accompanied by creaking, cracking, and popping noises (Abdelli-Beruh et al., 2014). A literature review of Cielo et al. (2011) showed that glottal fry is predominantly produced by the action of the thyroarytenoid muscle (especially its inner portion), which gets shortened, dropping the mucosa in great volume along the free edge, increasing subglottic pressure, reducing airflow, and increasing jitter, shimmer and noise levels of the acoustic signal. Other authors mentioned decreased subglottic pressure when producing glottal fry (Blomgren et al., 1998; Chen et al., 2002; Nix et al., 2005; Boone et al., 2010). According to Boone et al. (2010), glottal fry has therapeutic indications due to its production with minimal airflow and subglottic pressure, relaxed vocal folds and reduced friction between the folds.

Remarkably, glottal fry has mainly been considered a perceptual, and often diagnostic, vocal parameter instead of a therapeutic technique (Ross et al., 1998; Hartelius et al., 2003; Chen et al., 2007; Gottliebson et al., 2007; Vertigan et al., 2008; Gibson & Vertigan, 2009; Nguyen et al., 2009; Iwarsson & Petersen, 2012). Perceptually, a distinction has been made between persistent or sporadic presence of glottal fry, respectively associated with vocal pathology or non-pathological communicative roles (Cielo et al., 2011). The persistent use of glottal fry is often considered harmful and may represent vocal hyperfunction (Gottliebson et al., 2007; Cielo et al., 2011). It often co-occurs with other signs such as hoarse, harsh and rough vocal qualities (Blomgren et al., 1998). Besides, daily communication requires sufficient volume and projection that is impossible to achieve in this register; the attempt to raise the intensity in glottal fry may then in turn built up vocal tension (Cielo et al., 2011). On the other hand, several authors (Slifka, 2006; Yuesa, 2010; Wolk et al., 2012; Abdelli-Beruh et al., 2014; Abdelli-Beruh et al., 2016; Oliveira et al., 2016) have shown that glottal fry is sporadically present in healthy adult American-English speakers, particularly when vocalizing words occurring at the end of sentences. Only a few authors (Bolzan et al., 2008; Pimenta et al., 2013), besides Boone et al. (2010) and Cielo et al. (2011), considered glottal fry a facilitating technique and investigated its immediate effects on the voice. Bolzan et al. (2008) found an improvement in glottal closure and in the amplitude of the vocal folds' mucosa vibration immediately after glottal fry in females with an incomplete glottal closure. However, a worsening in the perceptual evaluation of the voice and increased jitter and noise were also measured. Pimenta et al. (2013) found a decreased closing phase and, unlike Bolzan et al. (2008), decreased jitter in healthy females after producing glottal fry for 1 minute. Using glottal fry in singing training seems controversial as well (Nix et al., 2005). Some authors describe its usefulness to extend the low range of baritones and basses (Leyerly, 1986; Brown, 1996; Stark, 1999), or to encourage spontaneity of voice onset, decrease compensatory muscle behaviors, and shape the glottal configuration and epilarynx to optimize vocal output (Nix et al., 2005), whereas others do not even mention glottal fry in their books or are very outspoken in rejecting the technique (Reid, 1983). Thus, few studies examined glottal fry as a facilitating technique and the existing literature shows conflicting results.

Yawn-sigh, on the contrary, has been cited frequently as an efficient facilitating technique, especially for patients with hyperfunctional dysphonia (Brodnitz, 1968; Moncur & Brackett, 1974; Pershall & Boone, 1985; Boone & McFarlane, 1988; Casper et al., 1990; Colton & Casper, 1990; Boone et al., 2010). The technique has been shown to reduce muscular tension in the vocal tract by lowering the larynx and widening the supraglottal airway (Brodnitz, 1968; Moncur & Brackett, 1974; Wilson, 1979; Pershall & Boone, 1985; Boone & McFarlane, 1988;

Casper et al., 1990; Colton & Casper, 1990; Boone, 1991; Moore, 1990; Boone & McFarlane, 1993; Dworkin et al., 2000; Shrivastav et al., 2000; Holmberg et al., 2001; Roy, 2003a; Schneider & Sataloff, 2007; Boone et al., 2010; Duan et al., 2010). Titze & Verdolini Abbott (2012) suppose yawn-sigh may be a good combination for some voice therapy because sigh involves a glottal posture with low glottal impedance that matches a "yawny" vocal tract, which is a wide epilarynx tube and pharynx. Phonating in that way appears to be produced with a slight glottal opening, the opposite of excessive vocal fold compression often seen in patients with vocal hyperfunction (Boone & McFarlane, 1993). Boone (1991) introduced the "invisible yawn-sigh" (with the mouth closed) for relaxing the vocal tract in healthy subjects who experience a tense voice in public situations. Though often cited as a facilitating technique and used for more than 20 years in voice therapy, the effectiveness of yawn-sigh remains unclear. The existing literature is limited because studies either investigated the effects during a one-time performance of yawn-sigh in healthy participants (Boone & McFalane, 1993; Shrivastav et al., 2000) or investigated the technique as part of a broader therapy program in dysphonic patients (Carding et al., 1998; Holmberg et al., 2001; Duan et al., 2010).

The literature overview demonstrates the need for studies that investigate the effect of glottal fry or yawn-sigh in isolation (rather than within a broader therapy or training program) and over a longer time span (rather than during a one-time performance). In this pilot study, a vocally healthy subject sample was selected for an initial exploration of the potential facilitating effects of both techniques. Healthy future occupational voice users, namely SLP students, were recruited as they may benefit from learning techniques that facilitate their voice, both during their education as well as their future job performance. The vocal demands of SLPs require special skills that go beyond the everyday conversational level (Van Lierde et al., 2010b; Van Lierde et al., 2011). Previous research has shown that SLP students have a borderline vocal quality corresponding to a Dysphonia Severity Index of 1.8 (or 68%), with 1.6 (or 66%) being the threshold separating normal voices from dysphonic voices (Van Lierde et al., 2010b). Furthermore, voice problems among future SLPs are more common (12%) than the 3-9% reported in the general population (Gottliebson et al., 2007). The purpose of this study was to determine the effect of a glottal fry or yawn-sigh training program on the phonation of vocally healthy female speech-language pathology (SLP) students.

MATERIAL AND METHODS

This study was approved by the Ethics Committee of Ghent University Hospital.

Participants

A total of 38 female students enrolled in the first year of the bachelor program Logopaedic and Audiological Sciences at Ghent University were selected to participate in this study. Exclusion criteria included diagnoses of voice disorders, nasal and ear diseases, mental health conditions, and physically-limiting diseases that might interfere with study completion. To determine that participants were not currently suffering from a voice disorder or nasal or ear disease, each subject was assessed by an otorhinolaryngologist and audiologist performing a nasopharyngeal and laryngeal evaluation, videolaryngostroboscopy, otoscopy, and audiometry. On the basis of these results, two students were excluded because of vocal fold edema and an incomplete glottal closure (longitudinal gap).

The remaining participants included a homogeneous group of 36 vocally healthy female students with a mean age of 18 years (SD, 0.8 years; range, 17-21 years). Based on the first letter of their last name, students were randomly assigned to one of three groups: a glottal fry group (practicing the facilitating technique glottal fry across 18 weeks, $n = 12$), a yawn-sigh group (practicing the facilitating technique yawn-sigh across 18 weeks, $n = 12$), or a control group (receiving no facilitating techniques, $n = 12$). There were no differences among the three groups in mean age (Kruskal-Wallis test; $p = 0.297$). All participants were non-smokers, none of them had previously participated in voice therapy or training, or was an occupational voice user or an elite vocal performer. A flowchart of the study phases is presented in Figure 4.1.

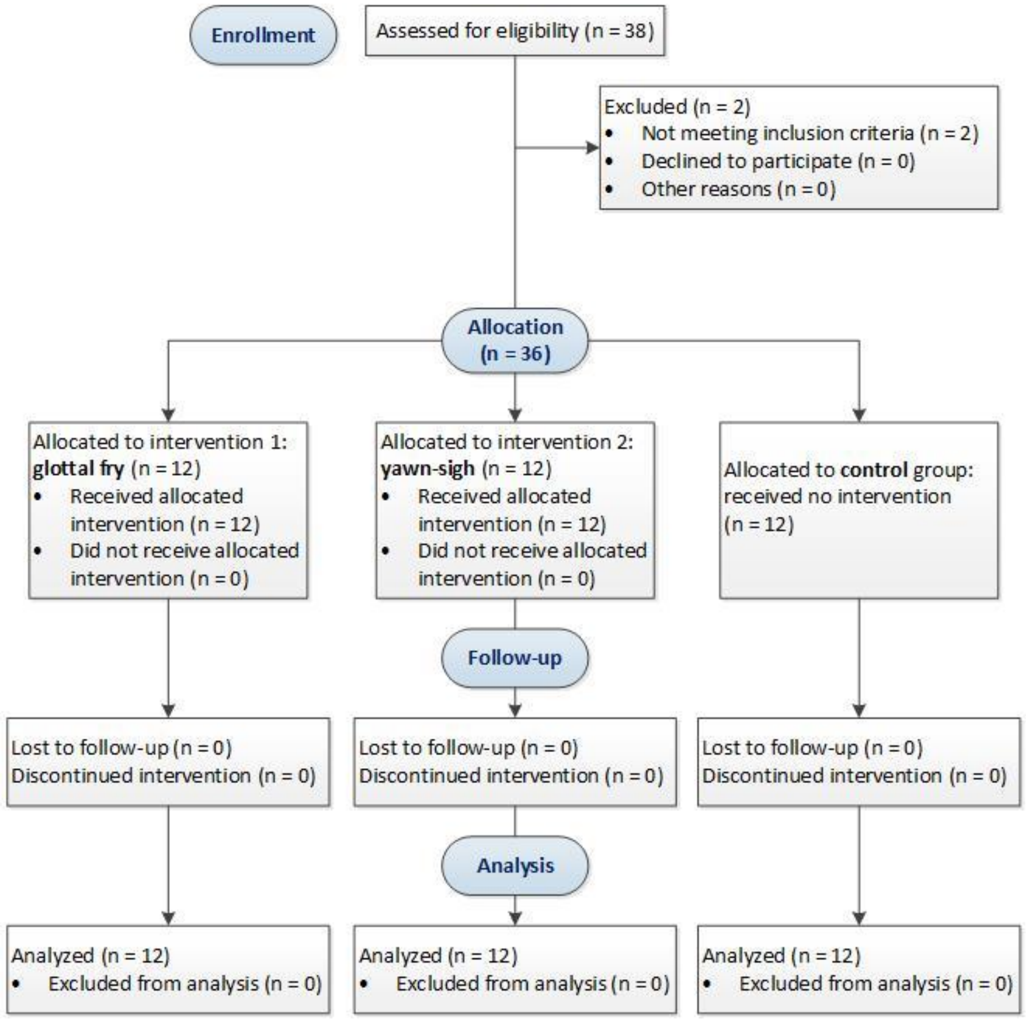


Figure 4.1 Flowchart of the study phases.

Voice assessment

Voice Questionnaire

A voice questionnaire based on the voice assessment protocol of the European Study Group on Voice Disorders (De Bodt et al., 1996) was presented at the pretest to explore vocal complaints and risk factors, and to confirm the success of randomization.

Objective voice assessment

The three groups completed a pre- and post-objective voice assessment. Pretests were performed in the week before the start of the training, and posttests were performed in the week after the 18-week training period. Both pre- and post-tests were spread over 3 consecutive days and each day an equal number of subjects of the three groups were tested in an alternating sequence.

Maximum performance task. To measure the maximum phonation time (MPT), the participants were asked to sustain the vowel /a/ at their habitual pitch and loudness in free field while seated. The MPT was modeled by the experimenters and the participants received visual and verbal encouragements to produce the longest possible sample. The length of the sustained vowel was measured in seconds. The best trial of three attempts was retained for further analysis.

Acoustic analysis. The fundamental frequency (f_o, Hz), jitter (%), shimmer (%), and noise-to-harmonic ratio (NHR) were obtained by the Multi Dimensional Voice Program of the Computerized Speech Lab (CSL; model 4500, KayPENTAX, Montvale, NY). A Shure SM-48 microphone located at a distance of 15 cm from the mouth and angled at 45 degrees was used. The subjects were instructed to produce the vowel /a/ at their habitual pitch and loudness. A midvowel segment of 3 seconds registered with a sampling rate of 50 kHz was used for analysis. Acoustic testing post-intervention did not control for pre-intervention f_0 and sound pressure level (SPL).

Voice Range Profile. The voice range assessment was performed with the CSL and the Shure SM-48 microphone (with a 15 cm mouth-to-microphone distance angled at 45 degrees) following the procedure outlined by Heylen et al. (1998). This assessment includes determination of the highest and the lowest fundamental frequency (F-high, F-low) and intensity (I-high, I-low). The participants were instructed to produce the vowel /a/ for at least 2 seconds using, respectively, a habitual pitch and loudness, a minimal pitch, a minimal intensity, a maximal pitch, and a maximal intensity. Each production was modeled by the experimenters and the participants received visual and verbal encouragement.

Dysphonia Severity Index (DSI). The DSI is a multiparameter approach designed to establish an objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000). The DSI is based on a weighted combination of the following parameters: MPT (in s), highest frequency (F-high, in Hz), lowest intensity (I-low, in dB) and jitter (in %). The DSI is constructed as 0.13 MPT + 0.0053 F-high − 0.26 I-low − 1.18 jitter + 12.4. The index ranges from -5 to +5 for severely dysphonic to normal voices. A more negative index indicates a worse vocal quality. A DSI of 1.6 is the threshold separating normal voices from dysphonic voices (Raes et al., 2002). The DSI can be calculated as a percentage by increasing the value with five points and then multiplying it by 10. A higher percentage indicates a better vocal quality (Raes et al., 2002).

Facilitating techniques

The glottal fry and yawn-sigh groups practiced their respective facilitating techniques across 18 weeks. To avoid potential bleeding among the conditions, participants were explicitly asked not to teach the technique to the other 2 groups throughout the experiment. At the end of the study, all subjects confirmed their adherence to this recommendation before starting the posttests. Both programs (glottal fry and yawn-sigh) consisted of 6 weekly 1-hour group sessions, each guided by the same 2 experimenters. The content of the training programs, based on the procedure outlined by Boone at al. (2010), is presented in Table 4.9. The experimenters provided verbal information, examples and corrective feedback. In addition to the exercises during training, the subjects were instructed to practice the facilitating technique individually at home twice a day for 10 minutes. Instruction papers, offering vocal exercises with a difficulty level adapted to the level achieved in group sessions, were provided after each session to stimulate home practice.

From week 7-17, the subjects repeated the technique independently at home two times a day for 10 minutes and were guided by an instruction booklet. Meanwhile, they had the opportunity to contact the experimenters for feedback or questions. In week 18, an interactive rehearsal session was organized during which subgroups (2 subjects) of both the glottal fry and the yawn-sigh group presented one of the steps learned in training (vowels, words, automatic sequences, phrases/sentences, texts, spontaneous speech). The other subjects followed their instructions. The control group did not receive any facilitating techniques in these 18 weeks and were instructed to use their voice as in everyday life.

Table 4.9 Content of the training programs glottal fry and yawn-sigh based on Boone et al. (2010).

Session	Glottal fry (GF)	Yawn-sigh (YS)
1	Education and counseling - Explaining the physiology of glottal fry and its potential therapeutic indications: minimal subglottal pressure and airflow, relaxed vocal folds and reduced friction between the folds Demonstration - Demonstrating GF by the experimenters - Imitation and familiarization by the subjects	Education and counseling - Explaining the physiology of a yawn and its potential therapeutic indications: a prolonged inspiration with maximum widening and relaxation of the supraglottal airways (characterized by a wide opening of the mouth) Demonstration - Demonstrating YS by the experimenters - Describing the relaxed supraglottal feeling - Imitation and familiarization by the subjects
2	Practicing GF: - Basic production vowels /i/ and /a/ on exhalation - Producing GF with medium opened mouth, protruded tongue and open throat, creating a deep resonant tone with slow series of individual pops. *+ tactile feedback: placing the fingers on the thyroid cartilage to feel the vocal fold vibrations*	Practicing YS: a yawn followed by an exhalation with a light phonation of - Open vowels preceded with /h/ - Words beginning with /h/ and open vowels: monosyllabic, polysyllabic *+ tactile feedback: placing the fingers on the thyroid cartilage to feel the lower position of the larynx*
3	Practicing GF - Vowels: stretching the vowels as long as possible (with vocal rest between each production to recover the intrinsic laryngeal musculature) - Words: monosyllabic, polysyllabic	Practicing YS - Open vowels preceded with /h/ - Words beginning with /h/, open vowels and midvowels: one word per yawn, several words per yawn
4	Practicing GF - Words - Automatic sequences - Phrases - Sentences	Practicing YS - Automatic sequences - Phrases - Sentences beginning with /h/, open vowels and midvowels
5	Practicing GF + gradually reducing GF to habitual phonation - Vowels - Words - Automatic sequences - Sentences	Normal open-mouth inhalation + sigh - Open vowels and midvowels - Words - Automatic sequences - Sentences beginning with /h/, open vowels or midvowels
6	Gradually reducing GF to habitual phonation - Vowels - Words - Automatic sequences - Sentences - Texts - Spontaneous speech	Imagining the yawn-sigh approach with the relaxed supraglottal feeling - Vowels - Words - Automatic sequences - Sentences - Texts - Spontaneous speech

Statistical analysis

SPSS version 24 (SPSS Corporation, Chicago, IL) was used for the statistical analysis of the data. Statistician was blinded to group assignment during data analysis.

Voice questionnaire

A chi-square test of independence was used to verify if there were differences among the three groups in baseline vocal complaints and risk factors. Analyses were conducted at $\alpha = 0.05$.

Objective voice assessment

Linear mixed models were used to compare groups over time on each outcome measure, using the restricted maximum likelihood estimation and scaled identity covariance structure. Time, group, and time-by-group interaction were specified as fixed factors. A random intercept for subjects was included. Model assumptions were checked by inspecting whether residuals were normally distributed. A significant time-by-group group interaction indicates a difference in evolution over time among groups. Bonferroni adjustments were made and analyses were conducted at $\alpha = 0.005$ (0.05/10) to diminish the risk of type 1 errors due to outcome measures that are potentially correlated. If a significant interaction effect was found, within-group effects of time were determined using pairwise comparisons (pre- versus post-training).

RESULTS

Voice questionnaire

The results of the voice questionnaire indicate that healthy SLP students present with a substantial degree of vocal complaints and risk factors (Table 4.10). Hoarseness was reported in 50% of the students, followed by vocal fatigue (47.2%), decreased vocal quality in the morning (38.9%), laryngeal irritations (36.1%), and decreased vocal range and breath support (22.2%). The risk factors shouting and overpassing noise were most frequently reported in 69.4% and 61.1% of the students, respectively. Stress is another common risk factor (50%), followed by being a member in a youth organization (36.1%), throat clearing (36.1%), nasal airway obstructions (30.6%), allergies (25%), and reflux (19.4%). No significant differences were found among the three groups at baseline (chi-square test, $p > 0.05$).

Objective voice assessment

Table 4.11 presents the evolution of the objective vocal outcome measures in the three groups. Linear mixed models showed significant time-by-group interactions for the acoustic measures f_o, jitter, shimmer, and NHR, and for the voice range measures I-low and I-high, indicating significant differences in evolution over time among the three groups.

Within-group effects of time showed that glottal fry resulted in a significant decrease in I-low (-3.9 dB, $p < 0.001$) and I-high (-5.8 dB, $p = 0.001$). Yawn-sigh resulted in a significant increase in f_o (+17.5 Hz, $p = 0.001$), a significant decrease in shimmer (-1.098 %, $p = 0.002$) and NHR (-0.029, $p = 0.001$), and a significant increase in I-high (+5.4 dB, $p = 0.001$).

DISCUSSION

The purpose of this pilot study was to investigate the effect of a glottal fry or yawn-sigh training program on the phonation of vocally healthy females enrolled in an SLP program. The experiment started with a homogeneous group of 36 female future occupational voice users (mean age: 18 years) with healthy vocal fold anatomy and physiology. No significant differences were found among the three groups in mean age, vocal complaints and vocal risk factors before introduction of a facilitating technique.

Glottal fry resulted in an improved (decreased) voice range measure I-low. A possible hypothesis for the decrease in I-low is based on the literature review of Cielo et al. (2011) which stated that practicing with lower frequency sounds (as in glottal fry) may stimulate the production of mucous secretion from the glands of Morgagni's ventricle and increase lubrication of the vocal folds epithelium (Cronemberger, 1999; Pinho, 2001; Pinho, 2003). This vocal fold surface hydration may in turn lower the phonation threshold pressure and optimize oscillation in the low intensities (Leydon et al., 2009; Leydon et al., 2010; Solomon & DiMattia, 2000; Verdolini-Marston et al., 1990). A potential lowering in subglottic pressure during glottal fry (Boone et al., 2010; Nix et al., 2005; Blomgren et al., 1998; Chen et al., 2002)

Table 4.10 Baseline vocal complaints and risk factors in the glottal fry group, the yawn-sigh group and the control group.

	Glottal fry		Yawn-sigh		Control group		Total			
Vocal complaints and risk factors	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	χ^2	*p*-value
Vocal complaints										
Vocal fatigue	41.6	5/12	41.6	5/12	58.3	7/12	47.2	17/36	0.892	0.640
Hoarseness	41.6	5/12	50	6/12	58.3	7/12	50.0	18/36	0.667	0.717
Decreased vocal quality in the morning	33.3	4/12	41.6	5/12	41.6	5/12	38.9	14/36	0.234	0.890
Decreased vocal range	16.6	2/12	25.0	3/12	25.0	3/12	22.2	8/36	0.321	0.852
Laryngeal irritations	33.3	4/12	33.3	4/12	41.6	5/12	36.1	13/36	0.241	0.887
Decreased breath support	25.0	3/12	16.6	2/12	25.0	3/12	22.2	8/36	0.321	0.852
Risk factors										
Vocal abuse										
Shouting	58.3	7/12	75.0	9/12	75.0	9/12	69.4	25/36	1.047	0.592
Overpassing noise	50.0	6/12	25.0	7/12	75.0	9/12	61.1	22/36	1.636	0.441
Member youth organization	50.0	6/12	25.0	3/12	33.3	4/12	36.1	13/36	1.686	0.430
Throat clearing	41.6	5/12	25.0	3/12	41.6	5/12	36.1	13/36	0.963	0.618
Nasal airway obstructions	16.6	2/12	33.3	4/12	41.6	5/12	30.6	11/36	1.833	0.400
Smoking	0	0/12	0	0/12	0	0/12	0	0/36	-	-
Reflux	8.3	1/12	25.0	3/12	25.0	3/12	19.4	7/36	1.419	0.492
Allergy	25.0	3/12	16.6	2/12	33.3	4/12	25.0	9/36	0.889	0.641
Stress	58.3	7/12	50.0	6/12	58.3	7/12	55.6	20/36	0.225	0.894

Table 4.11 Evolution of the objective vocal measures in the glottal fry group (GF), the yawn-sigh group (YS) and the control group (C).

		Pre		Post		Evolution Pre-Post		Time* Group	Group	Time	Comparison time within groups
Parameters	Group	EM	95% CI	EM	95% CI	EM	95% CI	*p*-value	*p*-value	*p*-value	*p*-value
Maximum performance											
MPT (s)	GF	19.4	[16.0, 22.7]	20.8	[17.5, 24.2]	+1.4	[-0.8, 3.7]	0.213	0.303	0.627	-
	YS	17.0	[13.7, 20.4]	17.8	[14.5, 21.2]	+0.8	[-1.5, 3.0]				-
	C	21.3	[18.0, 24.7]	20.0	[16.7, 23.4]	-1.3	[-3.5, 1.0]				-
Acoustic analysis											
f_o (Hz)	GF	218.7	[210.7, 226.6]	212.4	[204.4, 220.3]	-6.3	[-16.1, 3.4]	0.002*	0.127	0.476	0.196
	YS	208.5	[200.5, 216.5]	226.0	[218.1, 234.0]	+17.5	[7.8, 27.3]				0.001*
	C	211.0	[203.0, 218.9]	205.8	[197.8, 213.7]	-5.2	[-15.0, 4.5]				0.285
jitter (%)	GF	1.6	[1.1, 2.0]	2.3	[1.8, 2.7]	+0.7	[0.1, 1.3]	0.002*	0.669	0.550	0.031
	YS	2.1	[1.7, 2.6]	1.3	[0.9, 1.8]	-0.8	[-1.5, 0.2]				0.012
	C	1.7	[1.2, 2.1]	2.1	[1.7, 2.6]	+0.5	[-0.2, 1.1]				0.157
shimmer (%)	GF	5.6	[4.8, 6.5]	6.2	[5.4, 7.1]	+0.6	[-0.1, 1.3]	0.001*	0.108	0.784	0.093
	YS	5.3	[4.4, 6.2]	4.2	[3.3, 5.1]	-1.1	[-1.8, -0.4]				0.002*
	C	4.7	[3.9, 5.6]	5.4	[4.5, 6.3]	+0.7	[0.0, 1.4]				0.048
NHR	GF	0.138	[0.124, 0.151]	0.159	[0.145, 0.172]	+0.021	[0.005, 0.036]	<0.001*	0.276	0.806	0.010
	YS	0.151	[0.137, 0.164]	0.122	[0.108, 0.135]	-0.029	[-0.045, -0.014]				0.001*
	C	0.135	[0.121, 0.148]	0.140	[0.126, 0.153]	+0.005	[-0.010, 0.020]				0.515
Voice Range Profile											
I-low (dB)	GF	60.3	[58.2, 62.5]	56.4	[54.3, 58.5]	-3.9	[-5.6, -2.2]	0.001*	0.146	0.020	<0.001*
	YS	59.8	[57.6, 61.9]	60.4	[58.3, 62.5]	+0.6	[-1.0, 2.3]				0.425
	C	61.3	[59.1, 63.4]	61.0	[58.9, 63.1]	-0.3	[-1.9, 1.4]				0.764
I-high (dB)	GF	106.0	[102.8, 109.2]	100.2	[97.0, 103.4]	-5.8	[-9.1, -2.6]	<0.001*	0.224	0.360	0.001*
	YS	103.8	[100.6, 107.0]	109.2	[106.0, 112.5]	+5.4	[2.1, 8.7]				0.002*
	C	103.2	[100.0, 106.4]	106.2	[103.0, 109.4]	+3.0	[-0.3, 6.3]				0.071
F-low (Hz)	GF	159.8	[153.0, 166.7]	147.4	[140.5, 154.3]	-12.4	[-21.3, -3.5]	0.064	0.023	0.139	-
	YS	159.1	[152.2, 166.0]	161.1	[154.2, 168.0]	+2.0	[-6.9, 10.9]				-
	C	165.0	[158.2, 171.9]	164.0	[157.1, 170.8]	-1.0	[-10.0, 7.8]				-
F-high (Hz)	GF	670.3	[575.0, 765.5]	632.6	[537.3, 727.9]	-37.7	[-125.5, 50.2]	0.560	0.146	0.861	-
	YS	748.6	[653.3, 843.9]	777.2	[681.9, 872.5]	+28.6	[-59.2, 116.4]				-
	C	669.2	[573.9, 764.4]	665.0	[569.7, 760.3]	-4.2	[-92.1, 33.6]				-
DSI	GF	0.9	[-0.2, 2.1]	1.1	[-0.1, 2.3]	+0.2	[-0.9, 1.2]	0.105	0.669	0.614	-
	YS	0.6	[-0.5, 1.8]	1.5	[0.4, 2.7]	+0.9	[-0.1, 2.0]				-
	C	0.8	[-0.3, 2.0]	0.2	[-1.0, 1.3]	-0.6	[-1.7, 0.4]				-

Note: EM, estimated mean; IQR, interquartile range; MPT. maximum phonation time; f_o, fundamental frequency; NHR, noise-to-harmonic ratio; I-low, lowest intensity; I-high, highest intensity; F-low, lowest frequency; F-high, highest frequency; DSI, Dysphonia Severity Index. * indicates a significant effect.

possibly contributes to this mechanism. Another hypothesis for the decreased I-low after glottal fry may be related to the fact that lower frequency signals do have less acoustic energy compared to higher frequency signals (Titze & Sundberg, 1992). However, alertness is necessary when interpreting the above result because the decrease in I-low was associated with an even greater decrease in I-high. Therefore, the range itself did not expand or even truncated, indicating less flexibility in the phonatory system. To our knowledge, this is the first study investigating the effect of a glottal fry training on voice range measures. In general, clear positive results are lacking and this study is not supportive for using glottal fry as a training facilitating technique for healthy participants.

Yawn-sigh, on the other hand, seems more promising as it did result in clear improvements of multiple objective vocal measures. A significant decrease in shimmer and NHR supports the facilitating effect of the technique on the phonation of healthy SLP students as less acoustic perturbation and noise were measured after the training program. Physiologically, we may assume decreased cycle-to-cycle irregularities with more consistent contact between the vocal fold edges and improved glottal closure (Oguz et al., 2007; Petrovic-Lazic et al., 2015). Duan et al. (2010) also found a decrease in NHR (but no decrease in shimmer) and Carding et al. (1998) found a decrease in shimmer (but no decrease in noise) after a therapy program including yawn-sigh. However, comparison with current results is difficult because those programs included multiple vocal techniques and investigated patients with voice disorders. In addition to the improved perturbation and noise measures, yawn-sigh resulted in a significantly increased I-high, indicating improved vocal capacities and higher flexibility in the phonatory system. To our knowledge, this is the first study investigating the effect of yawn-sigh on voice range measures.

Finally, yawn-sigh resulted in a significant increase in f_o from 208.5 Hz pre- to 226 Hz post-training with the last value being less close to the mean norm defined for women (212 Hz), but within the normal range (167-258 Hz) (De Bodt et al., 2008a). An increase in f_o is often associated with increased tension in the vocal folds, controlled by activation of the thyroarytenoid and cricothyroid muscles (Titze, 2000a; De Bodt et al., 2008a). Hypothetically, yawn-sigh may have influenced the activation of these muscles. According to Shrivastav et al.

(2000), the technique causes significant airway dilation and is characterized by increased activity of the abductor muscles (posterior cricoarytenoid muscles, Titze, 2000a; De Bodt et al., 2008a). The abductor muscles may counteract the adduction force, thereby increasing the overall tension in the vocal folds, which in turn results in a higher f_o. The authors refer to a condition called “nonadducted hyperfunction”, in which the vocal folds are stiff and tense, but do not approximate completely.

Although these speculations seem contradictory with the earlier described physiology of reduced muscle tension (Boone & McFarlane, 1988; Boone et al., 2010; Brodnitz, 1968; Colton & Casper, 1990; Pershall & Boone, 1985; Casper et al., 1990; Moncur & Brackett, 1974; Wilson, 1979; Moore, 1990; Boone & McFarlane, 1993; Schneider & Sataloff, 2007; Roy, 2003a; Dworkin et al., 2000; Holmberg et al., 2001; Shrivastav et al., 2000; Boone, 1991; Duan et al., 2010), further investigation of the exact muscle activation is necessary. Suggesting that increased tension in the intrinsic laryngeal muscles would indeed be found, does not necessarily indicate pathological or inefficient voice use (on the condition that the voice user does not strain the laryngeal framework - such as cartilages, joints, and ligaments - to maintain adequate vocal fold tension and length) (Titze, 2000a). Moreover, an increased f_o after voice training in healthy participants is not uncommon and has been identified in previous studies (Van Lierde et al., 2011; Meerschman et al., 2016a. Meerschman et al., 2016b). When comparing the current results with those of prior studies investigating yawn-sigh, Shrivastav et al. (2000) also found a higher f_o during yawn-sigh in healthy female singers, whereas Boone and McFarlane (1993) found no differences in f_o between normal and yawn-sigh productions of the vowels /i/ and /a/ in healthy subjects. Holmberg et al. (2001) did measure a higher f_o in patients with vocal nodules after a therapy program including yawn-sigh, likely due to the decreased size of the nodules after therapy. Variations in the observed effects on f_o are probably due to differences in methodology (measured during a one-time performance versus posttherapy) and selected subjects (healthy subjects versus dysphonic patients).

This pilot study focused on glottal fry and yawn-sigh as techniques that may facilitate the healthy voice. Although these techniques were originally listed as rehabilitation techniques (for dysphonic patients, Boone et al., 2010), they were now used in voice training (of future occupational voice users). The rationale for selecting vocally healthy subjects must be sought in the fact that this is a pilot study aiming for an initial exploration of the potential beneficial effects of the techniques in isolation and over a longer time span. Future SLPs were recruited as they may benefit from techniques that facilitate their voice, both during their education as well as their future job performance. Previous research by Van Lierde et al. (2010b) showed that SLP students have a borderline vocal quality corresponding to a DSI of 1.8 (or 68%). Students in the current study achieved an even lower mean DSI of 0.8 (or 58%), which corresponds to a slight dysphonia (De Bodt et al., 2008a). Furthermore, they showed a substantial degree of vocal complaints with hoarseness and vocal fatigue occurring in about 50% of the students. Shouting, overpassing noise and stress were important risk factors for more than 50% of the students. Above findings clearly highlights the potential and the need to optimize SLP students' voice.

A similar trend of using identical techniques for both rehabilitation and training can be seen in multiple studies (Van Lierde et al., 2011; Meerschman et al., 2016a. Meerschman et al., 2016b; D'haeseleer et al., 2013; Santos et al., 2015; Timmermans et al., 2004; Timmermans et al., 2011). This is no surprise keeping in mind the common goal of both interventions, namely improving vocal capacities (De Bodt et al., 2008a). Training programs including some of these techniques (such as manual circumlaryngeal therapy, the open-mouth approach, glottal fry, resonant exercises, voiced tongue and lip trills, the hand-over-mouth technique, relaxation and respiration) appear to improve vocal capacities in healthy subjects as well, more specifically in future occupational voice users or elite vocal performers (Van Lierde et al., 2011; Meerschman et al., 2016a., Meerschman et al., 2016b; D'haeseleer et al., 2013; Santos et al., 2015; Timmermans et al., 2004; Timmermans et al., 2011). Based on the results of the current study, yawn-sigh may possibly be added to the list of useful training techniques, although this awaits further study. Regarding glottal fry, more prudence is required. Use of the technique may cautiously be encouraged because of an improvement in I-low but this does not outweigh the truncation in I-range. Whether similar results can be expected in patients with voice disorders can only be suggested and is subject for further research.

Some contradictions and hypotheses arise based on previously reported data. Boone et al. (2010) originally assumed that both glottal fry and yawn-sigh are effective for patients with hyperfunctional dysphonia. However, glottal fry seems to be produced with tightly adducted vocal folds (Cielo et al., 2011; Blomgren et al., 1998; Doellinger et al., 2005), whereas yawn-sigh is probably associated with a slightly open glottis (Boone & McFarlane, 1993). Tightly adducted vocal folds lean more toward the 'pressed' end of the voice continuum, whereas a slightly open glottis leans more toward the 'breathy' end of the voice continuum (Titze & Verdolini Abbott, 2012). Maximum vocal economy is achieved somewhere in between these extremes with barely abducted or barely adducted vocal folds (Titze & Verdolini Abbott, 2012; Verdolini et al., 1998). Therefore, we may cautiously hypothesize that glottal fry might be efficient in glottal hypofunction, whereas yawn-sigh might be efficient in glottal hyperfunction. Also notable is the existing contradiction regarding the physiological mechanisms of glottal fry. The minimal subglottic pressure and reduced friction between the vocal folds originally described by Boone et al. (2010) has later been contradicted by authors who mentioned an increase in subglottal pressure and tightly adducted vocal folds (Cielo et al., 2011; Blomgren et al., 1998; Doellinger et al., 2005). As an increase in subglottic pressure is associated with higher impact stress (Jiang & Titze, 1994), the therapeutic benefit of glottal fry may be questioned. Such ambiguities confirm the need for studies that investigate the underlying physiological mechanisms of both techniques and their effect in patients with a variety of voice disorders. A potential differential use of glottal fry versus yawn-sigh based on the presentation of one's baseline phonatory behavior may be expected.

The limitations of this study should be recognized and taken into account for further research. One of these limitations is that subjects and experimenters were not blinded to the purpose of the study and no sham training was provided for the control group. Besides, no voice data were obtained on participants during the 18-week time span. Follow-up assessment during those weeks, including both the voice questionnaire and the voice measures, would have provided valuable information. This follow-up assessment could also have been extended to examine the long-term outcome of the technique. Another shortcoming of the study is the lack of information about whether or not home instructions were followed by all students.

Hence, adherence to the practice schedules for both techniques cannot be ensured. This study also lacks training fidelity measures that indicate how well the training plans were followed by the experimenters. Furthermore, evaluation of vocal capacities was limited to objective measures. Since reliability of these measures has not always been found to be high (Carding et al., 2004), they should be integrated in a complementary clinical evaluation in future studies, including a subjective perceptual evaluation of the voice (e.g. GRBASI scale, Hirano, 1981) and a patient’s self-report (e.g. Voice Handicap Index, Jacobson et al., 1997). No reliability measures were conducted on the outcome measures in this study. Besides, the current study lacks information on SPL during the acoustic analysis and did not control for pre-intervention f_o and SPL in general. Several authors have shown that pitch and loudness may influence jitter and shimmer (Fitch, 1990; Orlikoff & Baken, 1990; Nittrouer et al., 1990; Pabon, 1991; Brown et al., 2000; Brockman et al., 2011). Therefore, these results should be interpreted with caution. Finally, the objective measures were only based on sustained vowel samples. Including voice assessments based on both sustained vowels and continuous speech (e.g. Acoustic Voice Quality Index, Maryn et al., 2010a) would be a merit in approximating daily speech and voice use patterns.

Despite the above-described limitations, this pilot study is unique and provides useful first-stage results about the exclusive effect of two longstanding and understudied vocal facilitating techniques. Yawn-sigh may have a positive effect on the phonation of vocally healthy female future SLPs, whereas results are less supportive for using glottal fry in training this population’s voice.

CONCLUSIONS

The results of this pilot study suggest a positive effect of the facilitating technique yawn-sigh on the phonation of female future SLPs. The technique may improve acoustic perturbation and noise levels and expand the students’ intensity range. Glottal fry, on the other hand, shows less promising results as no acoustic measures improved and the intensity range truncated. Larger-scale investigation will have to confirm these preliminary results.

Investigating the underlying mechanisms and the effect of both techniques in patients with a variety of voice disorders is subject for further research.

CHAPTER 5

Effect of the semi-occluded vocal tract exercises (content)

5.1 Effect of two semi-occluded vocal tract training programs on the phonation of future occupational voice users: resonant voice training using nasal consonants versus straw phonation

Based on: Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. (2017). Short-term effect of two semi-occluded vocal tract training programs on the vocal quality of future occupational voice users: "resonant voice training using nasal consonants" versus "straw phonation". *Journal of Speech, Language, and Hearing Research,* 60(9), 2519-2536.

ABSTRACT

Purpose. The aim of this study was to determine the short-term effect of two semi-occluded vocal tract training programs, "resonant voice training using nasal consonants" versus "straw phonation," on the phonation of vocally healthy future occupational voice users.

Methods. A multigroup pretest-posttest randomized control group design was used. Thirty vocally healthy speech-language pathology students with a mean age of 19 years were randomly assigned to either a resonant voice training group (practicing resonant exercises across 6 weeks, *n* = 10), a straw phonation group (practicing straw phonation across 6 weeks, *n* = 10), or a control group (receiving no voice training, *n* = 10). A voice assessment protocol consisting of both subjective (questionnaire, participant's self-report, auditory-perceptual evaluation) and objective (maximum performance task, aerodynamic assessment, voice range profile, acoustic analysis, acoustic voice quality index, Dysphonia Severity Index) measurements and determinations was used to evaluate the participants' voice pre- and post-training. Groups were compared over time using linear mixed models and generalized linear mixed models. Within-group effects of time were determined using post hoc pairwise comparisons.

Results. No significant time-by-group interactions were found for any of the outcome measures, indicating no differences in evolution over time among the three groups. Within-group effects of time showed a significant improvement in Dysphonia Severity Index in the resonant voice training group, and a significant improvement in the intensity range in the straw phonation group.

Conclusions. Results suggest that the semi-occluded vocal tract training programs using resonant voice training and straw phonation may have a positive impact on the vocal quality and vocal capacities of future occupational voice users.

INTRODUCTION

Semi-occluded vocal tract (SOVT) exercises are known worldwide in the field of vocology. They have been used for decades as warm-ups by elite vocal performers and occupational voice users, and they have more recently gained popularity in rehabilitating the voice of patients with dysphonia (Dargin & Searl, 2015; Kapsner-Smith et al., 2015; Maxfield et al., 2015; Mills et al., 2017; Smith & Titze, 2017). Examples of SOVT exercises are the use of voiced fricatives ([v], [z], [ʒ]), lip-rounded vowels ([o], [u]), nasal consonants ([m], [n], [ŋ]), lip and tongue trills, raspberries (lingo-labial trill), y-buzz (sustained [j]), phonation while covering the mouth by hand (hand-over-mouth) or finger kazoo, and phonation into straws or tubes with the outer end in the air or immersed in water (flow-resistant straws, resonance tubes, or Lax Vox) (Andrade et al., 2014; Dargin & Searl, 2015; Fantini et al., 2017; Guzman et al., 2013a; Guzman et al., 2016; Kapsner-Smith et al., 2015; Maxfield et al., 2015; Titze, 2006). The common feature of these exercises is a reduction in the cross-sectional area of the vocal tract while voicing (Andrade et al., 2014; Dargin & Searl, 2015; Fantini et al., 2017). These vocal tract semi-occlusions can be formed by the articulators (lips and/or tongue), the nostrils (in case of the nasal consonants), or by a straw or tube inserted between the lips (Maxfield et al., 2015; Titze, 2006). In the latter case, an additional and artificial lengthening of the vocal tract is achieved (Conroy et al., 2014).

The emerging literature regarding SOVT exercises suggests that specific physical and physiological changes may occur during and after the semi-occlusion tasks, although much remains to be evaluated (Conroy et al., 2014; Dargin et al., 2016; Dargin & Searl, 2015). In general, SOVT exercises elicit a voice production that relies more heavily on source-filter interaction than on adductory stress to give the voice acoustic power (Maxfield et al., 2015). In other words, the exercises lead to more economic voice production (ratio of vocal output to effort), which in turn minimizes vocal injury (Croake et al., 2017; Gaskill & Quinney, 2012; Mills et al., 2017; Titze, 2006). Semi-occluding the vocal tract increases the acoustic impedance, or, more specifically, the inertive reactance, in the vocal tract, which facilitates voice initiation and self-sustained oscillation via a heightened nonlinear source-filter interaction (Andrade et al., 2014; Conroy et al., 2014; Croake et al., 2017; Fantini et al., 2017;

Gaskill & Quinney, 2012; Guzman et al., 2013a; Guzman et al., 2013b; Mills et al., 2017; Rosenberg, 2013; Titze, 2006; Titze & Laukkanen, 2007). Acoustic energy is reflected back to the vocal folds, which lowers the phonation threshold pressure and eases phonation (Guzman et al., 2013a; Guzman et al., 2013b; Guzman et al., 2017a; Kapsner-Smith et al., 2015; Titze, 1988;, Titze, 2002a). The greater supraglottal pressure achieved by the semi-occlusion results in a reduced transglottal pressure, which in turn leads to a relatively small vibrational amplitude and barely abducted or adducted vocal folds (Guzman et al., 2013a; Hampaia et al., 2015; Ogawa et al., 2014; Smith & Titze, 2017; Titze, 2000b, Titze, 2002a, Titze, 2006). Phonation with high subglottal pressure and high pitch is therefore possible without risking injury to the vocal fold mucosa, making SOVT exercises the ideal vocal warm-up (Guzman et al,. 2013b; Hampaia et al., 2015; Ogawa et al., 2014; Smith & Titze, 2017; Titze, 2000b, Titze, 2002a, Titze, 2006). Moreover, a barely abducted or adducted vocal fold configuration is the target for both patients with glottal hyperfunction and glottal hypofunction (Berry et al., 2001; Guzman et al., 2015; Titze & Verdolini Abbott, 2012; Verdolini et al., 1998).

The semi-occlusions of the vocal tract that are probably one of the longest used in vocology, and perhaps therefore not often associated with the recent term SOVT, are the nasal consonants ([m], [n], or [ŋ]). The oral construction is complete at the lip, alveolar, or velar position, and the velar port is opened to allow sustained phonation with nasal sound production. The upper part of the vocal tract becomes the nasal airway, and the nostrils offer the semi-occlusion (Dargin et al., 2016; Titze, 2006; Titze & Verdolini Abbott, 2012). Use of nasal consonants in the form of humming is a standard practice in singing training (Nix & Simpson, 2008; Westerman, 1990, Westerman, 1996). Several voice therapy and training programs have been built on the frequent use of nasal consonants, such as the Lessac-Madsen Resonant Voice Therapy (Kapsner-Smith et al., 2015; Titze & Verdolini Abbott, 2012; Verdolini, 2000; Verdolini-Marston et al., 1995). This program was developed to help people perceive and acquire resonant voice, starting with humming exercises (relaxed sustained phonation of [m], [n], or [ŋ]) and gradually proceeding to speech-embedded semi-occlusions and spontaneous habitual speech (Dargin et al., 2016; Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015; Rosenberg, 2013). A resonant voice or a voice created with forward tone focus is associated with vibratory sensations in the midfacial region, indicating an effective conversion of aerodynamic energy to acoustic energy during phonation (Chen et al., 2007; Roy et al., 2003b). The ultimate goal of resonant voice therapy or training is to achieve the strongest and clearest possible voice with the least effort and impact stress between the vocal folds to minimize the likelihood of vocal fold injury (Chen et al., 2007; Roy et al., 2003b). Verdolini et al. (1998) suggested that the associated laryngeal configuration consists of vocal folds that are barely adducted or barely abducted. An improved vocal fold closure during humming compared with normal phonation was found in healthy female participants by De Bodt et al. (2012) using fiberoptic laryngovideoendoscopy.

A SOVT exercise that recently gained more popularity is the use of flow-resistant straws, often named "straw phonation" (Titze, 2000b). This technique involves holding a straw between the lips while producing a sustained vowel (Dargin & Searl, 2015; Rosenberg, 2013). The diameter of the straw can be altered to result in more or less resistance to airflow, ranging from the more common drinking straws to very narrow stirring straws (Dargin & Searl, 2015; Titze, 2002a). The additional lengthening of the vocal tract by the straw allows for an even greater supraglottal pressure and inertive reactance in the vocal tract, providing a better source-filter interaction and maximal effects as previously described (Gaskill & Quinney, 2012; Titze, 2006; Titze & Verdolini Abbott, 2012). In contrast to resonant voice training, straw phonation is a nonspeech SOVT exercise. Articulating with the straw between the lips is impossible, although prosodic speech patterns can be produced (Andrade et al., 2014; Kapsner-Smith et al., 2015).

To date, most authors have been interested in the immediate, often physical or physiological, effects of a single SOVT performance (Andrade et al., 2014; Conroy et al., 2014; Croake et al., 2017; Dargin & Searl, 2015; Dargin et al., 2016; Fantini et al., 2017; Gaskill & Quinney, 2012; Guzman et al., 2013a; Guzman et al., 2013b; Guzman et al., 2015, 2016; Hampaia et al., 2015; Maxfield et al., 2015; Mills et al., 2017; Ogawa et al., 2014; Smith & Titze, 2017; Titze, 2006; Titze & Laukkanen, 2007). It is not yet sufficiently confirmed whether a training or therapy program using SOVT exercises leads to more economic voice production and enhanced vocal quality on the short or longer term (Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015).

Studies that have investigated these effects for resonant voice training/therapy or straw phonation in (future) occupational voice users and patients with voice disorders are summarized in Table 5.1 and Table 5.2, respectively. Only studies that provide information about the exclusive effect of the techniques (and not when part of a broader training or therapy program) were incorporated in the tables. Objective vocal measures are lacking in most of the studies (Kapsner-Smith et al., 2015; Nanjundeswaran et al., 2012; Roy et al., 2003b; Verdolini-Marston et al., 1995), and some of them did not incorporate a control group (Chen et al., 2007; Guzman et al., 2017a; Roy et al., 2003b).

The purpose of this study was to determine the short-term effect of two semi-occluded vocal tract training programs, “resonant voice training using nasal consonants” versus “straw phonation,” on the vocal quality of vocally healthy future occupational voice users using both a randomized control group design and a standardized voice assessment consisting of subjective and objective vocal measures. A positive effect of both SOVT training programs on the vocal quality of future occupational voice users was hypothesized. Resonant voice training may be effective because the semi-occlusions are speech-embedded, whereas straw phonation may be effective due to higher inertive reactance in the vocal tract.

Table 5.1 Summary of studies investigating the effects of a resonant voice training or therapy program.

Authors	Subjects	Therapy/training	Assessment	Results
Verdolini-Marston et al., 1995	n = 13 Females Mean age: 20 yrs. (range: 18-22 yrs.) Recruited from college sororities Vocal nodules	1. Resonant voice therapy (n = 3) 2. Confidential voice therapy (n = 5) 3. Control group: no voice therapy (n = 5) Nine therapy sessions of 1 hour across 2 weeks Group assignment was based on severity ratings made before the initiation of the protocol	1. Phonatory effort ratings: perceived effort of phonation on a magnitude estimation scale (100: comfortable amount, 200: twice as much effort as comfortable, 50: half as much effort as comfortable) 2. Auditory-perceptual ratings: healthy voice, mildly impaired voice, moderate, moderate-severely, severely impaired voice 3. Visual-perceptual ratings of the larynx using videolaryngostroboscopy: healthy vocal folds, mild nodules/polyps or related, moderate, moderately severe, severe nodules/polyps or related Pre and post + 2 weeks follow-up	Three of 8 subjects in therapy groups improved on all 3 measures, as compared with 0 of 5 control subjects Treatment benefits were dependent upon compliance, but not therapy type.
Roy et al., 2003b	n = 64 Mean age: 43 yrs. Teachers who reported present voice difficulties and/or regular voice problems in the past	1. Resonance therapy (n = 19) → twice-daily home-practice sessions across 6 weeks 2. Voice amplification using the ChatterVox portable amplifier (n = 25) → record number of hours of amplifier use each day across 6 weeks 3. Respiratory muscle training (n = 20) → daily training program across 6 weeks Group assignment by randomization	1. Voice severity self-rating scale (no problem, mild problem, moderate problem, severe problem) 2. Voice Handicap Index Pre and post	Significant reduction in VHI scores and self-ratings of severity in resonance therapy group and voice amplification group

Table 5.1 *(Continued)*

Authors	Subjects	Therapy/training	Assessment	Results
Chen et al., 2007	n = 24 Females Mean age: 37 yrs. (range: 26-56 yrs.) Teachers who reported the following 2 criteria in voice questionnaires: (1) have at least one voice symptom (2) voice symptoms frequently appear	Resonant voice therapy No control group One session of 90 minutes per week for 8 weeks (groups of 4 subjects)	1. Auditory-perceptual ratings: breathiness, roughness, strain, monotone, resonance, hard attack, glottal fry 2. Videostroboscopic examination: laryngeal pathology, mucosal wave, amplitude, vocal fold closure, phase asymmetry 3. Acoustic measurements: jitter, shimmer, noise-to-harmonic ratio, breathiness in the amplitude differences of the first and second harmonics (H1-H2), speaking fundamental frequency and intensity, maximum range of speaking fundamental frequency and intensity 4. Aerodynamic measurements: phonation threshold pressure, maximum phonation time, airflow rate 5. Functional measurements: Voice Handicap Index and WHOQOL-BREF Taiwan Version for assessment of functional impact in communication and overall life quality Pre and post	1. Significant reduction in severity of roughness, strain, monotone, resonance, hard attack, glottal fry 2. Significant reduction in severity of vocal fold pathology, mucosal wave, amplitude, vocal fold closure 3. Significant increase in speaking fundamental frequency, maximum range of speaking fundamental frequency, maximum range of speaking intensity 4. Significant reduction in phonation threshold pressure 5. Significant reduction in score of physical scale in the voice handicap index
Nanjundeswaran et al., 2012	n = 31 29 Females, 2 Males Vocally healthy student teachers (based on auditory-perceptual assessment) with low (good) and high (poor) Voice Handicap Index	1. Vocal hygiene program: 2-hour group educational seminar + twice weekly adherence checking by an internet-based follow-up system across 4 weeks 2. Vocal hygiene program (identical of 1) + resonant voice training: 4-hour group seminar + twice weekly home-practice exercises across 4 weeks 3. Control group Group assignment by randomization	Voice Handicap Index Pre and post (4-8 weeks)	Vocal hygiene program was sufficient to prevent worsening of VHI scores that occurred in all control participants over the first 4-8 weeks of student teaching. For participants with initially poor VHI scores, the vocal hygiene program failed to produce VHI benefits over the control condition. The addition of resonant voice training was required to optimize results.

Table 5.1 *(Continued)*

Authors	Subjects	Therapy/training	Assessment	Results
Verdolini Abbott et al., 2012	n = 9 6 Females (21-46 yrs.) 3 Males (21-29 yrs.) Vocally healthy participants (based on self-report and laryngologic examination)	60-minute vocal loading session, followed by: 1. resonant voice exercises: alternating cycles of 4 minutes followed by 16 minutes of voice rest 2. spontaneous speech: alternating intervals of 16 minutes speaking in normal voice about topics of interest, followed by 4-minute periods of voice rest 3. vocal rest: absolute silence Four hours in the clinic, home-practice extraclinically for the remainder of the day (evening) and next morning until they returned to the clinic Group assignment by randomization	1. Secretion analysis: concentration of inflammatory mediators 2. Phonation threshold pressure 3. Self-report: direct magnitude estimation of perceived phonatory effort Pre and post vocal loading, after the 4-four in-clinic treatment and 24-hour follow-up	Results were poorest at 24-hour follow-up in the spontaneous speech condition, sharply improved in the voice rest condition, and were the best in the resonant voice exercise condition.

Table 5.2 Summary of studies investigating the effect of a straw phonation therapy or training program.

Authors	Subjects	Therapy/training	Assessment	Results
Kapsner-Smith et al., 2015	n = 20 16 Females, 4 males Mean age: 51.5 yrs. (range: 32-72 yrs.) Complain of chronic vocal fatigue and/or hoarseness (laryngopharyngeal reflux with vocal fold edema, vocal fold lesions, vocal fold paresis or paralysis)	1. Immediate straw phonation (SP) therapy (n = 5) 2. Immediate vocal function exercises (VFE) therapy (n = 5) 3. Delayed SP therapy (n = 5) 4. Delayed VFE therapy (n = 5) → six 30-60-min weekly treatment sessions + home exercise program Groups 1 and 2: therapy 1 week following pretest Groups 3 and 4: 6-week no-treatment period after pretest, followed by re-assessment and therapy (no-treatment control group) Group assignment by randomization	1. Voice Handicap Index 2. Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) Pre and post	VHI significantly improved for both treatment groups relative to no-treatment group. Significant reductions in roughness on the CAPE-V for the SP group.
Guzman et al., 2017a	n = 20 Mean age: 27.5 yrs. (range: 18 – 35 yrs.) Muscle tension dysphonia	1. straw phonation (straw in air) (n = 10) 2. water resistance therapy (straw in water) (n = 10) 8 weekly sessions of 30 minutes Group assignment by randomization	1. Aerodynamic measurements 2. Elektroglottographic assessment 3. Acoustic analysis 4. Auditory-perceptual evaluation 5. Voice Handicap Index 6. Self-assessment of resonant voice quality	Decrease in VHI for both groups Decrease in subglottic pressure for both groups Decrease in phonation threshold pressure for both groups Increase in self-perception of resonant voice quality in both groups Improvement in auditory-perceptual assessment was only found the SP group (in air)

MATERIAL AND METHODS

This study was approved by the Ethics Committee of Ghent University Hospital (EC/2015/0960).

Participants

Forty students enrolled in the second year of the bachelor program Logopaedic and Audiological Sciences (main subject logopaedics) at Ghent University were asked to participate in this study. Exclusion criteria included smoking, current participation in voice therapy or training, voice disorders, and nasal or ear diseases. Ten students were excluded because of voice disorders diagnosed at the beginning of their bachelor program by an otolaryngologist performing a flexible videolaryngostroboscopy.

The remaining participants included a group of 28 female and two male students with a mean age of 19 years (SD, 1.0 years; range, 17-22 years). Participants were randomly assigned to either a resonant voice training group (practicing resonant voice training across 6 weeks, n = 10), a straw phonation group (practicing straw phonation training across 6 weeks, n = 10), or a control group (practicing no voice techniques, n = 10). Randomization was stratified by gender: one male student was assigned to each training condition. There were no differences among the three groups in gender (chi-square test; p = 0.617) and mean age (Kruskall–Wallis test; p = 0.329). One participant from the control group left the study prior to termination because of personal reasons.

Voice assessment

A standardized voice assessment consisting of both subjective (questionnaire, participant's self-report, auditory-perceptual evaluation) and objective vocal measures and determinations (maximum performance task, aerodynamic measurements, voice range profile, acoustic analysis, acoustic voice quality index [AVQI], dysphonia severity index [DSI]) was used to evaluate the participants' voices. The assessment was performed before and after the 6-week training program, except for a part of the questionnaire that was only presented at the pretest. Measurements were collected in a sound-treated room at Ghent

University Hospital by two experimenters (E.M. and K.P.). To avoid observer bias, participants were investigated by the experimenter who did not guided their training sessions.

Questionnaire

A questionnaire created using the checklists of Russel et al., (2000), De Bodt et al., (2008), and Van Lierde et al. (2010a, 2010b) was presented at the pretest to explore voice-related symptoms, risk factors, vocal load, and lifestyle habits and to confirm the success of randomization. The presence of voice-related symptoms was rechecked with a posttest questionnaire.

Participant's self-report

The Dutch version of the Voice Handicap Index (De Bodt et al., 2000; Jacobson et al., 1997) was used to evaluate the psychosocial impact of potential voice problems. The Voice Handicap Index is a self-administered questionnaire consisting of 30 statements, evaluating functional (10 statements, F-scale), physical (10 statements, P-scale), and emotional (10 statements, E-scale) restrictions. Each statement was scored on a five-point scale (0 = never, 1 = almost never, 2 = sometimes, 3 = almost always, 4 = always). The total Voice Handicap Index score varies between 0 and 120. A higher score indicates a more severe psychosocial impact.

Auditory-perceptual evaluation

The GRBASI scale (Hirano, 1981; completed with an "I" parameter by Dejonckere et al., 1996) was used for the auditory-perceptual evaluation of the participants' voices. This scale consists of six parameters: G (overall grade of hoarseness), R (roughness), B (breathiness), A (asthenia), S (strain), and I (instability), and it is scored using a four-point grading scale (0 = absent, 1 = mild, 2 = moderate, 3 = severe). Participants sustained the vowel /a/ for at least 3 s and read aloud the Dutch phonetically balanced text "Papa en Marloes" while voice samples were audio-recorded using a C01U USB Studio Condenser Microphone (Samson, Syosset, NY) and the software program PRAAT. Samples were randomized and rated blinded by the same voice therapist (I.M.). To assure interrater reliability, 20 samples (33.3%) were randomly selected and rated blindly and independently by another voice therapist (E.D.).

Maximum performance task

To measure the maximum phonation time (MPT, in s), participants were asked to sustain the vowel /a/ at their habitual pitch and loudness after a maximal inspiration, in free field while seated. The MPT was modeled by the experimenters, and the participants received visual and verbal encouragements to produce the longest possible sample. The length of the sustained vowel was measured with a chronometer. The best trial of three attempts was retained for further analysis.

Aerodynamic measurements

A dry spirometer (Riester, Jungingen, Germany) was used to determine the vital capacity (VC, cc). The best trial of three attempts was retained for further analysis and used for the calculation of the phonation quotient (PQ, cc/s), which is the ratio of VC to MPT.

Voice range profile

The voice range profile (VRP) was determined by the Computerized Speech Lab (model 4500, KayPENTAX, Montvale, NY), using a Shure SM-48 microphone located at a distance of 15 cm from the mouth and angled at 45°. The procedure outlined by Heylen et al. (1998) was used. This assessment included determination of the highest and the lowest fundamental frequency (F-high, F-low) and intensity (I-high, I-low), and the frequency (F-range) and intensity range (I-range). Participants were instructed to produce the vowel /a/ for at least 2s using, respectively, a habitual pitch and loudness, a minimal pitch, a minimal intensity, a maximal pitch, and a maximal intensity. Each production was modeled by the experimenters, and the participants received visual and verbal encouragement.

Acoustic analysis during sustained phonation of /a/ vowel

The fundamental frequency (f_o, Hz), jitter (%), shimmer (%), noise-to-harmonic ratio, and variation in fundamental frequency (vf_o, %) were obtained by the Multi-Dimensional Voice Program of the Computerized Speech Lab and a Shure SM-48 microphone (with a 15-cm mouth-to-microphone distance angled at 45°). The participants were instructed to produce the vowel /a/ at their habitual pitch and loudness. A midvowel segment of 3 s registered with a sampling rate of 50 kHz was used for analysis.

Acoustic analysis during sustained phonation of /a/ vowel and continuous speech: AVQI

The AVQI is a recently developed, objective, multiparameter approach to quantify dysphonia severity on the basis of both sustained vowels and continuous speech (Maryn et al., 2010a). The AVQI consists of a weighted combination of six time-domain (i.e., shimmer local [SL], shimmer local decibels [SLdB], and harmonics-to-noise ratio [HNR]), frequency-domain (i.e., general slope of the spectrum [slope] and tilt of the regression line through the spectrum [tilt]), and quefrency-domain (i.e., smoothed cepstral peak prominence [CPPs]) measures (Maryn et al., 2010b). The index is constructed as $2.571 (3.295 - 0.111 \text{ CPPs} - 0.073 \text{ HNR} - 0.213 \text{ SL} + 2.789 \text{ SLdB} - 0.032 \text{ slope} + 0.077 \text{ tilt})$ and ranges from 0 to 10. A higher index indicates a worse vocal quality. The threshold score separating normophonic from dysphonic persons in Dutch is 2.95 (Maryn et al., 2010a). AVQI (version 02.03) was calculated on an audio recording of a sustained /a/ vowel and the first two sentences of the Dutch phonetically balanced text “Papa en Marloes” using the software program PRAAT.

Dysphonia Severity Index (DSI)

The DSI (Wuyts et al., 2000) is a multiparameter approach designed to establish an objective and quantitative correlate of the perceived vocal quality. The DSI is based on a weighted combination of the following parameters: MPT (in s), highest frequency (F-high, in Hz), lowest intensity (I-low, in dB), and jitter (in %). The DSI is constructed as $0.13 \text{ MPT} + 0.0053 \text{ F-high} - 0.26 \text{ I-low} - 1.18 \text{ jitter} + 12.4$. The index ranges from −5 to +5 for severely dysphonic to normal voices. A more negative index indicates a worse vocal quality. Values higher than 5 are possible in participants with very good vocal capacities. A DSI of 1.6 is the threshold separating normal voices from dysphonic voices (Raes et al., 2002). The DSI can be calculated as a percentage by increasing the value with 5 points and then multiplying it by 10 (Raes et al., 2002). A higher percentage indicates a better vocal quality.

Voice training

Participants in the resonant voice training group and the straw phonation group practiced resonant voice training (R) or straw phonation (SP) across 6 weeks, with a frequency of two 30-min sessions a week. Sessions were planned in the months October and November. To avoid observer or trainer bias, both the R group and the SP group were split, so that four training groups were formed: R1, R2, SP1, and SP2. Experimenter 1 guided groups R1 and SP1; experimenter 2 guided groups R2 and SP2. The other experimenter collected the vocal measures (e.g., experimenter 1 collected the vocal measures of groups R2 and SP2). Participants in the control group received no voice training.

Resonant voice training (using nasal consonants)

Training started with sustained phonation of [m], [n], and [ŋ] (humming), paying attention to sensory feedback and forward focus. Nasal consonants were subsequently combined with rounded vowels, unrounded vowels, and consonants. Pitch and loudness exercises were then introduced and repeated in all subsequent sessions (e.g., pitch glides, loudness shifts, emphasis, melodies). The second half of the training (starting from session 7) focused on speech-embedded nasals and transfer to normal open-mouth phonation. Word, phrase, sentence, and text levels were trained, and resonance levels were gradually reduced. Spontaneous speech was addressed in the last three sessions. The experimenters provided verbal information, examples, and corrective feedback during all sessions. A detailed overview of the resonant training can be found in Table 5.3.

Straw phonation training

Training started with basic straw phonation on an [o] and [ɔ] vowel using a drinking straw with a diameter of 5 mm and a length of 21 cm. Students were familiarized with the higher resistance to airflow while phonating. Pitch and loudness exercises were introduced in session 2 and repeated in all subsequent sessions (e.g., pitch glides, emphasis, melodies). To increase vocal tract inertive reactance, a smaller and shorter stirring straw (diameter = 2.5 mm, length = 11.5 cm) was used from session 7 onward. The second half of the training sessions (starting from session 7) focused mainly on transfer to normal open-mouth phonation. Words, phrases, sentences, and texts were alternately phonated through the straw (using an adequate intonation pattern, no articulation) and without the straw. Later in the training, the drinking straw was re-introduced to better approximate the natural open-mouth configuration. Spontaneous speech was addressed in the last three sessions. The experimenters provided verbal information, examples, and corrective feedback during all sessions. A detailed overview of the straw phonation training is presented in Table 5.4.

At the end of every session, participants of both groups were encouraged to practice on a daily basis during the week. Whether the participants actually practiced was checked by the experimenters at the beginning of each session by asking, “Who practiced at home the last few days?” At the posttest, participants were asked to score their frequency of home practice as follows: “(nearly) daily home practice”; “one home practice day a week”; or “no home practice”.

Statistical analysis

SPSS version 24 (SPSS Corporation, Chicago, IL) was used for the statistical analysis of the data. Analyses were conducted at $\alpha = 0.05$. Fisher’s exact tests were used to compare the three groups regarding voice-related symptoms, risk factors, vocal abuse, vocal load, and lifestyle habits at baseline and to confirm the success of randomization. Pairwise comparisons with Bonferroni corrections ($\alpha < 0.016$) were performed when a significant group difference was found. A Fisher’s exact test was also used to compare the frequency of home practice between the resonant voice training group and the straw phonation group.

Cohen’s κ was run to determine the interrater reliability for the auditory-perceptual evaluation (GRBASI). Linear mixed models were used to compare groups over time on each continuous outcome measure, using the restricted maximum likelihood estimation and scaled identity covariance structure. Time, group, and time-by-group interaction were specified as fixed factors. A random intercept for participants was included. Model assumptions were checked by inspecting whether residuals were normally distributed. Generalized linear mixed models were used for the categorical outcome measures. A significant time-by-group interaction effect indicates a difference in evolution over time among groups. The effect over time within each group was determined using pairwise comparisons (pre- vs. post-training).

Table 5.3 Detailed overview of the resonant voice training sessions.

Session	Resonant voice training
1	o sustained phonation of the nasal consonant [m] (= humming) - lips are loosely closed, mandible is lowered, jaw is relaxed, tongue is low - the appropriate pitch and loudness is selected for each individual - use of costo-abdominal breathing pattern - sensory feedback and forward focus: vibratory sensations in the midfacial region, bringing the voice 'out of the throat' and 'thinking' it forward o sustained phonation of [m] alternated with rounded vowels (e.g. [mo:mo:mo:m]), unrounded vowels (e.g. [mɑmɑmɑm]), or both (e.g. [momɑmum]) - resonance of the nasal consonant is transmitted to the vowel o sustained phonation of the nasal consonant [n] - tongue tip gently against the superior alveolar ridge, mandible is lowered, jaw is relaxed - focus on sensory feedback and forward focus o sustained phonation of [n] alternated with rounded vowels, unrounded vowels, or both - resonance of the nasal consonant is transmitted to the vowel
2	o repetition session 1 [m] and [n] o sustained phonation of the nasal consonant [ŋ] - back of the tongue gently against velum, mandible is lowered, jaw is relaxed - focus on sensory feedback and forward focus o sustained phonation of [ŋ] alternated with rounded vowels, unrounded vowels, or both o mixed exercises [m], [n] and [ŋ] (e.g. [muŋma:nmoŋ]) o pitch glides [m] and [mo:m]: ascending, descending and alternating tones - gradually building up, each subjects uses its own comfortable pitch extremes and avoids hypertension (feedback experimenters)
3	o repetition session 1 and 2 [m], [n] and [ŋ] o sustained phonation [m], [n] and [ŋ] alternated with oral sounds (vowels + consonants (e.g. [mulumulum], [mybymybym]) - resonance of the nasal is transmitted to the oral sound o pitch glides [m] and [mo:m]: ascending, descending and alternating tones o pitch inflections [m]: using a variety of patterns, supported by visual feedback (arrows)
4	o sustained phonation [m], [n] and [ŋ] + alternated with oral sounds o pitch glides [mo:m]: ascending, descending and alternating tones o pitch inflections [m], [n] and [ŋ]: using a variety of patterns, supported by visual feedback (arrows)
5	o sustained phonation [m], [n] and [ŋ] + alternated with oral sounds o pitch glides and pitch inflections [m] and [mo:m] o separate pitch levels [mo:m] (no glides, but separate levels) o loudness shifts /mom/: crescendo, decrescendo - gradually building up, each subjects uses its own comfortable loudness extremes and avoids hypertension (feedback experimenters) - avoiding pitch changes during the loudness exercises
6	o sustained phonation [m], [n] and [ŋ] + alternated with oral sounds o pitch glides, pitch inflections, and separate pitch levels [n] and [nɔn] o crescendo, decrescendo, and separate loudness levels [nɔn] o resonance with emphasis (e.g. [mó:mó:mó:m]) - use of the diaphragm and the abdominal muscles, avoid production by the laryngeal region (feedback experimenters) o resonating melodies [m] + [m] alternated with oral sounds: tonal scale, songs
7	o sustained phonation [m], [n] and [ŋ] + alternated with oral sounds o pitch glides, pitch inflections, separate pitch levels o crescendo, decrescendo, separate loudness levels o resonance with emphasis o resonance word level: [m], [n] and [ŋ] alternated with vowels e.g. [manən] *(moons)*, [nemən] *(taking)*

Table 5.3 *(Continued)*

Session	Resonant voice training
8	○ sustained phonation [m], [n] and [ŋ] + alternated with oral sounds ○ pitch glides [m], [n], [mɔm], [nɔn] ○ resonance word level: [m], [n] and [ŋ] alternated with oral sounds (vowels + consonants) e.g. /[lanən] *(lanes)*, [benən] *(legs)* ○ word level with gradually reducing resonance (3 levels) - relaxed phonation and forward focus is retained ○ phrase level with gradually reducing resonance (3 levels) e.g. [namən numən] *(naming names)* - relaxed phonation and forward focus is retained
9	○ sustained phonation [m], [n] and [ŋ] + alternated with oral sounds ○ resonance with emphasis ○ pitch glides [m], [n], [mɔm], [nɔn] ○ phrase level with gradually reducing resonance (3 levels) ○ sentence level with gradually reducing resonance (3 levels) e.g. [ɪk num də nam vɑn dezə mɑnən] *(I mention the name of these men)*
10	○ sustained phonation [m], [n] and [ŋ] + alternated with oral sounds ○ resonance with emphasis ○ pitch glides [m], [n], [mɔm], [nɔn] ○ sentence level with gradually reducing resonance (3 levels) ○ text level with gradually reducing resonance (3 levels) e.g. [wɪl jə mɛin nam numən, mɛin mojə namən? ny mɛin fɑmilinam? nen, ɪk num zə nit, wɑnt mɛt ən niwə nam zɑl mɛn y num ə n. kʏn jə mɛi menemən? nen, ɪk nem nimɑnt me. nem om ɛn nɑn ɛn omɑ dɑn me. di zɛin ɑləmal wandələn ɪn də plɑntəntœyn.] *(Do you want to mention my name, my beautiful names? Now my family name?...)* - texts containing a lot of nasal consonants - texts containing less nasal consonants (relaxed phonation and forward focus should be retained) ○ spontaneous speech level: answering standard questions e.g. How old are you, What are your hobbies? - relaxed phonation and forward focus should be retained
11	○ sustained phonation [m], [n] and [ŋ] + alternated with oral sounds ○ pitch glides [m], [n], [mɔm], [nɔn] ○ sentence level with gradually reducing resonance (3 levels) ○ text level with gradually reducing resonance (3 levels) - texts containing a lot of nasal consonants - texts containing less nasal consonants (relaxed phonation and forward focus should be retained) ○ spontaneous speech level - answering questions - introducing themselves - having a conversation
12	○ sustained phonation [m], [n] and [ŋ] + alternated with oral sounds ○ pitch glides [m], [n], [mɔm], [nɔn] ○ crescendo, decrescendo [mɔm], [nɔn] ○ text level with gradually reducing resonance (3 levels) ○ spontaneous speech level - answering question, conversation

Table 5.4 Detailed overview of the straw phonation training sessions.

Session	Straw phonation training
1	○ basic straw phonation (SP) on [o] and [ɔ] vowel (diameter: 5 mm, length: 21 cm) - straw is placed between or in front of the front incisors and above the tongue, tongue is low and relaxed, lips are closed around the straw - breathing in through the nose, breathing out + phonating through the straw ! phonation should happen through the straw and not through the nose (sound should not change when pinching the nose) - use of costo-abdominal breathing pattern - use of soft voice onset [ho] and [hɔ] - sensory feedback and forward focus: vibratory sensations in the midfacial region, bringing the voice 'out of the throat' and 'thinking' it forward ○ awareness of an "open pharynx" - SP on [o], followed by phonation on [o] without the straw - feeling a wider and open pharynx when performing the second exercise
2	○ SP on [o] and [ɔ] vowel ○ SP with emphasis [o] - making 'waves' with extra abdominal pressure [ho:hó:ho:hó:ho:hó] - use of the diaphragm and the abdominal muscles, avoid production by the laryngeal region (feedback experimenters) ○ SP with pitch glides [o]: ascending, descending and alternating tones
3	○ SP on [o] and [ɔ] vowel ○ SP with emphasis [o] and [ɔ] ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] - making 'waves' with extra abdominal pressure + pitch rises within each wave ○ SP with pitch inflections [o] and [ɔ]: variety of patterns, supported by visual feedback (arrows)
4	○ SP on [o] and [ɔ] vowel ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP with separate pitch levels [o] and [ɔ] (no glides, but separate levels)
5	○ SP on [o] and [ɔ] vowel ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP with songs - half of the group phonates a song through the straw, other half guesses which song
6	○ SP on [o] and [ɔ] vowel ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP with songs
7	○ introduction of a straw with a smaller diameter (diameter: 2.5 mm, length: 11.5 cm) ○ SP on [o] and [ɔ] vowel using the smaller straw ○ awareness of an "open pharynx" - SP on [o], followed by phonation on [o] without the straw - feeling of a wider and open pharynx when performing the second exercise - temporarily switching back to the wider diameter if subjects experience too much tension in the laryngeal region ○ SP with emphasis [o] and [ɔ] ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP when "reading" sentences with adequate intonation pattern [ɘ], [o] or [ɔ] - phonation on [ɘ], [o] or [ɔ], no articulation

Table 5.4 *(Continued)*

Session	Straw phonation training
8	○ SP on [o] and [ɔ] vowel using the smaller straw ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP when “reading” sentences with adequate intonation pattern [ɘ], [o] or [ɔ] ○ SP on word level, followed by normal open-mouth phonation - “reading” the word through the straw - reading the word without the straw
9	○ SP on [o] and [ɔ] vowel using the smaller straw ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP on word level, followed by normal open-mouth phonation ○ SP on sentence level, followed by normal open-mouth phonation - “reading” the sentence through the straw - reading the sentence without the straw
10	○ SP on [o] and [ɔ] vowel using the smaller straw ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP on word level, followed by normal open-mouth phonation ○ SP on sentence level, followed by normal open-mouth phonation ○ SP on text level, followed by normal open-mouth phonation - “reading” the first sentence of the text through the straw - reading the text without the straw ○ SP on spontaneous speech level: answering questions - “answering” the first sentence through the straw - continuing the answer without the straw
11	○ SP on [o] and [ɔ] vowel using the wider straw ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP on word level, followed by normal open-mouth phonation ○ SP on sentence level, followed by normal open-mouth phonation ○ SP on text level, followed by normal open-mouth phonation ○ SP on spontaneous speech level, followed by normal open-mouth phonation
12	○ SP on [o] and [ɔ] vowel, using both the smaller and wider straw ○ SP with pitch glides [o] and [ɔ] ○ SP with a combination of emphasis and pitch glides [o] and [ɔ] ○ SP with pitch inflections [o] and [ɔ] ○ SP on word level, followed by normal open-mouth phonation ○ SP on sentence level, followed by normal open-mouth phonation ○ SP on text level, followed by normal open-mouth phonation ○ SP on spontaneous speech level, followed by normal open-mouth phonation

RESULTS

Baseline voice-related symptoms, risk factors, vocal abuse, vocal load, and lifestyle habits

Results on the questionnaire regarding voice-related symptoms, risk factors, vocal abuse, vocal load, and lifestyle habits are presented in Table 5.5. Fischer’s exact tests showed no significant baseline differences among the resonant training group, the straw phonation group, and the control group, except for the parameters “whispering” ($p = 0.025$) and “drinking coffee” ($p = 0.018$). Pairwise comparisons with Bonferroni corrections ($\alpha < 0.016$) showed that participants in the control group whispered more often than participants in the resonant training group ($p = 0.005$), and that participants in the resonant training group consumed more coffee than participants in the straw phonation group ($p = 0.011$). Voice-related symptoms did not differ among groups when rechecked at the posttest.

Frequency of home practice

Four participants of the resonant voice training group and eight participants of the straw phonation group reported a (nearly) daily home practice. In each group, four participants practiced at home one day a week. Twelve participants of the resonant training group and eight participants of the straw phonation group reported no home practice. Fischer’s exact test showed no significant difference in frequency of home practice across the three groups ($p = 0.385$).

Interrater reliability auditory-perceptual evaluation

Cohen’s κ showed fair to excellent degrees of interrater reliability for the GRBASI parameters. An excellent degree of reliability was found for the parameters G, A, and I, with $\kappa = 0.733$, $\kappa = 1.0$, and $\kappa = 1.0$, respectively. A moderate degree of reliability was found for the parameter B, with $\kappa = 0.510$. The poorest, but still fair, degrees of reliability were found for the parameters R and S, with $\kappa = 0.318$.

Table 5.5 Baseline voice-related symptoms, risk factors, vocal abuse, vocal load and lifestyle habits in the resonant voice training group (R), the straw phonation group (SP) and the control group (C).

	Occurrence	R (*n* = 10)	SP (*n* = 10)	C (*n* = 10)	*p*-value
Symptoms *(at moment of testing)*					
Vocal complaints	Pre-test	1	1	2	> 0.999
	Post-test	1	2	0	0.754
Throat pain or irritation	Pre-test	1	2	1	> 0.999
	Post-test	2	2	0	0.477
Upper respiratory tract infection	Pre-test	3	1	0	0.286
	Post-test	1	0	1	0.754
Risk factors					
Reflux	Never	9	9	8	> 0.999
	Sometimes	1	1	2	
	Often	0	0	0	
Allergies	Never	6	4	7	0.151
	Seasonal	3	6	1	
	Often	1	0	2	
Upper respiratory tract infections	Never	1	1	1	0.939
	Sometimes	8	9	7	
	Often	1	0	2	
Astma	Never	9	10	9	> 0.999
	Sometimes	1	0	0	
	Often	0	0	1	
Pulmonary diseases	Never	10	10	9	> 0.999
	Sometimes	0	0	0	
	Often	0	0	1	
Tension in neck or shoulders	Never	4	6	5	0.582
	Sometimes	6	3	5	
	Often	0	1	0	
Stress	Never	1	0	0	0.754
	Sometimes	9	9	8	
	Often	0	1	2	
Vocal abuse					
Coughing or throat clearing	Never	1	1	0	0.829
	Sometimes	9	8	8	
	Often	0	1	2	
Whispering	Never	6	2	0	0.025*
	Sometimes	4	7	9	
	Often	0	1	1	
Screaming or yelling	Never	3	1	3	0.751
	Sometimes	6	8	7	
	Often	1	1	0	
Imitating voices or sounds	Never	7	7	6	> 0.999
	Sometimes	3	3	4	
	Often	0	0	0	
Hard glottal onset	Never	6	6	5	> 0.999
	Sometimes	4	4	5	
	Often	0	0	0	
Vocal load					
Speaking at inappropriate loudness	Never	4	3	3	0.893
	Sometimes	6	5	7	
	Often	0	1	0	
Speaking at heightened pitch	Never	7	8	9	0.574
	Sometimes	3	1	1	
	Often	0	1	0	
High speech rate	Never	4	2	4	0.811
	Sometimes	4	4	3	
	Often	2	4	3	

Table 5.5 (*Continued)*

	Occurrence	R (*n* = 10)	SP (*n* = 10)	C (*n* = 10)	*p*-value
Strained phonation	Never	7	8	6	0.879
	Sometimes	3	2	4	
	Often	0	0	0	
Speaking for large audience	Never	5	6	5	0.193
	Sometimes	2	1	5	
	Often	3	3	0	
Speaking with irregular respiratory breaks	Never	7	7	3	0.146
	Sometimes	3	7	7	
	Often	0	0	0	
Speaking for a long period of time without vocal rest	Never	6	5	5	> 0.999
	Sometimes	4	4	4	
	Often	0	1	1	
Hobbies with high vocal load	No	6	5	4	0.948
	Periodic	3	3	4	
	Yes	1	2	2	
Professional voice use	No	7	9	8	0.939
	In the past	2	0	1	
	Yes	1	1	1	
Lifestyle habits					
Eating late and heavy food	Never	2	4	2	0.668
	Sometimes	8	6	7	
	Often	0	0	1	
Alcohol use	Never	1	2	1	0.659
	Sometimes	7	8	9	
	Often	2	0	0	
Smoking	Never	10	10	10	-
	Sometimes	0	0	0	
	Often	0	0	0	
Recreative drug use and automedication	Never	10	10	10	-
	Sometimes	0	0	0	
	Often	0	0	0	
Coffee	Never	2	9	5	0.018*
	Sometimes	4	1	4	
	Often	4	0	1	
Sleep deprivation	Never	6	2	1	0.077
	Sometimes	4	8	8	
	Often	0	0	1	

Evolution outcome measures

Tables 5.6 and 5.7 show the evolution of the outcome measures in the three groups. (Generalized) linear mixed models showed no significant time-by-group interactions for any of the outcome measures, indicating no significant differences in evolution over time among the three groups. No significant group effects were found for any of the outcome measures, indicating no differences among groups independent of time. Significant time effects were found for the parameters MPT, I-low, and I-range, indicating significant changes over time in the sample as a whole, independent of group assignment.

Within-group effects of time showed a significant improvement in DSI in the resonant voice training group (+1.2, *p* = 0.022). In the straw phonation group, I-low (−2.3, *p* = 0.040), I-high (+3.8, *p* = 0.019), and I-range (+6.1, *p* = 0.002) significantly improved. A significantly increased value for jitter (0.586, *p* = 0.049) and a decreased value for I-low (−2.7, *p* = 0.025) were found in the control group.

DISCUSSION

The purpose of this study was to determine the short-term effect of two semi-occluded vocal tract training programs, “resonant voice training using nasal consonants” versus “straw phonation,” on the phonation of vocally healthy future occupational voice users. To date, research has mainly been devoted to the immediate effects of a single SOVT performance instead of the effect of a complete SOVT training program (Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015). We hypothesized that both SOVT training programs would have a positive effect on the vocal quality of future occupational voice users. Resonant voice training may be effective because the semi-occlusions are speech-embedded, whereas straw phonation may be effective due to higher inertive reactance in the vocal tract.

The experiment started with a group of 30 speech-language pathology students with healthy vocal fold anatomy and physiology. No significant differences were found regarding age, gender, voice-related symptoms, risk factors, vocal abuse, vocal load, and lifestyle habits among the resonant training group, the straw phonation group, and the control group, except for the parameters “whispering” and “drinking coffee.”

Table 5.6 Evolution of the categorical outcome measures in the resonant voice training group (R), the straw phonation group (SP) and the control group (C).

		Pre		Post		Time*Group	Group	Time	Comparison Time within groups
Parameters	Group	Median	IQR	Median	IQR	*p*-value	*p*-value	*p*-value	*p*-value
Auditory-perceptual evaluation									
G	R	0	[0, 0.25]	0	[0,1]	0.495	0.887	0.805	0.157
	SP	0	[0, 0.25]	0	[0, 0.25]				>0.999
	C	0	[0, 1]	0	[0, 0.5]				0.317
R	R	0	[0, 1]	0	[0, 0.25]	0.986	0.887	0.994	0.317
	SP	0	[0, 0]	0	[0,1]				0.083
	C	0	[0, 0.5]	0	[0, 0]				0.317
B	R	0	[0, 1]	0	[0,1]	0.793	0.328	0.422	0.564
	SP	0	[0, 0]	0	[0, 0]				>0.999
	C	0	[0, 0.5]	0	[0,1]				0.157
A	R	0	[0, 0]	0	[0, 0]	0.856	0.663	0.704	>0.999
	SP	0	[0, 0]	0	[0, 0]				>0.999
	C	0	[0, 0]	0	[0, 0]				0.317
S	R	0	[0, 0.25]	0	[0, 0.25]	0.887	0.858	0.726	>0.999
	SP	0	[0, 1]	0	[0,1]				>0.999
	C	0	[0, 1]	0	[0, 0.5]				0.317
I	R	0	[0, 0]	0	[0,1]	>0.999	>0.999	0.999	0.083
	SP	0	[0, 0]	0	[0, 0]				>0.999
	C	0	[0, 0]	0	[0,1]				0.157

Note: IQR, interquartile range; R, roughness; B, breathiness; A, asthenia; S, strain; I, instability.

Table 5.7 Evolution of the continuous outcome measures in the resonant voice training group (R), the straw phonation group (SP) and the control group (C).

		Pre		Post		Evolution Pre-Post		Time* Group	Group	Time	Comparison time within groups
Parameters	Group	EM	95% CI	EM	95% CI	EM Difference	95% CI	*p*-value	*p*-value	*p*-value	*p*-value
Maximum performance task											
MPT (s)	R	24.4	[20.0, 28.9]	27.3	[22.9, 31.8]	+2.9	[-0.4, 6.2]	0.817	0.169	0.035*	0.078
	SP	19.6	[15.1, 24.0]	21.2	[16.7, 25.6]	+1.6	[-1.7, 4.9]				0.320
	C	21.1	[16.7, 25.8]	22.8	[18.2, 27.5]	+1.7	[-1.7, 5.2]				0.313
Aerodynamic assessment											
VC (cc)	R	2490	[2134, 2846]	2560	[2204, 2916]	+70	[-147, 287]	0.446	0.819	0.232	0.513
	SP	2410	[2054, 2766]	2390	[2034, 2746]	-20	[-237, 197]				0.851
	C	2300	[1924, 2676]	2478	[2102, 2853]	+178	[-51, 406]				0.122
PQ (cc/s)	R	105.6	[83.8, 127.5]	102.5	[80.7, 124.3]	-3.1	[-21.5, 15.3]	0.816	0.275	0.196	0.731
	SP	132.4	[110.6, 154.2]	121.2	[99.4, 143.1]	-11.2	[-29.6, 7.2]				0.222
	C	117.1	[94.1, 140.2]	110.5	[87.5, 133.5]	-6.6	[-26.0, 12.8]				0.489
Accoustic analysis											
f_o (Hz)	R	196.0	[173.0, 219.0]	198.6	[175.6, 221.6]	+2.6	[-4.7, 9.9]	0.491	0.471	0.444	0.470
	SP	196.2	[173.2, 219.2]	200.4	[177.4, 223.4]	+4.2	[-3.1, 11.5]				0.252
	C	216.2	[192.0, 240.5]	214.3	[190.1, 238.6]	-1.9	[-9.6, 5.8]				0.618
jitter (%)	R	1.535	[0.998, 2.072]	1.250	[0.713, 1.787]	-0.285	[-0.839, 0.269]	0.070	0.623	0.125	0.300
	SP	1.473	[0.936, 2.010]	1.926	[1.389, 2.463]	+0.453	[-1.101, 1.007]				0.105
	C	1.328	[0.762, 1.893]	1.913	[1.348, 2.479]	+0.586	[0.001, 1.170]				0.049*
shimmer (%)	R	6.126	[5.112, 7.140]	5.034	[4.020, 6.048]	-1.092	[-2.282, 0.098]	0.150	0.186	0.416	0.070
	SP	4.657	[3.643, 5.671]	4.298	[3.284, 5.312]	-0.359	[-1.549, 0.831]				0.540
	C	4.650	[3.581, 5.719]	5.257	[4.188, 6.326]	+0.607	[-0.647, 1.861]				0.329
vf_o (%)	R	1.556	[1.187, 1.925]	1.295	[0.926, 1.664]	-0.261	[-0.629, 0.107]	0.082	0.681	0.442	0.156
	SP	1.516	[1.147, 1.885]	1.721	[1.352, 2.090]	+0.205	[-0.163, 0.573]				0.262
	C	1.327	[0.938, 1.716]	1.629	[1.240, 2.018]	+0.302	[-0.085, 0.690]				0.121
NHR	R	0.138	[0.124, 0.152]	0.131	[0.117, 0.145]	-0.007	[-0.028, 0.014]	0.632	0.976	0.297	0.493
	SP	0.142	[0.128, 0.156]	0.129	[0.115, 0.143	-0.013	[-0.034, 0.008]				0.208
	C	0.133	[0.118, 0.149]	0.134	[0.119, 0.150]	+0.001	[-0.021, 0.023]				0.917
Voice Range Profile											
I-low (dB)	R	60.1	[57.8, 62.4]	58.6	[56.3, 60.9]	-1.5	[-3.7, 0.7]	0.742	0.675	0.002*	0.171
	SP	61.7	[59.4, 64.0]	59.4	[57.1, 61.7]	-2.3	[-4.5, 0.1]				0.040*
	C	61.7	[59.2, 64.1]	59.0	[56.6, 61.4]	-2.7	[-5.0, -0.4]				0.025*
I-high (dB)	R	102.3	[98.8, 105.8]	102.2	[98.7, 105.7]	-0.1	[-3.2, 3.0]	0.113	0.265	0.234	0.948
	SP	96.7	[93.2, 100.2]	100.5	[97.0, 104.0]	+3.8	[0.7, 7.0]				0.019*
	C	100.0	[96.3, 103.7]	99.6	[95.8, 103.3]	-0.4	[-3.7, 2.8]				0.783

Table 5.7 *(Continued)*

		Pre		Post		Evolution Pre-Post		Time* Group	Group	Time	Comparison time within groups
Parameters	Group	EM	95% CI	EM	95% CI	EM Difference	95% CI	*p*-value	*p*-value	*p*-value	*p*-value
I-range (dB)	R	42.2	[38.0, 46.4]	43.6	[39.4, 47.8]	+1.4	[-2.2, 5.0]	0.152	0.187	0.004*	0.432
	SP	35.0	[30.8, 39.2]	41.1	[36.9, 45.3]	+6.1	[2.5, 9.7]				0.002*
	C	38.3	[33.9, 42.7]	40.5	[36.2, 45.0]	+2.2	[-1.6, 6.0]				0.240
F-low (Hz)	R	148.1	[127.0, 169.2]	148.0	[126.9, 169.1]	-0.1	[-12.3, 12.1]	0.824	0.174	0.376	0.987
	SP	161.7	[140.6, 182.8]	157.4	[136.3, 178.5]	-4.3	[-16.5, 7.9]				0.474
	C	178.3	[156.1, 200.6]	173.3	[151.1, 195.6]	-5.0	[-17.8, 7.8]				0.430
F-high (Hz)	R	697.7	[612.6, 782.8]	707.8	[622.7, 792.9]	+10.1	[-57.3, 77.5]	0.611	0.713	0.537	0.760
	SP	712.9	[627.8, 798.0]	704.1	[619.0, 789.2]	-8.8	[-76.2, 58.6]				0.790
	C	764.6	[674.8, 854.3]	727.1	[637.4, 816.8]	-37.4	[-108.5, 33.6]				0.288
F-range (Hz)	R	549.6	[466.5, 632.7]	559.8	[476.7, 642.9]	+10.2	[-62.0, 82.4]	0.703	0.923	0.670	0.774
	SP	551.2	[468.1, 634.3]	546.7	[463.6, 629.8]	-4.5	[-76.7, 67.7]				0.899
	C	586.2	[498.6, 673.9]	553.8	[466.1, 641.4]	-32.4	[-108.6, 43.7]				0.389
Dysphonia Severity Index											
DSI	R	1.9	[0.5, 3.4]	3.1	[1.7, 4.6]	+1.2	[0.2, 2.2]	0.224	0.364	0.109	0.022*
	SP	1.1	[-0.4, 2.5]	1.3	[-0.1, 2.7]	+0.2	[-0.8, 1.2]				0.637
	C	1.7	[0.2, 3.2]	1.7	[0.2, 3.2]	0	[-1.0, 1.1]				0.983
Acoustic Voice Quality Index											
AVQI	R	3.60	[3.07, 4.14]	3.58	[3.04, 4.12]	-0.02	[-0.59, 0.54]	0.862	0.716	0.758	0.931
	SP	3.42	[2.88, 3.95]	3.25	[2.71, 3.78]	-0.17	[-0.74, 0.40]				0.543
	C	3.48	[2.92, 4.05]	3.52	[2.96, 4.09]	+0.04	[-0.56, 0.64]				0.886
CPPS	R	11.95	[10.92, 12.98]	12.16	[11.13, 13.19]	+0.21	[-0.65, 1.07]	0.804	0.564	0.329	0.623
	SP	12.62	[11.59, 13.64]	12.68	[11.65, 13.71]	+0.06	[-0.80, 0.93]				0.882
	C	11.77	[10.69, 12.86]	12.24	[11.16, 13.32]	+0.47	[-0.45, 1.37]				0.304
HNR (dB)	R	16.46	[15.08, 17.84]	16.29	[14.91, 17.67]	-0.18	[-1.81, 1.44]	0.433	0.193	0.419	0.825
	SP	17.47	[16.09, 18.85]	17.72	[16.34, 19.10]	+0.25	[-1.37, 1.87]				0.751
	C	18.36	[16.90, 19.82]	17.14	[15.68, 18.60]	-1.22	[-2.9, 0.49]				0.154
Shimmer Local (%)	R	5.87	[5.07, 6.66]	5.30	[4.51, 6.09]	-0.57	[-1.68, 0.55]	0.463	0.183	0.355	0.308
	SP	5.17	[4.38, 5.96]	4.56	[3.76, 5.35]	-0.61	[-1.73, 0.50]				0.269
	C	5.33	[4.50, 6.17]	5.61	[4.78, 6.45]	+0.28	[-0.90, 1.46]				0.632
Shimmer Local (dB)	R	0.57	[0.51, 0.64]	0.51	[0.44, 0.58]	-0.06	[-0.15, 0.03]	0.266	0.067	0.227	0.194
	SP	0.50	[0.44, 0.57]	0.43	[0.37, 0.50]	-0.07	[-0.16, 0.02]				0.137
	C	0.51	[0.44, 0.58]	0.54	[0.47, 0.61]	+0.03	[-0.07, 0.13]				0.527

Table 5.7 *(Continued)*

		Pre		Post		Evolution Pre-Post		Time* Group	Group	Time	Comparison time within groups
Parameters	Group	EM	95% CI	EM	95% CI	EM Difference	95% CI	*p*-value	*p*-value	*p*-value	*p*-value
Slope of LTAS (dB)	R	-16.75	[-18.98, -14.52]	-17.56	[-19.79, -15.34]	-0.81	[-2.77, 1.14]	0.428	0.392	0.673	0.399
	SP	-18.56	[-20.79, -16.33]	-19.29	[-21.52, -17.06]	-0.73	[-2.68, 1.23]				0.452
	C	-19.20	[-21.55, -16.85]	-18.38	[-20.73, -16.03]	+0.82	[-1.23, 2.88]				0.418
Tilt of trendline through LTAS (dB)	R	-10.61	[-11.15, -10.07]	-10.50	[-11.04, -9.96]	+0.11	[-0.41, 0.63]	0.654	0.597	0.570	0.674
	SP	-10.13	[-10.67, -9.59]	-10.32	[-10.85, -9.78]	-0.19	[-0.71, 0.33]				0.463
	C	-10.36	[-10.92, -9.79]	-10.53	[-11.10, -9.97]	-0.17	[-0.73, 0.37]				0.515
Voice Handicap Index											
F-scale	R	4	[2, 5]	3	[1, 4]	-1	[-2, 0]	0.311	0.999	0.039	0.097
	SP	3	[2, 5]	3	[2, 5]	0	[-1, 1]				>0.999
	C	3	[2, 5]	2	[1, 4]	-1	[-2, 0]				0.056
P-scale	R	5	[3, 7]	5	[3, 7]	0	[-2, 2]	0.354	0.968	0.347	>0.999
	SP	4	[2, 6]	4	[2, 7]	0	[-2, 2]				0.909
	C	5	[3, 8]	4	[1, 6]	-1	[-3, 0]				0.099
E-scale	R	1	[0, 3]	1	[0, 3]	0	[-2, 1]	0.406	0.212	0.901	0.600
	SP	2	[1, 4]	3	[2, 5]	+1	[-1, 2]				0.243
	C	1	[-1, 3]	1	[-1, 2]	0	[-2, 1]				0.678
Total VHI	R	10	[6, 14]	9	[4, 13]	-1	[-5, 2]	0.234	0.854	0.232	0.398
	SP	10	[5, 14]	11	[6, 15]	+1.0	[-2, 4]				0.544
	C	10	[6, 15]	7	[3, 11]	-3	[-7, 0]				0.081

Note: EM, estimated mean; CI, confidence interval; MPT, maximum phonation time; VC, vital capacity; PQ, phonation quotient; f_o, fundamental frequency; vf_o, variation in fundamental frequency; NHR, noise-to-harmonic ratio; I-low, lowest intensity; I-high, highest intensity; I-range, intensity range; F-low, lowest frequency; F-high, highest frequency; F-range, frequency range; DSI, Dysphonia Severity Index; AVQI, Acoustic Voice Quality Index; CPPS, smoothed cepstral peak prominence; HNR, harmonics-to-noise ratio; LTAS, long-term average spectrum; F, functional; P, physical; E, emotional; VHI, Voice Handicap Index. * indicates a significant effect.

Within-group effects of time showed a significant improvement in DSI in the resonant voice training group, and a significant expansion of the intensity range in the straw phonation group. The DSI improved from 1.9 (69%) pre-training to 3.1 (81%) post-training in the resonant voice training group, corresponding to an increment of 1.2 or 12%. The DSI is an objective and quantitative correlate of the perceived vocal quality and is sensitive to detecting small changes in vocal quality (Wuyts et al., 2000). Analysis of the components of the DSI showed that all parameters trended in the positive directions (MPT = +2.9 s; jitter = −0.285 %; I-low = −1.5 dB; F-high = +10.1 Hz). The intensity range increased from 35.0 dB pre-training to 41.1 dB post-training in the straw phonation group. The significant decrease in I-low (−2.3 dB) may be explained by a lower phonation threshold pressure associated with the SOVT (Guzman et al., 2013a; Guzman et al., 2013b; Guzman et al., 2017a; Kapsner-Smith et al., 2015; Titze, 1988, Titze, 2002a), requiring less subglottal pressure to induce vocal fold oscillation. However, a similar decrease in I-low (−2.7 dB) observed in the control group possibly indicates a practice effect for this parameter. The significantly increased I-high value after straw phonation fits within the hypothesis of obtaining greater vocal output with less physical effort and vocal fold impact stress (Croake et al., 2017; Gaskill & Quinney, 2012; Maxfield et al., 2015; Mills et al., 2017; Titze, 2006).

(Generalized) linear mixed models showed no significant time-by-group interaction for any of the outcome measures, indicating no significantly better evolution in the resonant voice training group or straw phonation group compared with the control group. Possible reasons for this lack of significance are the use of small sample sizes, or the fact that participants were vocally healthy, which allows less significant progress. Nevertheless, the within-group effects showed a clear benefit for the resonant voice training group regarding the evolution in DSI, and for the straw phonation group regarding the evolution in intensity range. Those results suggest transfer of the previously described positive effects of the semi-occluded mouth postures to normal open-mouth phonation (production of the vowel /a/).

Whether transfer to normal open-mouth phonation can actually be expected needs further investigation. At first, transfer might be closely linked to frequency of practice. A frequency of two sessions of 30 min per week, as applied in this study, may be insufficient. Practicing several minutes at a time, multiple times each day, is recommended (Gaskill & Quinney, 2012; Rosenberg, 2013). Variation between several SOVT exercises, and between semi-occluded phonation and normal open-mouth phonation, might be a second important factor (Gaskill & Quinney, 2012; Nix & Simpson, 2008). Third, transfer may depend on whether semi-occlusions are speech-embedded or not (Kapsner-Smith et al., 2015). Speech can easily be implemented in resonant voice training, which might favor transfer. However, using prosodic patterns in non-speech SOVT exercises, such as straw phonation, can also be a useful transition to speech (Kapsner-Smith et al., 2015; Titze, 2006). In addition, straw phonation has the advantage of creating higher inertive reactance in the vocal tract, which may in turn positively affect transfer (Gaskill & Quinney, 2012; Guzman et al., 2015; Titze, 2006).

Titze (2006) highlighted the importance of the epilarynx in the process of transfer to normal open-mouth phonation. The epilarynx, which is a tube just above the glottis, probably narrows during SOVT exercises (Titze, 2006; Titze & Verdolini Abbott, 2012). The oral semi-occlusion is then accompanied with a semi-occlusion at the back end of the vocal tract, further reinforcing the source-filter interaction. The hypothesis is that the vocalist or patient wants to hold on to the sensation of resistance and back pressure associated with the SOVT exercise and therefore retains some epilarynx narrowing when transferring to normal open-mouth phonation (Titze, 2006). The vocal tract configuration evolves from an inverted megaphone shape during the SOVT exercise to a megaphone shape after the SOVT exercise (Titze, 2006). In other words, the epilarynx could serve as an impedance matcher between the vocal folds and the vocal tract in trained speakers and singers, and SOVT exercises may assist in the awareness of this impedance matching (Titze, 2006; Titze & Laukkanen, 2007; Titze & Story, 1997). Theoretically, training should start with the greatest resistance, and thus the highest source-filter interaction, and proceed hierarchically through less resistive and more natural SOVT exercises (Gaskill & Quinney, 2012; Titze, 2006). For the SOVT exercises discussed here, this would mean that straw phonation should be addressed before resonant voice training, and stirring straws should be used before drinking straws. However, some people need time to familiarize themselves with the higher resistance to airflow during SOVT exercises, and an individualized trajectory tailored for comfort and ease of phonation will be necessary (Gaskill & Quinney, 2012; Titze, 2006). These practical aspects of comfort were combined with the theoretical aspect of reducing resistance in the current straw phonation training. A drinking straw was introduced before a stirring straw for the aim of comfort, but the drinking straw was reintroduced in the last two sessions for the aim of reducing resistance. If students felt a persistent discomfort using the stirring straw, the drinking straw was reintroduced earlier in the training process. It should be acknowledged that the appropriate diameter of the straw also depends on the natural glottal resistance of the participant (Maxfield et al., 2015). Further research is needed to find the best matched diameters for each individual, which will probably depend on multiple factors, such as gender, age, type of voice user, history of voice training, vocal fold pathology, and so forth.

In summary, a hierarchical and individualized SOVT training program consisting of a variety of techniques that involve factors essential for transfer seems advisable for clinical practice. Current results are in line with this recommendation, as an improved DSI was found after resonant voice training and better vocal capacities in terms of an intensity range enlargement were found after straw phonation training, suggesting that the two SOVT exercises are helpful in training future occupational voice users and should both be implemented to obtain an optimized cumulative effect.

Limitations of this study are that participants were not blinded to the purpose of the study, and no sham training condition was provided for the control group. Subjective vocal measures could be better adapted to the specific audience used. Because the Voice Handicap Index was developed for dysphonic patients, useful self-report information may have been lost in this study. Visual analog scales, such as the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V; American Speech-Language Hearing Association, 2002) scale, may be more sensitive than the ordinal GRBASI scale to measure auditory-perceptual differences in this population (Nemr et al., 2012). Larger sample sizes and long-term results need to be implemented in further studies. Investigating the short- and long-term effects of different SOVT training and therapy programs in elite vocal performers and patients with a variety of voice disorders are subjects for further research.

CONCLUSIONS

Results suggest that the SOVT training programs including resonant voice training and straw phonation may have a positive impact on the objective vocal quality and vocal capacities of future occupational voice users. The resonant voice training caused an improved DSI, and the straw phonation training caused an expansion of the intensity range in this population. Future studies that implement larger sample sizes, a sham training condition for the control group, and long-term effects need to support these preliminary results. Investigating the effect of different SOVT therapy programs in patients with a variety of voice disorders is also a subject for further research.

5.2 Effect of three semi-occluded vocal tract therapy programs on the phonation of patients with dysphonia: Lip trill, water-resistance therapy or straw phonation

Based on: Meerschman, I., Van Lierde, K., Ketels, J., Coppieters, C. Claeys, S., & D'haeseleer, E. Effect of three semi-occluded vocal tract therapy programs on the phonation of patients with dysphonia: Lip trill, water-resistance therapy or straw phonation. *Submitted to International Journal of Language & Communication Disorders.*

ABSTRACT

Objective. The purpose of this study was to investigate the effect of three SOVT therapy programs "lip trill", "water-resistance therapy" and "straw phonation" on the vocal quality, vocal capacities, psychosocial impact and vocal tract discomfort of patients with dysphonia.

Methods. A blocked-randomized sham-controlled trial was used. Thirty-five patients with dysphonia (mean age, 21 years; 33 females, 2 males) were assigned to either a lip trill group, a water-resistance therapy group, a straw phonation group, or a control group using blocked randomization. The lip trill, water-resistance therapy and straw phonation groups practiced their respective SOVT exercise across 3 weeks, whereas the control group received a sham treatment across the same time span. A multidimensional voice assessment consisting of both objective (maximum performance task, aerodynamic measurements, voice range profile, acoustic analysis, Acoustic Voice Quality Index, Dysphonia Severity Index) and subjective vocal outcomes (subject's self-report, auditory-perceptual evaluation) was performed by a blinded assessor pre- and post-therapy.

Results. Lip trill therapy led to a significant improvement in lowest intensity, Dysphonia Severity Index and Voice Handicap Index. Water-resistance therapy significantly improved Voice Handicap Index and self-perceived vocal quality. Straw phonation therapy showed significant improvements in jitter, variation in fundamental frequency, Dysphonia Severity Index, and auditory-perceptual grade and roughness. No changes were found after the sham treatment in the control group.

Conclusion. Results suggest that SOVT therapy programs including straw phonation or lip trill can improve objective vocal quality and capacities in patients with dysphonia. Auditory-perceptual improvements can be expected after straw phonation therapy, whereas psychosocial improvements can be expected after lip trill and water-resistance therapy. Patients seem to experience more comfort and a better self-perceived vocal quality immediately after a water-resistance therapy session.

INTRODUCTION

Obtaining an economic and efficient voice production is the main aim of voice therapy. The intent is to produce a normal vocal intensity and power with less mechanical stress to laryngeal tissues, less muscular effort, and less energy loss. These factors will decrease the risk of laryngeal hyperfunction, vocal fatigue and vocal injury (Titze, 2006; Titze & Verolini Abbott, 2012; Gaskill & Quinney, 2012; Croake et al., 2017; Mills et al., 2017). A promising way to obtain vocal economy and efficiency is by semi-occluding the vocal tract while phonating (Titze, 2006; Gaskill & Quinney, 2012; Croake et al., 2017; Mills et al., 2017). A semi-occluded vocal tract (SOVT) creates a heightened supraglottal pressure and inertive reactance, which enhances the vocal fold vibration and assist its production of acoustic energy via a non-linear feedback mechanism (Titze, 2006; Titze & Verdolini Abbott, 2012; Conroy et al., 2014; Kapsner-Smith et al., 2015; Guzman et al., 2017a). In general, SOVT exercises elicit a voice production that relies more heavily on that non-linear source-filter interaction than on adductory stress to give the voice acoustic power (Maxfield et al., 2015).

Several subgroups of SOVT exercises can be distinguished. First, semi-occlusions of the vocal tract can either be formed by the articulators (lips and/or tongue) or by the use of an assistive device (Titze, 2006; Andrade et al., 2014; Dargin & Searl, 2015; Maxfield et al., 2015; Fantini et al., 2017). Lip trill is an example of an SOVT exercise solely formed by the articulators, whereas water-resistance therapy (WRT) and straw phonation use a tube or straw inserted between the lips. In the latter cases, an artificial lengthening of the vocal tract is achieved (Conroy et al., 2014). This lengthening creates an additional increase in supraglottal pressure and inertive reactance, especially when small-diameter tubes or straws are used (Titze, 2006; Titze & Verdolini Abbott, 2012; Gaskill & Quinney, 2012; Maxfield et al., 2015). A second subdivision depends on whether the free end of the tube or straw is placed into air (straw phonation) or water (WRT). For WRT, both flexible soft-walled tubes, glass tubes or straws can be used (Sovijärvi, 1969; Sihvo, 2006; Simberg & Laine, 2007; Kapsner-Smith et al., 2015; Guzman et al., 2017a; Mailänder et al., 2017; Tyrmi et al., 2017). A last subdivision depends on the number of vibratory sources (Andrade et al., 2014; Guzman et al., 2017b). Straw phonation has a single source of vibration (i.e. vocal folds only), whereas lip trill and WRT have a secondary source of vibration (i.e. lip trilling and water bubbling). A secondary source of vibration at the distal part of the vocal tract produces a fluctuating intraoral pressure which is hypothesized to create a “massage-like” effect on the vocal folds and the vocal tract with a reduction of vocal tract discomfort and muscle tension (Andrade et al., 2014; Guzman et al., 2017b).

To date, most authors have been interested in the immediate, often physical or physiological, effects of a single SOVT performance. Whether a therapy program (i.e. longer than one session) using SOVT exercises leads to an enhanced phonation and improved vocal quality on the short or long term is not yet sufficiently confirmed (Gaskill & Quinney, 2012; Kapsner-Smith et al., 2015). To our knowledge, only three studies investigated the isolated effect of a lip trill, water-resistance and/or straw phonation therapy program (i.e. longer than one session) in a dysphonic population (Kapsner-Smith et al., 2015; Guzman et al., 2017a; Guzman et al., 2017b). Kapsner-Smith et al. (2015) found that straw phonation using stirring straws led to improvements in the psychosocial impact of dysphonia (Voice Handicap Index) and the auditory-perceptual parameter roughness (6 weekly sessions of 30-60 min, *n* = 10). Guzman et al. (2017a) also showed improvements in Voice Handicap index in patients with hyperfunctional dysphonia after both phonation through a drinking straw in air and water (i.e. WRT) (8 weekly sessions of 30 min, *n* = 10 per group). Furthermore, a better self-perceived resonant voice quality was found after therapy in both groups. In the straw phonation group, this auditory-perceptual improvement was also rated by the clinician. In a later study, Guzman et al. (2017b) showed that one session (30 min) of lip trills or WRT (drinking straw), followed by a 1 week home practice program, led to improvements in self-perceived muscle relaxation, vocal tract discomfort and resonant voice quality (*n* = 21 per group). None of the above studies included objective multiparametric vocal quality indices or control groups receiving sham (placebo) treatment.

The purpose of this study was to investigate the effect of three SOVT therapy programs “lip trill”, “WRT” and “straw phonation” on the vocal quality, vocal capacities, psychosocial impact and vocal tract discomfort of patients with dysphonia using a blocked-randomized sham-controlled trial and a multidimensional voice assessment performed by an assessor blinded to group allocation. Based on the promising physics of a semi-occluded vocal tract, positive results were expected for the three SOVT therapy programs. Straw phonation might have the largest positive impact on the objective vocal quality due to the highest inertive reactance in the vocal tract and therefore the most optimal source-filter interaction (Titze, 2006; Titze & Verdolini Abbott, 2012; Gaskill & Quinney, 2012; Maxfield et al., 2015). Lip trill and WRT might specifically decrease vocal tract discomfort due to the double source of vibration which produces a fluctuating intraoral pressure and possibly creates a “massage-like” effect on the vocal tract with reduction of muscle tension (Andrade et al., 2014; Guzman et al., 2017b). Changes in psychosocial impact and auditory-perceptual vocal quality were not yet expected after 3 weeks of practice.

MATERIAL AND METHODS

Participants

Participants were recruited at the departments of Speech, Language and Hearing Sciences and Otorhinolaryngology of Ghent University and Ghent University Hospital in September and October, 2017. Inclusion criteria were patients diagnosed with dysphonia and referred for voice therapy. Diagnosis was based on the results of a multidimensional voice assessment, performed by a speech-language pathologist (SLP) experienced in voice diagnostics. Smoking, pregnancy, current participation in voice training or therapy, mental health conditions, and physically-limiting diseases that might interfere with study completion were selected as exclusion criteria. Thirty-five patients, 33 females and 2 males, with a mean age of 21 years (SD, 5.3 years; range, 17-44 years) participated in the study. Three subjects left the study prior to termination (one subject of the lip trill group, one subject of the WRT group and one subject of the control group).

Design

A blocked-randomized sham-controlled trial was used. Participants were assigned to either a lip trill group (*n* = 9), a WRT group (*n* = 9), a straw phonation group (*n* = 9) or a control group (*n* = 8), using blocked randomization, stratified by age, gender, and being a student versus an employee. There were no differences among the four groups in gender (chi-square test; *p* =

0.572) and mean age (Kruskall–Wallis test; $p = 0.759$). An overview of the studies and occupations per group can be found in Table 5.8.

Table 5.8 Professions and studies of the participants in the lip trill group, the WRT group, the straw phonation group and the control groups.

	Lip trill (*n* = 9)	**WRT** (*n* = 9)	**Straw phonation** (*n* = 9)	**Control group** (*n* = 8)
Professions				
Teacher	1	1	0	0
Animator nursing home	0	0	1	0
Occupational therapist	0	0	1	0
Studies				
Speech-language pathology	4	6	7	6
Communication management	1	0	0	1
Podology	0	0	0	1
Educational sciences	0	1	0	0
Pharmaceutical sciences	1	0	0	0
Social work and welfare	1	0	0	0
Dental care	1	0	0	0
High school (human sciences)	0	1	0	0

Voice therapy

The lip trill, WRT and straw phonation groups practiced their respective SOVT exercise across 3 weeks with a frequency of two 30-min sessions a week. A detailed overview of the three therapy programs can be found in Table 5.9. Subjects of the control group received a sham (placebo) treatment across the same time span with a frequency of one 1-h session a week. They learnt how to perform an auditory-perceptual evaluation of voice samples using the GRBASI scale and a visual analogue scale. They did not evaluate their own voices, nor receive any active vocal techniques.

The voice therapy programs were guided by two therapists (J.K. and C.K.). The content and structure of the therapy programs were discussed and described in detail before the study started. Most therapy sessions were guided by both therapists, whereas others were guided by one of them (due to practical reasons). Therapist bias was avoided by equally distributing these sessions between the two therapists.

Table 5.9 Content of the lip trill, WRT and straw phonation therapy programs.

Session	Lip trill	WRT	Straw phonation
1	Lip trills without phonation ○ Correct and eutonic posture in sitting and standing position ○ Costo-abdominal breathing ○ Moistening of the lips and/or light push on the cheeks with thumb and index finger to facilitate lip trill production (if necessary) Lip trills with phonation ○ Habitual pitch ○ Sensory feedback and forward focus: vibrations in midfacial region	Introduction to the material ○ Flexible, soft-walled tube ○ Diameter 10mm; length 35cm Water bottle, water depth: 2 cm Blowing through the tube ○ Correct and eutonic posture in sitting and standing position ○ Costo-abdominal breathing ○ Breathing in through the nose, blowing out through the mouth ○ Relaxed cheeks Phonation through the tube ○ [o] or [ɔ] sound ○ Use of soft voice onset [hɔ], [ho] ○ Habitual pitch ○ Mild and constant water bubbling ○ Sensory feedback and forward focus: vibrations in midfacial region, cheeks	Introduction to the material ○ Drinking straw ○ Diameter 5mm; length 21cm Blowing through the straw ○ Correct and eutonic posture in sitting and standing position ○ Costo-abdominal breathing ○ Breathing in through the nose, blowing out through the mouth ○ Relaxed cheeks Phonation through the straw ○ [o] or [ɔ] sound ○ Use of soft voice onset [hɔ], [ho] ○ Habitual pitch ○ Sensory feedback and forward focus: vibrations in midfacial region
2	Lip trills without phonation Lip trills with phonation ○ Habitual pitch Lip trills with pitch variations ○ Pitch glides: ascending, descending ○ Pitch inflections: supported by visual feedback (hand) ○ High pitch, low pitch Lip trills with loudness variations ○ Crescendo, decrescendo ○ Loud sound, soft sound	Blowing through the tube WRT with phonation ○ Habitual pitch WRT with pitch variations ○ Pitch glides: ascending, descending ○ Pitch inflections: supported by visual feedback (hand) ○ High pitch, low pitch WRT with loudness variations ○ Crescendo, decrescendo ○ Loud sound, soft sound	Blowing through the straw Straw phonation ○ Habitual pitch Straw phonation with pitch variations ○ Pitch glides: ascending, descending ○ Pitch inflections: supported by visual feedback (hand) ○ High pitch, low pitch Straw phonation with loudness variations ○ Crescendo, decrescendo ○ Loud sound, soft sound

Table 5.9 *(Continued)*

Session	Lip trill	WRT	Straw phonation
3	Lip trills with pitch and loudness variations Lip trills when “reading” words and sentences ○ Using prosodic patterns ○ Alternating between lip trill “reading” and normal open-mouth reading	WRT with pitch and loudness variations WRT when “reading” words and sentences ○ Using prosodic patterns ○ Alternating between WRT “reading” and normal open-mouth reading	Straw phonation with pitch and loudness variations Straw phonation when “reading” words and sentences ○ Using prosodic patterns ○ Alternating between WRT “reading” and normal open-mouth reading
4	Lip trills with pitch and loudness variations Lip trills when “reading” words and sentences	WRT with pitch and loudness variations WRT when “reading” words and sentences	Straw phonation with pitch and loudness variations Straw phonation when “reading” words and sentences
5	Lip trills when “reading” words and sentences Lip trills when “reading” texts ○ Alternating between lip trill “reading” and normal open-mouth reading	WRT when “reading” words and sentences WRT when “reading” texts ○ Alternating between lip trill “reading” and normal open-mouth reading	Straw phonation when “reading” words and sentences Straw phonation when “reading” texts ○ Alternating between lip trill “reading” and normal open-mouth reading
6	Lip trills when “reading” words and sentences Lip trills when “reading” texts Lip trills when spontaneous “speaking” ○ Alternating between lip trill “speaking” and normal-open mouth speaking	WRT when “reading” words and sentences WRT when “reading” texts WRT when spontaneous “speaking” ○ Alternating between lip trill “speaking” and normal-open mouth speaking	Straw phonation when “reading” words and sentences Straw phonation when “reading” texts Straw phonation when spontaneous “speaking” ○ Alternating between lip trill “speaking” and normal-open mouth speaking

Voice assessment

A multidimensional voice assessment including both objective and subjective vocal measures and determinations was used to evaluate the patients' voice pre- and post-therapy. Assessments were performed in a sound-treated room at Ghent University Hospital by an SLP experienced in voice diagnostics and blinded to group allocation (I.M.).

Maximum performance task. Maximum phonation time (MPT, in s) was determined by asking the participants to sustain the vowel /a/ at their habitual pitch and loudness after a maximal inspiration, in free field while seated. The production was modeled by the experimenter and the participants received visual and verbal encouragements to produce the longest possible sample. The length of the sustained vowel was measured with a chronometer and the best trials of three attempts was retained for further analysis.

Aerodynamic measurements. A dry spirometer (Riester, Jungingen, Germany) was used for determination of the vital capacity (VC, in cc). The best trial of three attempt was retained for further analysis and used for the calculation of the phonation quotient (PQ, in cc/s), which is the ratio of VC to MPT.

Voice range profile. The voice range profile was obtained using the Computerized Speech Lab (CSL: model 4500, KayPENTAX, Montvale, NY) and a Shure SM-48 microphone (located at a distance of 15 cm from the mouth, angled at 45 degrees). The procedure of Heylen et al. (1998) was used to determine the lowest and highest frequency (F-low, F-high) and the lowest and highest intensity (I-low, I-high). Subjects were instructed to produce the vowel /a/ for at least 2 seconds using, respectively, a habitual pitch and loudness, a minimal pitch, a minimal intensity, a maximal pitch, and a maximal intensity. Each production was modeled by the experimenter and the subjects received visual and verbal encouragement.

Acoustic analysis based on sustained /a/ vowel. The fundamental frequency (f_o, in Hz), jitter (in %), shimmer (in %), variation in f_0 ($vf_{o,}$ in %) and noise-to-harmonic ratio (NHR) were obtained by the Multi Dimensional Voice Program of the CSL and a Shure SM-48 microphone (located at a distance of 15 cm from the mouth, angled at 45 degrees). Participants produced the vowel /a/ at their habitual pitch and loudness following an automatic series (counting to

2). A midvowel segment of 3 seconds registered with a sampling rate of 50 kHz was used for the analysis.

Acoustic analyses based on sustained /a/ vowel and continuous speech: Acoustic Voice Quality Index (AVQI). The AVQI is a recently developed objective multiparametric approach to quantify dysphonia severity based on both a sustained vowel and continuous speech (Maryn et al., 2010a). The AVQI consists of a weighted combination of 6 time- [i.e., shimmer local (SL), shimmer local dB (SLdB) and harmonics-to-noise ratio (HNR)], frequency- [i.e., general slope of the spectrum (Slope) and tilt of the regression line through the spectrum (Tilt)] and quefrency-domain [i.e., smoothed cepstral peak prominence (CPPs)] measures (Maryn et al. 2010b). The formula of the index is 2.571 [3.295 - 0.111 CPPs - 0.073 HNR - 0.213 shimmer local + 2.789 shimmer local dB - 0.032 slope + 0.077 tilt] and ranges from 0 to 10. A higher index indicates a worse vocal quality. The threshold score separating normophonic from dysphonic persons in Dutch is 2.95 (Maryn et al., 2010a). AVQI (version 02.03) was calculated on an audio recording of a sustained /a/ vowel and the first two sentences of the Dutch phonetically balanced text “Papa en Marloes” (Van de Weijer & Slis, 1991) using the software program PRAAT version 6.0.14 (Boersma & Weenink).

Dysphonia Severity Index (DSI). The DSI is a multiparametric approach designed to establish an objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000). The index is based on a weighted combination of the following parameters: MPT (in s), highest frequency (F-high, in Hz), lowest intensity (I-low, in dB) and jitter (in %). The DSI is constructed as 0.13 MPT + 0.0053 F-high − 0.26 I-low − 1.18 jitter + 12.4. The index ranges from -5 to +5 for severely dysphonic to normal voices. A more negative index indicates a worse vocal quality. Values higher than 5 are possible in subjects with excellent vocal capacities. A DSI of 1.6 is the threshold separating normophonic from dysphonic persons (Raes et al., 2002).

Subject’s self-report. Subjects filled in the Dutch version of the Voice Handicap index (VHI) to evaluate the psychosocial impact of the voice disorder (Jacobson et al., 1997; De Bodt et al., 2000). The VHI is a self-rating questionnaire consisting of 30 statements, evaluating functional

(10 statements, F-scale), physical (10 statements, P-scale), and emotional (10 statements, E-scale) restrictions. Every statement is scored on a 5-point Likert scale (0: never, 1: almost never, 2: sometimes; 3: almost always; 4: always). The total VHI-score ranges from 0 to 120 with higher scores indicating greater impacts. Subjects also completed the Dutch version of the Vocal Tract Discomfort Scale (VTDS) (Mathieson et al., 2009; Luyten et al. 2016). This scale consists of eight sensations that can be felt in or around the throat: burning, tight, dry, aching, tickling, sore, irritable and globus. Each item should be scored on frequency (never, seldom, sometimes, more than sometimes, often, very often, always) and severity (no, almost no, limited, more than limited, moderate, more than moderate, severe perception) using a 7-point Likert scale. The total VTDS score (sum of frequency and severity) can range from 0 to 96 with higher scores indicating more discomfort. An additional questionnaire based on the checklists of Russell et al. (2000), De Bodt et al. (2008b) and Van Lierde et al. (2010b, 2010c) was presented at baseline to explore voice-related symptoms, risk factors, vocal abuse, vocal load and lifestyle habits. At the posttest, subjects filled in a last questionnaire to check their frequency of home practice and their opinion regarding the received therapy program. Subjects completed this questionnaire before they received any information about their vocal progress.

Auditory-perceptual evaluation. For the auditory-perceptual evaluation of the subjects' voices, the GRBASI scale was used (Hirano, 1981; completed with an "I" parameter by Dejonckere et al., 1996). The six parameters “overall grade of hoarseness” (G), “roughness” (R), “breathiness” (B), “asthenia” (A), “strain” (S), and “instability” (I) were scored using a 4-point grading scale (0: absent, 1: mild, 2: moderate, 3: severe). Evaluations were based on a sustained /a/ vowel and reading aloud the Dutch phonetically balanced text “Papa en Marloes” (Van de Weijer & Slis, 1991).

Statistical analysis

SPSS version 25 (SPSS Corporation, Chicago, IL) was used for the statistical analysis of the data. Analyses were conducted at $\alpha = 0.05$.

Fisher’s Exact tests were used to compare the groups regarding self-reported voice-related symptoms, risk factors, vocal abuse and lifestyle habits (baseline), the frequency of home practice, and the subject’s opinion regarding the received therapy program (posttherapy).

Linear mixed models were used to compare groups over time on each continuous outcome measure, using the restricted maximum likelihood estimation and scaled identity covariance structure. Time, group, and time-by-group interaction were specified as fixed factors. A random intercept for subjects was included. Model assumptions were checked by inspecting whether residuals were normally distributed. Generalized linear mixed models were used for the categorical outcome measures. Within-group effects of time were determined using pairwise comparisons.

RESULTS

Baseline voice-related symptoms, risk factors, vocal load and lifestyle habits

Table 5.10 presents the results of the questionnaire on voice-related symptoms, risk factors, vocal load and lifestyle habits in the lip trill group, the WRT group, the straw phonation group and the control group. Fischer’s Exact tests showed no significant differences in baseline occurrence between the four groups.

Pre- to post-therapy evolution

The results of the multidimensional voice assessment performed pre- and post-therapy can be found in Tables 5.11 – 5.17 (5.11: maximum performance task, aerodynamic assessment; 5.12: voice range profile; 5.13: acoustic analysis based on /a/ vowel; 5.14: acoustic analysis based on /a/ vowel and continuous speech; 5.15: multiparametric indices; 5.16: subject’s self-report; 5.17: auditory-perceptual evaluations). Lip trill therapy led to a significantly decreased I-low (EM difference: -3.0, p = 0.032), a significantly increased DSI (EM difference: +2.0, p = 0.031) and a significantly decreased VHI (EM difference: -8, p = 0.002). WRT led to a significantly decreased VHI (EM difference: -9, p = 0.001). Straw phonation therapy led to a significantly decreased jitter (EM difference: -0.86, p = 0.048) and vf_o (EM difference: - 1.80, p = 0.008), a significantly increased DSI (EM difference: +1.8, p = 0.042) and a significantly decreased auditory-perceptual dysphonia grade and roughness (p = 0.046). No significant changes were found for the control group.

Analyses of the VHI subscales, showed that lip trill led to a significant decrease in VHI-E (EM difference: -6, $p < 0.001$), and WRT led to a significant decrease in VHI-P (EM difference: -5, p = 0.002).

Frequency of home practice

Daily home practice was reported by 2 subjects of the lip trill group, 1 subject of the WRT group and 1 subject of the straw phonation group. Five subjects of the lip trill group, 5 subjects of the WRT group and 8 subjects of the straw phonation group practiced several days a week. Two subjects of the WRT group practiced one day a week, and 1 subject of the lip trill group did not practice at home. There was no significant difference in frequency of home practice among the three SOVT groups (Fischer's Exact test, p = 0.448). Subjects in the control group did not practice at home.

Subject's opinion regarding the received therapy program

The subject's opinion regarding the received therapy program can be found in Table 5.18. Fischer's Exact tests showed a significant difference among the three SOVT groups for the question "How did you evaluate your vocal quality after a session?" (p = 0.005). Six out of 8 subjects in the WRT group experienced a better vocal quality, whereas 6 out of 8 subjects in the lip trill group and 7 out of 9 subjects in the straw phonation group experienced a worse vocal quality.

Table 5.10 Baseline voice-related symptoms, risk factors, vocal load and lifestyle habits.

	Lip trill (*n* = 9)	**WRT** (*n* = 9)	**Straw phonation** (*n* = 9)	**Control group** (*n* = 8)	**Fischer's Exact test** *p*-value
Voice-related symptoms					
Hoarseness	7	6	5	3	0.420
Vocal fatigue	4	3	3	0	0.207
Sore throat	3	4	2	2	0.746
Risk factors					
Vocal abuse	7	6	5	5	0.871
Reflux	2	1	2	0	0.722
Allergies	2	4	1	5	0.138
Upper respiratory tract infections	3	8	5	5	0.128
Asthma	0	2	0	0	0.229
Stress	5	4	2	6	0.190
Tension in shoulders and/or neck	3	3	5	3	0.799
Vocal load					
Speaking in noisy environments	1	2	1	0	0.889
Hobbies with high vocal load	4	4	3	5	0.745
Professional voice use	2	2	2	0	0.576
Lifestyle habits					
Alcohol use	8	7	5	5	0.421
Smoking	0	0	0	0	-
Sleep deprivation	5	6	3	4	0.599

Table 5.11 Pre- to post-therapy evolution of the maximum performance task and aerodynamic assessment.

		Pre		Post		Evolution Pre-Post		Time*group	Comparison Time within groups
Parameters	Group	EM	95% CI	EM	95% CI	EM difference	95% CI	*p*-value	*p*-value
MPT (s)	LT	15.5	[11.6, 19.5]	16.2	[12.1, 20.3]	+0.7	[-3.1, +4.4]		0.714
	SP	17.3	[13.3, 21.2]	14.9	[10.9, 18.8]	-2.4	[-6.0, +1.2]		0.180
	WRT	16.6	[12.7, 20.6]	16.3	[12.2, 20.4]	-0.3	[-4.0, +3.5]		0.881
	C	17.1	[12.9, 21.3]	18.0	[13.6, 22.4]	+0.9	[-3.1, +4.9]	0.562	0.655
VC (cc)	LT	2488.9	[2199.4, 2778.4]	2453.9	[2159.1, 2748.8]	-35.0	[-222.4, 152.5]		0.705
	SP	2555.5	[2266.1, 2845.0]	2455.5	[2166.1, 2745.0]	-100.0	[-277.8, +77.8]		0.259
	WRT	2672.2	[2382.7, 2961.7]	2484.7	[2183.0, 2786.4]	-187.5	[-386.7, +11.7]		0.064
	C	2492.8	[2164.6, 2821.1]	2371.4	[2043.2, 2699.7]	-121.4	[-323.1, +80.2]	0.723	0.227
PQ (cc/s)	LT	181.1	[148.9, 213.3]	165.3	[131.4, 199.2]	-15.8	[-55.2, +23.6]		0.419
	SP	159.8	[127.6, 192.0]	181.0	[148.8, 213.3]	+21.2	[-16.7, +59.2]		0.261
	WRT	167.1	[134.9, 199.3]	155.9	[119.9, 191.9]	-11.2	[-52.4, +30.0]		0.584
	C	148.0	[111.5, 184.6]	138.6	[102.1, 175.2]	-9.4	[-52.4, +33.6]	0.502	0.657

Note: EM, estimated mean; CI, confidence interval; MPT, maximum phonation time; VC, vital capacity; PQ, phonation quotient; LT, lip trill group; SP, straw phonation group; WRT, water-resistance therapy group; C, control group.

Table 5.12 Pre- to post-therapy evolution of the voice range profile.

		Pre		**Post**		**Evolution Pre-Post**		**Time*Group**	**Comparison Time within groups**
Parameters	Group	EM	95% CI	EM	95% CI	EM difference	95% CI	*p*-value	*p*-value
I-low (dB)	LT	59.5	[57.5, 61.6]	56.5	[54.4, 58.7]	-3.0	[-5.8, -0.3]		0.032*
	SP	56.9	[54.8, 58.9]	55.6	[53.5, 57.6]	-1.3	[-4.0, +1.5]		0.312
	WRT	58.0	[56.0, 60.0]	56.8	[54.6, 59.0]	-1.2	[-3.9, +1.9]		0.378
	C	57.0	[54.8, 59.2]	56.8	[54.5, 59.1]	-0.2	[-3.1, +2.7]	0.542	0.903
I-high (dB)	LT	102.9	[99.2, 106.6]	103.6	[98.0, 109.2]	+0.7	[-2.8, +4.2]		0.689
	SP	99.7	[96.0, 103.4]	101.9	[98.2, 105.6]	+2.2	[-1.1, +5.6]		0.186
	WRT	102.4	[98.7, 106.2]	100.7	[96.9, 104.6]	-1.7	[-5.2, +1.8]		0.332
	C	99.5	[95.6, 103.4]	99.1	[95.0, 103.2]	-0.4	[4.1, +3.4]	0.413	0.839
F-low (Hz)	LT	144.4	[129.6, 159.3]	148.8	[133.8, 163.9]	+4.4	[-4.8, +13.6]		0.285
	SP	127.6	[112.8, 142.4]	123.8	[109.0, 138.6]	-3.8	[-12.5, +5.0]		0.384
	WRT	145.5	[130.7, 160.3]	141.4	[126.3, 156.5]	-4.1	[-13.4, +5.1]		0.413
	C	154.5	[138.8, 170.2]	154.3	[138.3, 170.3]	-0.2	[-10.0, +9.7]	0.509	0.857
F-high (Hz)	LT	628.9	[478.7, 779.1]	713.5	[559.4, 867.7]	+84.6	[-33.0, +202.3]		0.152
	SP	541.5	[391.3, 691.7]	605.2	[455.0, 755.4]	+63.7	[-48.2, +175.6]		0.253
	WRT	580.4	[430.2, 730.6]	683.4	[529.2, 837.6]	+103.0	[-14.7, +220.7]		0.084
	C	725.4	[566.1, 884.8]	726.9	[562.8; 891.0]	+1.5	[-124.2, +127.1]	0.658	0.981

Note: EM, estimated mean; CI, confidence interval; I-low, lowest intensity; I-high, highest intensity; F-low, lowest frequency; F-high, highest frequency; LT, lip trill group; SP, straw phonation group; WRT, water-resistance therapy group; C, control group. * indicates a significant effect.

Table 5.13 Pre- to post-therapy evolution of the acoustic analyses based on /a/ vowel.

		Pre		**Post**		**Evolution Pre-Post**		**Time*Group**	**Comparison Time within groups**
Parameters	Group	EM	95% CI	EM	95% CI	EM difference	95% CI	*p*-value	*p*-value
f_o (Hz)	LT	195.2	[177.0, 213.4]	198.0	[179.3, 216.8]	+2.8	[-12.0, +17.6]		0.701
	SP	186.3	[168.1, 204.5]	177.1	[158.9, 195.3]	-9.2	[-23.3, +4.8]		0.188
	WRT	189.8	[171.6, 208.0]	192.9	[174.1, 211.6]	+3.1	[-11.7, +17.9]		0.671
	C	205.6	[186.3, 224.9]	209.3	[189.4, 229.2]	+3.7	[-12.1, +19.4]	0.509	0.638
Jitter (%)	LT	2.19	[1.57, 2.82]	1.60	[0.94, 2.26]	-0.59	[-1.50, +0.31]		0.195
	SP	2.47	[1.85, 3.09]	1.61	[0.99, 2.23]	-0.86	[-1.74, +0.02]		0.048*
	WRT	2.05	[1.42, 2.67]	2.24	[1.58, 2.90]	+0.19	[-0.72, +1.10]		0.677
	C	1.99	[1.33, 2.65]	1.62	[0.92, 2.33]	-0.37	[-1.33, +0.60]	0.404	0.451
Shimmer (%)	LT	5.76	[4.53, 6.98]	5.36	[4.06, 6.65]	-0.40	[-1.92, +1.12]		0.596
	SP	6.40	[5.18, 7.63]	6.07	[4.84, 7.30]	-0.33	[-1.80, +1.13]		0.644
	WRT	5.66	[4.43, 6.89]	6.90	[5.60, 8.19]	+1.24	[-0.28, +2.76]		0.107
	C	5.86	[4.56, 7.16]	6.31	[4.93, 7.69]	+0.45	[-1.17, +2.07]	0.372	0.576
vf_o (%)	LT	1.93	[1.00, 2.85]	1.54	[0.56, 2.52]	-0.39	[-1.73, +0.96]		0.569
	SP	3.58	[2.65, 4.50]	1.78	[0.86, 2.70]	-1.80	[-3.10, -0.50]		0.008*
	WRT	1.97	[1.05, 2.89]	2.44	[1.46, 3.42]	+0.47	[-0.87, +1.82]		0.486
	C	1.90	[0.92, 2.87]	1.63	[0.58, 2.67]	-0.27	[-1.71, +1.16]	0.115	0.703
NHR	LT	0.15	[0.13, 0.17]	0.13	[0.11, 0.16]	-0.02	[-0.05, +0.02]		0.270
	SP	0.16	[0.13, 0.18]	0.15	[0.13, 0.17]	-0.01	[-0.04, +0.03]		0.568
	WRT	0.15	[0.13, 0.17]	0.18	[0.15, 0.20]	+0.03	[-0.01, +0.06]		0.102
	C	0.15	[0.13, 0.18]	0.15	[0.13, 0.18]	0	[-0.03, +0.04]	0.236	0.815

Note: EM, estimated mean; CI, confidence interval; f_o, fundamental frequency; vf_o, variation in fundamental frequency; NHR, noise-to-harmonic ratio; LT, lip trill group; SP, straw phonation group; WRT, water-resistance therapy group; C, control group. * indicates a significant effect.

Table 5.14 Pre- to post-therapy evolution of the acoustic analyses based on /a/ vowel and continuous speech.

		Pre		**Post**		**Evolution Pre-Post**		**Time*Group**	**Comparison Time within groups**
Parameters	Group	EM	95% CI	EM	95% CI	EM difference	95% CI	*p*-value	*p*-value
CPPS	LT	10.44	[9.41, 11.47]	11.31	[10.24, 12.39]	+0.87	[-0.27, +2.02]		0.130
	SP	10.96	[9.93, 11.99]	11.10	[10.07, 12.13]	+0.14	[-0.96, +1.25]		0.794
	WRT	10.37	[9.34, 11.40]	10.06	[8.98, 11.14]	-0.31	[-1.46, +0.84]		0.585
	C	11.36	[10.21, 12.51]	11.74	[10.58, 12.89]	+0.38	[-0.91, +1.66]	0.520	0.556
Shimmer Local (%)	LT	7.37	[5.67, 9.07]	7.58	[5.80, 9.37]	+0.21	[-1.80, +2.22]		0.833
	SP	6.66	[4.96, 8.36]	7.20	[5.50, 8.90]	+0.54	[-1.39; +2.48]		0.569
	WRT	7.18	[5.48, 8.88]	8.23	[6.45, 10.02]	+1.05	[-0.96, +3.07]		0.294
	C	5.67	[3.76, 7.58]	6.02	[4.11, 7.93]	+0.35	[-1.90, +2.59]	0.937	0.755
Shimmer Local (dB)	LT	0.67	[0.54, 0.81]	0.73	[0.59, 0.88]	+0.06	[-0.11, +0.22]		0.472
	SP	0.59	[0.46, 0.73]	0.67	[0.54, 0.82]	+0.08	[-0.07, +0.24]		0.285
	WRT	0.65	[0.52, 0.79]	0.77	[0.59, 0.88]	+0.12	[-0.05, +0.28]		0.152
	C	0.55	[0.40, 0.71]	0.58	[0.43, 0.73]	+0.03	[-0.15, +0.21]	0.894	0.749
HNR (dB)	LT	14.30	[12.62, 15.99]	15.11	[13.54, 16.88]	+0.81	[-1.01, +2.63]		0.369
	SP	14.95	[13.27, 16.64]	15.05	[13.36, 16.73]	+0.10	[-1.65, +1.84]		0.911
	WRT	14.56	[12.88, 16.25]	13.89	[12.13; 15.65]	-0.67	[-2.49, +1.14]		0.453
	C	16.22	[14.34, 18.10]	16.38	[14.50, 18.26]	+0.16	[-1.88, +2.19]	0.706	0.878
Slope of LTAS (dB)	LT	-18.69	[-20.69, -16.69]	-16.75	[-18.87, -14.73]	+1.94	[-0.96, +4.84]		0.182
	SP	-17.88	[-19.88, -15.88]	-19.06	[-21.06, -17.06]	-1.18	[-3.99, +1.64]		0.398
	WRT	-18.60	[-20.60, -16.60]	-19.32	[-21.44, -17.20]	-0.72	[-3.62, +2.18]		0.617
	C	-19.58	[-21.85, -17.31]	-17.62	[-19.88, -15.35]	+1.96	[-1.22, +5.15]	0.270	0.219
Tilt of trendline through LTAS (dB)	LT	-9.86	[-10.75, -8.98]	-9.80	[-10.72, -8.87]	+0.06	[-0.88, +1.10]		0.893
	SP	-10.23	[-11.12, -9.35]	-10.14	[-11.03, -9.26]	+0.09	[-0.81, +1.00]		0.834
	WRT	-9.53	[-10.41, -8.64]	-9.37	[-10.29, -8.44]	+0.16	[-0.78, +1.10]		0.732
	C	-9.78	[-10.77, -8.80]	-9.60	[-10.60, -8.62]	+0.18	[-0.88, +1.23]	0.998	0.736

Note: EM, estimated mean; CI, confidence interval; CPPS, smoothed cepstral peak prominence; HNR, harmonics-to-noise ratio; LTAS, long-term average spectrum; LT, lip trill group; SP, straw phonation group; WRT, water-resistance therapy group; C, control group.

Table 5.15 Pre- to post-therapy evolution of the multiparametric indices.

		Pre		Post		Evolution Pre-Post		Time*Group	Comparison Time within groups
Parameters	Group	EM	95% CI	EM	95% CI	EM difference	95% CI	*p*-value	*p*-value
DSI	LT	0.0	[-1.7, +1.6]	+2.0	[+0.2, +3.7]	+2.0	[+0.2, +3.7]		0.031*
	SP	-0.5	[-2.1, +1.2]	+1.3	[-0.4, +3.0]	+1.8	[+0.1, +3.4]		0.042*
	WRT	+0.1	[-1.5, +1.8]	+0.9	[-0.8, +2.7]	+0.8	[-1.0, +2.6]		0.359
	C	+1.3	[-0.4,+3.1]	+1.9	[+0.1, +3.8]	+0.6	[-1.3, +2.4]	0.623	0.513
AVQI	LT	4.53	[3.89, 5.17]	4.30	[3.64, 4.98]	-0.23	[-0.98, +0.52]		0.543
	SP	4.02	[3.38, 4.66]	4.33	[3.69, 4.97]	+0.31	[-0.41, +1.03]		0.384
	WRT	4.53	[3.89, 5.17]	5.01	[4.34, 5.68]	+0.48	[-0.27, +1.23]		0.205
	C	4.08	[3.37, 4.80]	3.91	[3.19, 4.63]	-0.17	[-1.01, +0.66]	0.465	0.677

Note: EM, estimated mean; CI, confidence interval; DSI, Dypshonia Severity Index; AVQI, Acoustic Voice Quality Index; LT, lip trill group; SP, straw phonation group; WRT, water-resistance therapy group; C, control group. * indicates a significant effect.

Table 5.16 Pre- to post-therapy evolution of the subject's self-report.

		Pre		Post		Evolution Pre-Post		Time*Group	Comparison Time within groups
Parameters	Group	EM	95% CI	EM	95% CI	EM difference	95% CI	*p*-value	*p*-value
VHI	LT	34	[20, 48]	26	[12, 40]	-8	[-13, -3]		0.002*
	SP	23	[8, 36]	24	[10, 38]	+1	[-3, +6]		0.482
	WRT	32	[18, 46]	23	[9, 37]	-9	[-14, -4]		0.001*
	C	15	[0, 30]	12	[0, 26]	-3	[-8, +2]	0.011*	0.171
VTDS	LT	29	[20, 37]	28	[19, 36]	-1	[-2, +2]		0.091
	SP	20	[11, 28]	20	[11, 28]	0	[-1, +1]		0.691
	WRT	33	[25, 42]	32	[24,41]	-1	[-2, +2]		0.089
	C	16	[7, 25]	16	[6; 25]	0	[-2, +1]	0.346	0.649

Note: EM, estimated mean; CI, confidence interval; VHI, Voice Handicap Index; VTDS, Vocal Tract Discomfort Scale; LT, lip trill group; SP, straw phonation group; WRT, water-resistance therapy; C, control group. * indicates a significant effect.

Table 5.17 Pre- to post-therapy evolution of the auditory-perceptual evaluation.

		Pre				Post				Time*Group	Comparison Time within groups
Parameters	Group	Median	IQR	Mean	SD	Median	IQR	Mean	SD	*p*-value	*p*-value
G	LT	2	[1.5, 2]	1.9	0.6	1	[1, 2]	1.6	0.8		0.180
	SP	1	[1, 2]	1.6	0.7	1	[0.5, 2]	1.1	0.8		0.046*
	WRT	1	[1, 2.5]	1.7	0.9	1	[1, 1.75]	1.3	0.9		0.414
	C	1	[1, 1]	0.9	0.4	1	[0, 2]	1.0	0.8	0.569	>0.999
R	LT	2	[1, 2]	1.6	0.7	1	[0, 2]	1.1	1.1		0.408
	SP	1	[0.5, 2]	1.2	1.0	1	[0, 1.5]	0.8	0.8		0.046*
	WRT	1	[0.5, 2]	1.2	0.8	0.5	[0, 1]	0.7	1.0		0.317
	C	1	[1, 1]	1.0	0.5	1	[0, 2]	0.7	0.8	0.987	0.414
B	LT	1	[0.5, 2]	1.2	1.0	1	[0, 2]	1.0	0.8		0.083
	SP	1	[0, 2]	1.0	1.1	1	[0, 1]	0.7	0.5		0.257
	WRT	1	[1, 2]	1.3	0.9	0.5	[0, 1]	0.6	0.7		0.157
	C	1	[1, 1.75]	1.1	0.6	1	[0, 1]	0.7	0.8	0.834	0.102
A	LT	1	[0.5, 2]	1.2	0.8	1	[0, 1]	0.6	0.5		0.096
	SP	1	[0, 1]	0.9	0.9	0	[0, 1]	0.6	0.7		0.083
	WRT	1	[0, 1]	0.8	0.7	0	[0, 1.75]	0.8	1.2		>0.999
	C	0.5	[0, 1]	0.5	0.5	0	[0, 1]	0.4	0.5	0.403	0.564
S	LT	1	[0.5, 2]	1.2	0.8	1	[0, 2]	1.0	0.8		0.257
	SP	1	[0.5, 1.5]	1.1	0.9	1	[0, 2]	0.9	0.9		0.317
	WRT	1	[0.5, 2]	1.3	1.0	0.5	[0, 1.75	0.9	1.1		0.516
	C	0	[0, 0.75]	0.3	0.5	0	[0, 0]	0.2	0.4	0.915	>0.999
I	LT	0	[0, 1]	0.4	0.5	0	[0, 1]	0.3	0.5		0.564
	SP	0	[0, 1]	0.6	1.0	0	[0, 0.5]	0.3	0.7		0.157
	WRT	0	[0, 1]	0.3	0.5	0	[0, 0]	0.2	0.7		>0.999
	C	0	[0, 0]	0.2	0.4	0	[0, 0]	0.2	0.4	0.916	>0.999

Note: IQR, interquartile range; G, grade; R, roughness; B, breathiness; A, asthenia; S, strain; I, instability; LT, lip trill group; SP, straw phonation group; WRT, water-resistance therapy group; C, control group. * indicates a significant effect.

Table 5.18 Subject's opinion regarding the received therapy program.

	Lip trill (*n* = 8)	**WRT** (*n* = 8)	**Straw phonation** (*n* = 9)	**Control group** (*n* = 7)
Do you think the therapy program was effective?	4	6	5	3
Did you become more aware of your voice use?	7	6	8	3
Did you experience a more comfortable voice production after a session?	3	6	2	0
How did you evaluate your vocal quality after a session?				
Better	0	6	1	0
Similar	2	1	1	0
Worse	6	2	7	0
How do you evaluate your vocal quality after the complete therapy program?				
Better	1	3	1	0
Similar	7	4	6	7
Worse	0	1	2	0
Do you experience improvements in your vocal capacities after the complete therapy program?	4	5	3	0
Do people in your environment experience differences in your voice production after the complete therapy program?	0	2	2	0

DISCUSSION

The purpose of this study was to investigate the effect of three SOVT therapy programs "lip trill", "WRT" or "straw phonation" on the vocal quality, vocal capacities, psychosocial impact and vocal tract discomfort of patients with dysphonia. Based on the promising physics of a semi-occluded vocal tract, positive results were expected for the three SOVT therapy programs. It was hypothesized that straw phonation might improve objective vocal quality due to the highest supraglottal pressure and inertive reactance in the vocal tract (Titze, 2006; Titze & Verdolini Abbott, 2012; Gaskill & Quinney, 2012; Maxfield et al., 2015). Lip trill and WRT were expected to decrease vocal tract discomfort due to the double source of vibration (Andrade et al., 2014; Guzman et al., 2017b). Changes in psychosocial impact and auditory-perceptual vocal quality were not yet expected after 3 weeks of practice.

As hypothesized, straw phonation had the largest impact on the objective vocal quality with significant improvements in jitter, vf_o and the multiparametric index DSI. Furthermore, these objective findings were supported by auditory-perceptual improvements of grade and roughness. A positive impact of straw phonation therapy on auditory-perceptual parameters has also been found in earlier studies (Kapsner-Smith et al., 2015; Guzman et al., 2017a). The reason why straw phonation led to pronounced improvements in vocal quality probably relates to the physics behind an SOVT. Straw phonation creates the highest resistance to airflow, which might create the best match between source and filter, and consequently lead to vocal economy and efficiency (Titze, 2006; Titze & Verdolini Abbott, 2012; Gaskill & Quinney, 2012; Maxfield et al., 2015). The fact that enhanced phonation remained after therapy and during normal open-mouth phonation (/a/ vowel and continuous speech), let us expect that the desired transfer occurred. Noteworthy, the improved vocal quality was in clear contrast with the subject's opinion. Six out of 9 subjects experienced no change in their vocal quality after the complete program. Furthermore, 7 out of 9 subjects reported a worse self-perceived vocal quality immediately after the sessions. Familiarization with the higher resistance to airflow and possible fatiguing factors might be a reason for these negative results (Gaskill & Quinney, 2012; Titze, 2006).

Lip trill also seems a promising SOVT exercise as improvements in both objective vocal quality (DSI) and capacities (I-low) were found. Due to the heightened non-linear source-filter interaction, SOVT exercises can be performed with a lower phonation threshold pressure (i.e. the minimal subglottal pressure needed to induce vocal fold vibration) (Titze & Verdolini Abbott, 2012; Guzman et al., 2013; Kapsner-Smith et al., 2015; Guzman et al., 2017a). It is plausible that transfer of this phenomenon occurred after practicing lip trills for 3 weeks, and that, therefore, subjects were able to produce lower intensities. Again, the improvements in objective vocal quality were not in line with the subject's opinion. Seven out of 8 subjects experienced no change in their vocal quality after the complete therapy program, and 6 out of 8 subjects reported a worse vocal quality immediately after the sessions. Nevertheless, lip trill therapy positively impacted daily life as less emotional restrictions (VHI-E) were reported at the posttest.

Surprisingly, WRT showed no improved objective or auditory-perceptual outcomes. A possible explanation for the lack of progress is the relatively limited water depth used in the current study. Guidelines for WRT with a flexible soft-walled tube (also called Lax Vox tube) describe an initial 2cm water depth which can gradually evolve to a maximum of 7cm (Sihvo, 2006; Tyrmi et al., 2017). In this study, water depth was restricted to 2cm to keep treatment conditions as strict as possible for every subject and every session. It can be hypothesized that an increase in water depth might lead to better results due to higher flow resistance (Andrade et al., 2016). Besides, the diameter of tubes and straws also plays a crucial role in modifying flow resistance. It might be assumed that a combination of smaller diameters with more water depth provides the best cumulative outcome. However, results of recent studies do not support this hypothesis. Guzman et al. (2017a, 2017b) found no acoustic or auditory-perceptual improvements after a water-resistance therapy that combined a 5mm diameter with a 5cm water depth. The authors hypothesized that water bubbling could disturb auditory feedback and therefore impair the improvement of vocal quality. Glass tubes absorb less sound and might possibly be more suitable (Simberg & Lane, 2007). In general, WRT shows contradictory results. There is need for further research to find the best matched materials, diameters and water depths for individual vocalists who all have unique glottal resistances (Titze, 2002a; Titze, 2002b; Maxfield et al., 2015).

Despite the lack of objective and auditory-perceptual progress, 6 out of 8 subjects of the WRT group reported a better self-perceived vocal quality immediately after the sessions, and 3 of them still experienced it at the posttest. Furthermore, the psychosocial impact associated with dysphonia (VHI) decreased after WRT. More-in-depth analysis of the VHI subscales gave clarity as only the physical subscale (P-VHI) decreased. Because the P-VHI is closely related to the degree of physical vocal tract discomfort (e.g., “I use a great deal of effort to speak,” “I feel as though I have to strain to produce my voice”; Guzman et al., 2017b), our second hypothesis got support. Less physical vocal tract discomfort might be achieved due to the “massage-like” effect of the double vibratory source (Andrade et al., 2014; Guzman et al., 2017b). Similar decreases in P-VHI were found after water-resistance therapy in patients with hyperfunctional dysphonia (Guzman et al., 2017a) and healthy teachers (Mailänder et al., 2017). Furthermore, six of the 8 subjects literally reported a more comfortable voice production after the WRT sessions. Current results of the VTDS, on the other hand, do not support the hypothesis as no changes were found after WRT (or lip trill). Guzman et al. (2017b), on the other hand, did find improvements in the VTDS after WRT and lip trill. These contradictory finding may be due to differences in inclusion criteria. Self-reported vocal complaints, including vocal fatigue and muscle tension perception, were specified as inclusion criteria in the study of Guzman et al. (2017b) but not in the current study. Further exploration of the impact of a double vibratory source on vocal tract discomfort is needed.

Unique for this study, is the inclusion of a control group that received a sham treatment. Unlike drug trials and some medical interventions, voice therapy trials cannot easily blind participants to the treatment they receive or trigger placebo effects (Bos-Clark & Carding, 2011). For the current sham treatment, we specifically chose an activity related to voice but without active vocal practice. Because of ethical reasons, the received therapy programs were kept relatively short (3 weeks) and subjects had the opportunity to follow a therapy program including all three SOVT exercises immediately after the post-test. Therefore, long-term follow-op outcomes could not be included in this study.

To our knowledge, this is the first study that investigated the isolated effect of SOVT therapy programs in patients with dysphonia using both a multidimensional voice assessment, an assessor blinded to group allocation and a sham-controlled trial. Limitations of this study are the use of smalls sample sizes and the lack of laryngostroboscopic data. Investigating long-term outcomes of SOVT therapy programs is subject for further research.

CONCLUSIONS

Results suggest that SOVT therapy programs including straw phonation or lip trill can improve objective vocal quality and capacities in patients with dysphonia. Auditory-perceptual improvements can be expected after straw phonation therapy. Lip trill and water-resistance therapy both led to a decrease in psychosocial impact associated with dysphonia. Patients seem to experience more comfort and a better self-perceived vocal quality immediately after a water-resistance therapy session.

CHAPTER 6

Effect of frequency and duration of practice (dosage)

6.1 Massed versus spaced practice in vocology: effect of a short-term intensive voice training versus a longer-term traditional voice training

Based on: Meerschman, I., Van Lierde, K., Van Puyvelde, C., Bostyn, A., Claeys, S., & D'haeseleer, E. (2017). Massed versus spaced practice in vocology: Effect of short-term intensive voice training versus a longer-term traditional voice training. *International Journal of Language & Communication Disorders,* 53(2), 393-404.

ABSTRACT

Objective. The aim of this study was to compare the effect of a short-term intensive voice training (IVT) with a longer-term traditional voice training (TVT) on the vocal quality and vocal capacities of vocally healthy non-professional voice users.

Methods. A longitudinal randomized control group design was used. Twenty healthy female non-professional voice users with a mean age of 22 years (range = 20-24 years) were randomly assigned to either a short-term IVT group (*n* = 10) or a longer-term TVT group (*n* = 10). Both groups received an identical 6-h lasting voice training. Only the distribution of practice varied between the groups: 2 h a day for 3 consecutive days for the IVT group versus two 30-min sessions a week for 6 weeks for the TVT group. In both groups, a voice assessment protocol consisting of subjective (questionnaire, participant's self-report, auditory-perceptual evaluation) and objective (maximum performance task, acoustic analysis, voice range profile, Dysphonia Severity Index) measurements and determinations was used to evaluate the participants' voice pre- and post-training and at 6 weeks follow-up. Groups were compared over time using linear mixed models and generalized linear mixed models. Within-group effects of time were determined using post-hoc pairwise comparisons with Bonferroni corrections.

Results. No significant time-by-group interactions were found for any of the outcome measures, indicating no significant differences in evolution over time between the groups. Significant time effects were found for maximum phonation time, lowest intensity, lowest frequency, highest frequency and Dysphonia Severity Index, all improving over time in both groups. More in-depth within-group analyses indicate a preference for the IVT group regarding the evolution of maximum phonation time, lowest frequency and dysphonia severity index, and a preference for the TVT group regarding the evolution of lowest intensity.

Conclusions. Short-term IVT may be equally, or even more, effective in training vocally healthy non-professional voice users compared with longer-term TVT.

INTRODUCTION

Voice therapy and voice training are processes of behavioral change (Behrman, 2006; Van Leer et al., 2008; Mcllwaine et al., 2010; Patel et al., 2011; Vinney & Turkstra, 2013; Wenke et al., 2014; Behlau et al., 2015; Iwarsson, 2015; Fu et al., 2015a; Fu et al., 2015b). They involve the acquisition, optimization, and maintenance of healthy and efficient vocal behaviors through (re)learning cognitive and motor skills (Mcllwaine et al., 2010; Patel et al., 2011; Fu et al., 2015a). Principles inherent to behavioral change (learning) are well known from the fields of neurobiology, exercise physiology, motor learning, psychology and language therapy (Patel et al., 2011). Nevertheless, limited research has been devoted to explore how these principles apply to voice therapy or training (Mcllwaine et al., 2010; Wenke et al., 2014).

Recently, increased attention has been paid to the principal "distribution" of practice (Patel et al., 2011; Wenke et al., 2014; Fu et al., 2015a). In motor learning, practice distribution may be categorized as "massed" versus "spaced". In massed practice, all practice sessions occur very closely together with little or no rest time between sessions. In spaced practice, the time interval between practice sessions is larger (Bergan, 2010). Practice sessions in vocology are traditionally organized according a spaced practice schedule with weekly sessions spread over several weeks to months (Carding et al., 1999; Chen et al., 2007; Fischer et al., 2009; Bergan, 2010, Demmink-Geertman & Dejonckere, 2010). A literature overview by De Bodt et al. (2015) between 1975 and May 2013 showed that voice therapy lasts an average of 9.25 weeks distributed over 10.87 sessions of mostly 30 or 60 min and occurs once or twice a week, although substantial geographical differences were observed.

In contrast with most medical and pharmaceutical therapies, the optimal dosage for voice therapy or training is unknown (De Bodt et al., 2015; Roy, 2012). The exact frequency and duration used today depends on several factors, such as the medical prescription, rules of reimbursement, the specific vocal pathology and its severity, the type of therapy or training, the client's limitations and expectations, and upcoming vocal performances (Mueller & Larson, 1992; De Bodt et al., 2008a; Van Lierde et al., 2007; Van Lierde et al., 2010a). Having standardized guidelines in terms of the ideal frequency and duration for voice therapy and training could be a merit for both the patient/client, the voice therapist/coach, and the healthcare system (Patel et al., 2011; Wenke et al., 2014; De Bodt et al., 2015).

Returning to the fields of neurobiology, exercise physiology, motor learning, psychology and language therapy, there seems to be a general preference for high-intensity training (i.e., massed practice) to obtain desirable learning and behavioral changes (Patel et al., 2011). To date, evidence for a high-intensity approach in vocology is limited to few specific programs, such as the Lee Silverman Voice Treatment (LSVT®) (Ramig et al., 1994) and the Vocal Function Exercises (VFE) (Stemple et al., 1994).

Although the preference for high-intensity training has not yet broken through our field, it recently gained interest through the concept article of Patel et al. (2011). They developed a "boot camp" voice therapy, which is an innovative approach of concentrated practice, performed in a time frame of 1-4 consecutive days with 4-7 h of therapy a day. In addition to the high-intensity principle, the boot camp therapy is also based on principles of "variability" and "specificity" of training, which may positively contribute to transfer and carryover. A variety of voice therapy techniques are given by a large number of clinicians (3 to 7) and therapy is tailored to the nature of the voice disturbance and the individual's specific needs. It is designed for people who have pressing needs to improve their voice (e.g., upcoming vocal performances), who failed traditional voice therapy (e.g., recalcitrant dysphonia), and/or have an inability to schedule weekly appointments (e.g., living at geographical distances far from a voice center). Behlau et al. (2014) mentioned the use of a similar intensive short-term voice therapy in Brazil for a variety of cases, including patients with iatrogenic dysphonia and elite vocal performers suffering from acute dysphonia. The therapy lasts 3 days to 2 weeks, with 3 to 4 sessions a day, and 2 to 4 speech-language pathologists.

Clinical trials comparing the effect of an intensive versus a traditional voice therapy are still in its infancy. Fu et al. (2015a) found comparable positive perceptual, physiological and acoustic outcomes for both models in patients with vocal nodules (eight 45-min sessions over 3 weeks versus eight 45-min sessions over 8 weeks). Limitations of this study are lack of long-term follow-up and self-rating questionnaires. Furthermore, a pragmatic randomized controlled trial (RCT) was used instead of an explanatory RCT in which subjects were assigned to either of two treatment groups according to their availability. Wenke et al. (2014) found high satisfaction and a significantly reduced voice handicap index (VHI) after an intensive treatment (four 1-h treatment sessions a week over 2 weeks) in patients with functional dysphonia. A general trend of improved mean VHI ratings was found in the standard group (one 1-h treatment session a week over 8 weeks) as well, although this improvement was not significant. Moreover, significantly higher attendance rates were found in the intensive group compared with the group receiving the standard therapy. A major limitation of the study is that the therapy program was not standardized (i.e., subjects received different treatment techniques depending on the individual’s profile), which means that it is not clear whether the treatment success was related to the type of techniques or the distribution of practice. Furthermore, perceptual and objective vocal measures were missing. Fischer et al. (2009) investigated the effect of a 2-week intensive voice therapy combined with elements of physical medicine (physiotherapy, manual therapy, inhalations, vibration massage etc.) in patients with chronic functional or organic dysphonia. The authors found a significantly reduced overall voice handicap in patients with moderate baseline voice handicap values, whereas no significant changes could be detected in patients with severe handicap. Because voice therapy was combined with physical therapies, the effect of intensive voice therapy alone cannot be concluded. Furthermore, the superiority of a more intensive schedule was postulated without an actual comparison with the traditional model. To our knowledge, no studies compared an intensive with a traditional voice training (TVT) in healthy subjects.

Possible advantages of a high-intensity approach in vocology are creating a greater opportunity to practice, giving the ability to focus entirely on improving vocal behavior, and obtaining a better simulation of cognitive, motor and physiological requirements of daily communication (Patel et al. 2011). These factors may in turn improve transfer of learned skills, and increase or regain client’s motivation and compliance (Patel et al., 2011; Wenke et al., 2014; Fu et al., 2015a). Motivation and compliance are essential for behavioral change and are often poor in the traditional model of voice therapy (Behrman, 2006; Patel et al., 2011; Wenke et al., 2014; Fu et al., 2015b), which may lead to emotional frustration for clinicians, a negative impact on the client’s vocal outcome and reduced cost effectiveness for healthcare services (Wenke et al., 2014).

Estimating the optimal dosage for therapy and training is an unsolved challenge in the field of vocology, particularly due to several influencing factors such as severity of the voice disturbance, and motivation and expectations of the patient or client. Fact remains that a general picture of the most effective and efficient frequency and duration of voice therapy and training is essential (Patel et al., 2011; Wenke et al., 2014; De Bodt et al., 2015). This study aims to explore the motor learning principle “distribution of practice” in our field. Therefore, two extreme “dosages” of voice training were compared using a study group of vocally healthy non-professional voice users. Every voice user, also a vocally healthy individual, is able to change his or her vocal behavior, and learn efficient and healthy voice use. Furthermore, the exact same vocal techniques can be used for both training as therapy, which makes this study population suitable for a preliminary exploration. At last, a stronger study design with randomization of the groups, a better control of influencing factors, and standardization of the training program is possible in a healthy study group.

The aim of this study was to compare the effect of a short-term intensive voice training (IVT) (2 h a day for 3 consecutive days) with a longer-term traditional voice training (TVT) (two 30-min sessions a week for 6 weeks) on the vocal quality and vocal capacities of vocally healthy non-professional voice users. Based on the principles of behavioral change and the previously mentioned possible advantages of high-intensity training, it was hypothesized that a short-term IVT may be equally, or even more, effective than a longer-term TVT.

MATERIAL AND METHODS

This study was approved by the Ethics Committee of Ghent University Hospital (EC/2014/0893).

Participants

Twenty young and healthy female participants with a mean age of 22 years (SD, 0.8 years; range, 20-24 years) participated in the study. Recruitment was based on convenience sampling. None of the participants reported hearing problems or voice problems. Fifteen subjects were students (studies: social work and social welfare, political sciences, international relations and diplomacy, law school (two), nursing, medicine (three), rehabilitation sciences and physiotherapy, educational sciences, linguistics and literature, multilingual professional communication, sociology, applied economic sciences) and five subjects were employed (nurse, midwife, process operator, pedagogue, sales manager). None was a professional voice user. All participants provided written informed consent at an initial briefing. They were randomly assigned into two groups: an experimental group (*n* = 10) receiving the intensive short-term voice training (IVT, 2 h a day for 3 consecutive days), and a control group (*n* = 10) receiving a longer-term TVT (two 30-min sessions a week for 6 weeks). There were no differences between the two groups in mean age (Mann-Whitney *U*-test: *p* = 0.108). Only women were recruited to avoid an unequal distribution of sex due to the small sample size and randomization procedure.

Voice assessment

An identical voice assessment protocol was used to evaluate the participants' voice pre- and post-training and at 6 weeks follow-up. A timeline of the voice assessments can be found in Figure 6.1. Data were collected in a sound-treated room at Ghent University Hospital. The voice assessment protocol included both subjective (questionnaire, participant's self-report and auditory-perceptual evaluations) and objective (maximum performance task, acoustic analysis, voice range profile (VRP), dysphonia severity index (DSI)) vocal measurements and determinations.

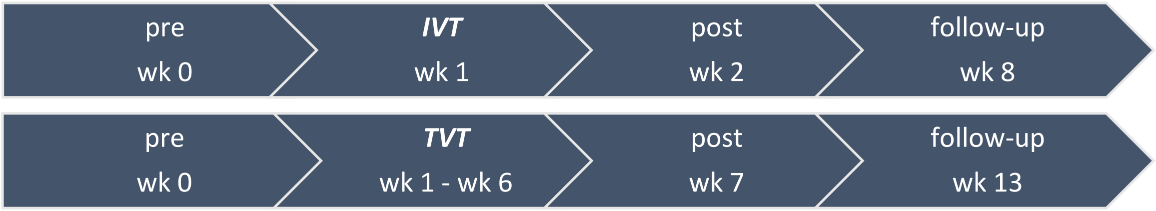


Figure 6.1 Timeline of the voice assessments performed in the IVT (above) and the TVT group (below). *Note:* IVT: 2h/day, 3 days: TVT: 2 x 30min/week, 6 weeks. wk, week.

Questionnaire voice-related symptoms, risk factors, vocal abuse and lifestyle habits

A questionnaire based on the checklists of Russell et al. (2000), De Bodt et al. (2008b) and Van Lierde et al. (2010b, 2010c) was presented at the pretest to explore voice-related symptoms, risk factors, vocal abuse and lifestyle habits, and to confirm the success of randomization. The presence of vocal complaints and upper respiratory tract infections was rechecked at the posttest and at 6 weeks follow-up.

Participant's self-report

The VHI (Jacobson et al., 1997; Dutch version: Belgian Study Group on Voice Disorders, De Bodt et al., 2000) was used to evaluate the psychosocial impact of potential voice problems. It is a self-administered questionnaire consisting of 30 statements, evaluating functional (10 statements, F-scale), physical (10 statements, P-scale) and emotional (10 statements, E-scale) restrictions. Each statement was scored on a five-point scale (0: never, 1: almost never, 2: sometimes; 3: almost always; 4: always). The total VHI score varies between 0 and 120. A higher score indicates a more severe psychosocial impact.

Auditory-perceptual evaluation

Voice samples of a sustained vowel /a/ and connected speech (reading aloud the phonetically balanced text "De noordenwind en de zon") were recorded for the auditory perceptual evaluation using a digital camera with high-quality microphone (Sony Handycam HDR-CX280E). The parameters grade, roughness, breathiness, asthenia, strain and instability were evaluated using the 0–3 intensity score (0: absent, 1: mild, 2: moderate, 3: severe) of the GRBASI scale (Hirano, 1981; completed with an "I" parameter by Dejonckere et al., 1996). Samples were randomized and rated blindly by the same voice therapist (I.M.). To ensure interrater reliability, 20 samples (33.3%) were randomly selected and rated blindly and independently by another voice therapist (E.D.).

Maximum performance task

To measure the maximum phonation time (MPT, in s), participants were asked to sustain the vowel /a/ at their habitual pitch and loudness after a maximal inspiration, in free field while seated. The MPT was modelled by the experimenters and the participants received visual and verbal encouragements to produce the longest possible sample. The length of the sustained vowel was measured with a chronometer. The best trial of three attempts was retained for further analysis.

Acoustic analysis

The fundamental frequency (f_o, Hz), jitter (%), shimmer (%), variation in f_o (vf_o, %) and noise-to-harmonic ratio (NHR) were obtained by the Multi Dimensional Voice Program of the Computerized Speech Lab (CSL; model 4500, KayPENTAX, Montvale, NY), using a Shure SM-48 microphone located at a distance of 15 cm from the mouth and angled at 45°. The subjects were instructed to produce the vowel /a/ at their habitual pitch and loudness. A midvowel segment of 3 s registered with a sampling rate of 50 kHz was used.

Voice range profile (VRP)

The VRP was determined using the CSL and a Shure SM-48 microphone (with a 15-cm mouth-to-microphone distance angled at 45°), following the procedure outlined by Heylen et al. (1998). This assessment includes determination of the highest and the lowest fundamental frequency (F-high, F-low) and intensity (I-high, I-low). Participants were instructed to produce the vowel /a/ for at least 2 s using a habitual pitch and loudness, a minimal pitch, a minimal intensity, a maximal pitch and a maximal intensity respectively. Each production was modelled by the experimenters and the participants received visual and verbal encouragement.

Dysphonia severity index (DSI)

The DSI is a multiparameter approach designed to establish an objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000). It is based on a weighted combination of the following parameters: MPT (s), highest frequency (F-high, Hz), lowest intensity (I-low, dB) and jitter (%). The DSI is constructed as 0.13 MPT + 0.0053 F-high – 0.26 I-low – 1.18 jitter + 12.4. The index ranges from –5 to 5 for severely dysphonic to normal voices. A more negative index indicates a worse vocal quality. Values higher than 5 are possible in subjects with very good vocal capacities. A DSI of 1.6 is the threshold separating normal voices from dysphonic voices (Raes et al., 2002).

Voice training

Both the IVT and TVT groups received an identical 6-h voice training. Only the distribution of practice varied between the groups: 2 h a day for 3 consecutive days for the IVT group versus two 30-min sessions a week for 6 weeks for the TVT group. The training program included counseling and vocal hygiene (30 min), posture and relaxation (30 min), respiration (1 h), humming and resonant voice (1 h), voice placing and forward focus (30 min), pitch and loudness control (30 min), vocal function exercises (30 min), voice onset (30 min), and generalization and transfer (1 h). Details of the training program are provided in Table 6.1 (De Bodt et al., 2008a; De Bodt et al., 2008b; Timmermans, 2008; Verdolini-Marston et al., 1995; Verdolini, 2000; Stemple et al., 1994).

Statistical analysis

SPSS version 24 (SPSS Corp., Chicago, IL) was used for the statistical analysis of the data. Analyses were conducted at $\alpha = 0.05$.

Fisher's exact tests were used to compare the groups regarding self-reported voice-related symptoms, risk factors, vocal abuse and lifestyle habits, and to confirm the success of randomization. Cohen's κ was run to determine the interrater reliability for the auditory-perceptual evaluation (GRBASI).

Linear mixed models were used to compare groups over time on each continuous outcome measure, using the restricted maximum likelihood estimation and scaled identity covariance structure. Time, group and time-by-group interaction were specified as fixed factors. A random intercept for subjects was included. Model assumptions were checked by inspecting whether residuals were normally distributed. Generalized linear mixed models were used for the categorical outcome measures. If a significant main (time-by-group, time or group) effect was found, within-group effects of time were determined using pairwise comparisons with Bonferroni corrections (pre- versus post-training, post-training versus 6 weeks follow-up, pre-training versus 6 weeks follow-up).

Table 6.1 Content of the voice training program.

Content	Time	Details
Counseling and vocal hygiene	30min	Counseling: - Explaining the anatomy and functioning of the larynx using simple educational images - Clarifying the distinction between normal and pathological voices Vocal hygiene: - Checking vocal abuse, vocal load, and influencing lifestyle habits using a questionnaire - Discussing feasible solutions and general advice concerning vocal hygiene
Posture and relaxation	30min	Posture: - Highlighting the importance of a correct posture for phonation - Demonstrating a correct posture while standing and sitting - Applying specific exercises to stimulate a correct posture (e.g. standing upright with your feet slightly apart, the knees relaxed, the pelvis balanced, lift one arm and then the other with the palm facing upward, pull the arms pretending to push the sky above with alternating hands) Relaxation: - Performing localized relaxation techniques: head, neck, shoulders, larynx, and pharynx (e.g. moving the head sideways as much as possible so that the ear almost touches the shoulder; lifting the shoulders as high as possible without movement of the back or trunk for a few seconds, then slowly lower the shoulders; pretending to drink out of cupped hands with deep inhalations; introducing a yawn while feeling a slight tension in the palate, lowering of the larynx and widening of the pharynx)
Respiration	1h	- Highlighting the importance of an efficient respiration type for phonation - Discussing and demonstrating the different respiration types (clavicular, costal, costo-abdominal, abdominal) - Advancing awareness of the subject’s habitual respiration type and adjusting to a costo-abdominal type while laying, sitting and standing; using tactile-kinesthetic and visual feedback - Practicing the costo-abdominal type and respiratory control on different hierarchical levels: inhaling through the nose and exhaling while producing voiceless fricatives (/f/ and /s/), voiced fricatives (/v/ and /z/), other consonants and vowels, words, automatic sequences, sentences, and texts
Humming and resonant voice	1h	- Explaining the physiology and the purpose of resonant voice exercises - Sensing “easy” phonation and vibrations in the midfacial region while humming on /m/, /n/, /ng/ - Practicing resonant voice exercises on different hierarchical levels (isolated, syllable, word, phrase, sentence, text) using tactile-kinesthetic and auditory feedback - Reducing the degree of resonance while maintaining the “easy phonation” with forward focus
Voice placing and forward focus	30min	- Highlighting the importance of removing the energy and muscle tension away from the larynx and bringing it to the mouth (“mask resonance”) - Highlighting the importance of transferring the message to the listener (“forward focus”) - Specific exercises using visual, auditory and tactile-kinesthetic feedback: gawking to reduce muscle tension in the cheeks and neck, humming to place the voice, using an imaginary megaphone to stimulate forward focus, “bringing” the voice to the nose, sighing, speaking while “throwing” away words like darts to a dartboard, using open and exaggerated articulation etc. (selection was adjusted to the participant, avoiding excessive muscle tension)

Table 6.1 *(Continued)*

Content	Time	Details
Pitch and loudness control	30min	- Ascending and descending pitch glides - Crescendo and decrescendo
Vocal function exercises	30min	Vocal Function Exercises - Warm-up: sustaining the vowel /i/ as long as possible on the musical note F above middle C - Stretching: upward pitch glide on /o/ - Contracting: downward pitch glide on /o/ - Adductory power: sustaining the vowel /o/ as long as possible on the musical notes C-D-E-F-G
Voice onset	30min	- Discussing and demonstrating the different types of voice onset (hard, aspirated/soft, balanced) - Practicing a balanced voice onset starting from an aspirated/soft onset: a) Blowing air through pursed lips, followed by a rounded vowel or diphthong, gradually reducing the blowing b) Producing words with a vowel or diphthong at medial position, inserting a /h/ sound between the vowel/diphthong, gradually reducing the /h/ production c) Producing words with a vowel or diphthong at initial position, adding a /h/ sound before the vowel/diphthong, gradually reducing the /h/ production d) practicing sentence and text level
Generalization and transfer	1h	Generalization of the learned techniques during reading aloud and spontaneous speech; using auditory, visual and tactile-kinesthetic feedback

RESULTS

Questionnaire voice-related symptoms, risk factors, vocal abuse and lifestyle habits

Results on the questionnaire regarding voice-related symptoms, risk factors, vocal abuse and lifestyle habits are presented in Table 6.2. Fischer's exact tests showed no significant baseline differences between the two groups. The presence of vocal complaints and upper respiratory tract infections did not differ between groups when rechecked at the post-test and at 6 weeks follow-up.

Table 6.2 Presence of voice-related symptoms, risk factors, vocal abuse, and lifestyle habits in the intensive voice training (IVT) and traditional voice training (TVT) groups.

Symptom or risk factor	Time	IVT (*n* = 10)	TVT (*n* = 10)	*p*-value
Vocal complaints	Pre-test	2	1	> 0.999
	Post-test	3	0	0.211
	6 weeks follow-up	1	4	0.303
Upper respiratory tract infection	Pre-test	2	4	0.628
	Post-test	5	4	> 0.999
	6 weeks follow-up	4	7	0.370
Allergy	Pre-test	4	3	> 0.999
Reflux	Pre-test	3	1	0.582
Vocal abuse	Pre-test	4	8	0.170
Smoking	Pre-test	4	0	0.087
Alcohol use	Pre-test	10	10	> 0.999
Coffee	Pre-test	6	4	0.656

Interrater reliability auditory-perceptual evaluation

Cohen's κ showed moderate to excellent degrees of interrater reliability for the GRBASI parameters. An excellent degree of reliability was found for the parameters G, B, A and I with κ = 0.77, 0.86, 1.00 and 1.00 respectively. A moderate degree of reliability was found for the parameters R and S, with κ = 0.50.

Evolution outcome measures

Evolution of the outcome measures in both groups is presented in Tables 6.3 and 6.4. (Generalized) linear mixed models showed no significant time-by-group interactions for any of the outcome measures, indicating no significant differences in evolution over time between both groups. A significant group effect was found for MPT ($F(1,18) = 5.423$, p = 0.032), indicating a significant difference among groups independent of time. Significant time effects were found for MPT ($F(2,36) = 11.990$, $p < 0.001$), I-low ($F(2,36) = 6.091$, $p = 0.005$), F-low ($F(2,36) = 5.667$, $p = 0.007$), F-high ($F(2,36) = 14,456$, $p < 0.001$), and DSI ($F(2,36) = 11.785$, $p < 0.001$), indicating significant changes over time in the sample as a whole, independent of group assignment. All these measures improved over time (for MPT, see Figure 6.2; for I-low, see Figure 6.3; for F-low, see Figure 6.4; for F-high, see Figure 6.5; and for DSI, see Figure 6.6).

Within-group effects of time showed a significant improvement in MPT pre- to post-training in the IVT group (+5.3 s, $p = 0.005$); MPT also improved pre- to post-training in the TVT group although not significantly (+3.5 s, $p = 0.090$). MPT did, however, significantly improve pre-training to 6 weeks follow-up in both groups (IVT: +4.4 s, $p = 0.022$, TVT: +5.3 s, $p = 0.005$), and improved MPTs post-training remained until 6 weeks follow-up in both groups (post - 6 weeks follow-up, $p > 0.05$). I-low significantly improved pre-training to 6 weeks follow-up in the TVT group (–2.1 dB, $p = 0.023$). F-low significantly improved pre- to post-training in the IVT group (–10.4 Hz, $p = 0.015$), and improvement remained until 6 weeks follow-up (post - 6 weeks follow-up, $p > 0.05$). F-high significantly improved pre- to post-training in both groups (IVT: +194.3 Hz, $p = 0.015$; TVT: +212.7 Hz, $p = 0.007$), and improvements remained until 6 weeks follow-up (post - 6 weeks follow-up, $p > 0.05$). DSI significantly improved pre- to post-training in the IVT group (+2.1, $p = 0.025$); DSI also improved pre- to post-training in the TVT group although not significantly (+1.8, $p = 0.055$). DSI did, however, significantly improve pre-training to 6 weeks follow-up in both groups (IVT: +2.3, $p = 0.016$; TVT: 2.5, $p = 0.004$), and improved DSI scores post-training remained until 6 weeks follow-up in both groups (post - 6 weeks follow-up, $p > 0.05$).

Table 6.3 Evolution of the categorical outcome measures in the intensive voice training (IVT) and traditional voice training (TVT) groups.

		Pre		**Post**		**6 weeks follow-up**		**Time*Group**	**Group**	**Time**
Parameters	Group	Median	IQR	Median	IQR	Median	IQR	*p*-value	*p*-value	*p*-value
G	IVT	0	[0, 0.75]	0	[0, 0]	0	[0, 0]			
	TVT	0	[0, 1]	0	[0, 0.5]	0	[0, 0.25]	0.905	0.856	0.597
R	IVT	0.5	[0, 1]	0	[0, 1]	1	[0, 1]			
	TVT	0	[0, 1]	0	[0, 1]	0	[0, 1]	0.434	0.466	0.782
B	IVT	0	[0, 0]	0	[0, 0]	0	[0, 0]			
	TVT	0	[0, 0.25]	0	[0, 1]	0	[0, 1]	>0.999	0.995	>0.999
A	IVT	0	[0, 0]	0	[0, 0]	0	[0, 0]			
	TVT	0	[0, 0]	0	[0, 0]	0	[0, 0]	>0.999	0.997	>0.999
S	IVT	0	[0, 0.75]	0	[0, 0]	0	[0, 0]			
	TVT	0	[0, 0.25]	0	[0, 0.5]	0	[0, 0.25]	0.798	0.993	0.836
I	IVT	0	[0, 0]	0	[0, 0]	0	[0, 0]			
	TVT	0	[0, 0]	0	[0, 0.5]	0	[0, 0]	0.769	0.658	0.769

Note: IQR, interquartile range; G, grade; R, roughness; B, breathiness; A, asthenia; S, strain; I, instability.

Table 6.4 Evolution of the continuous outcome measures in the intensive voice training (IVT) and traditional voice training (TVT) groups.

		Pre		Post		6 weeks follow-up		Time*Group	Group	Time	Comparison Time within groups		
											Pre – Post	Post – 6 weeks follow-up	Pre – 6 weeks follow-up
Parameters	Group	EM	95% CI	EM	95% CI	EM	95% CI	*p*-value	*p*-value	*p*-value	*p*-value	*p*-value	*p*-value
Maximum performance task													
MPT (s)	IVT	23.9	[19.9, 28.0]	29.2	[25.2, 33.3]	28.3	24.3, 32.4]	0.462	0.032*	<0.001*	0.005*	>0.999	0.022*
	TVT	18.4	[14.4, 22.5]	21.9	[17.9, 26.0]	23.7	[19.7, 27.8]				0.090	0.757	0.005*
Acoustic analysis													
f_o (Hz)	IVT	191.5	[175.7, 207.2]	193.8	[178.0, 209.5]	190.7	[174.9, 206.4]	0.197	0.264	0.508	-	-	-
	TVT	202.3	[186.5, 218.0]	196.8	[181.1, 212.5]	210.0	[194.3, 225.8]				-	-	-
jitter (%)	IVT	1.423	[0.834, 2.013]	1.493	[0.903, 2.083]	1.479	[0.889, 2.069]	0.720	0.631	0.752	-	-	-
	TVT	1.693	[1.103, 2.283]	1.748	[1.158, 2.338]	1.426	[0.836, 2.015]				-	-	-
shimmer (%)	IVT	4.929	[4.085, 5.772]	4.884	[4.040, 5.728]	4.004	[3.160, 4.848]	0.534	0.908	0.120	-	-	-
	TVT	4.609	[3.765, 5.452]	4.918	[4.075, 5.762]	4.446	[3.602, 5.290]				-	-	-
vf_o (%)	IVT	1.503	[1.075, 1.931]	1.583	[1.155, 2.011]	1.504	[1.076, 1.932]	0.611	0.960	0.530	-	-	-
	TVT	1.684	[1.256, 2.112]	1.595	[1.167, 2.023]	1.340	[0.912, 1.768]				-	-	-
NHR	IVT	0.131	[0.117, 0.144]	0.143	[0.129, 0.156]	0.126	[0.112, 0.139]	0.231	0.942	0.303	-	-	-
	TVT	0.127	[0.113, 0.140]	0.134	[0.120, 0.147]	0.137	[0.124, 0.151]				-	-	-
Voice Range Profile													
I-low (dB)	IVT	59.6	[57.8, 61.4]	58.0	[56.2, 59.9]	58.2	[56.4, 60.0]	0.524	0.561	0.005*	0.114	>0.999	0.203
	TVT	59.0	[57.2, 60.9]	57.9	[56.1, 59.8]	56.9	[55.1, 58.8]				0.443	0.560	0.023*
I-high (dB)	IVT	104.8	[99.9, 109.8]	107.6	[102.7, 112.5]	108.3	[103.4, 113.3]	0.877	0.496	0.077	-	-	-
	TVT	107.6	[102.7, 112.6]	109.0	[104.0, 114.0]	110.4	[105.5, 115.4]				-	-	-
F-low (Hz)	IVT	147.6	[134.6, 160.7]	137.2	[124.2, 150.3]	138.7	[125.6, 151.8]	0.232	0.274	0.007*	0.015*	>0.999	0.043*
	TVT	153.7	[140.6, 166.7]	151.5	[138.5, 164.6]	146.9	[133.9, 160.0]				>0.999	0.585	0.186
F-high (Hz)	IVT	664.4	[496.8, 832.1]	858.7	[691.1, 1026.4]	915.6	[748.0, 1083.3]	0.696	0.651	<0.001*	0.015*	>0.999	0.001*
	TVT	630.0	[462.4, 797.6]	842.7	[675.0, 1010.3]	824.2	[656.6, 991.8]				0.007*	>0.999	0.015*
Dysphonia Severity Index													
DSI	IVT	1.9	[0.0, 3.9]	4.0	[2.1, 5.9]	4.2	[2.2, 6.0]	0.838	0.385	<0.001*	0.025*	>0.999	0.016*
	TVT	0.9	[1.0, 2.8]	2.7	[0.8, 4.6]	3.4	[1.5, 5.3]				0.055	0.955	0.004*
Voice Handicap Index													
F-scale	IVT	3.9	[1.4, 6.4]	2.9	[0.4, 5.4]	2.7	[0.2, 5.2]	0.483	0.385	0.054	-	-	-
	TVT	5.0	[2.5, 7.5]	5.0	[2.5, 7.4]	3.7	[1.2, 6.2]				-	-	-
P-scale	IVT	5.7	[1.4, 10.0]	5.2	[0.9, 9.5]	4.7	[0.4, 9.0]	0.988	0.236	0.478	-	-	-
	TVT	9.1	[4.8, 13.4]	8.6	[4.3, 12.9]	8.3	[4.0, 12.6]				-	-	-
E-scale	IVT	0.9	[0, 3.7]	1.1	[0, 3.9]	1.1	[0, 3.9]	0.491	0.090	0.601	-	-	-
	TVT	4.6	[1.8, 7.4]	4.7	[1.9, 7.5]	3.7	[0.9, 6.5]				-	-	-
Total VHI	IVT	10.5	[1.9, 19.1]	9.2	[0.6, 17.8]	8.5	[0, 17.1]	0.784	0.169	0.160	-	-	-
	TVT	18.7	[10.1, 27.3]	18.2	[9.6, 26.8]	15.7	[7.1, 24.3]				-	-	-

Note: IQR, interquartile range; MPT, maximum phonation time; I-low, lowest intensity; I-high, highest intensity; F-low, lowest frequency; F-high, highest frequency; f_o, fundamental frequency; vf_o, variation in fundamental frequency; NHR, noise-to-harmonic ratio; DSI, Dysphonia Severity Index; F-scale, functional scale; P-scale, physical scale; E-scale, emotional scale; VHI, Voice Handicap Index.* indicates a significant effect.

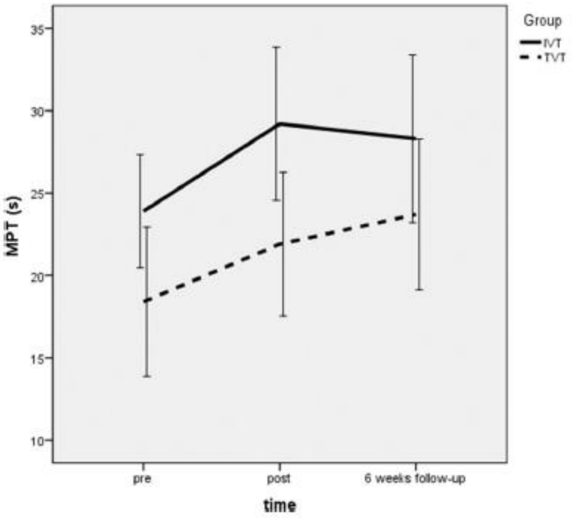


Figure 6.2 Evolution MPT (s) over time in the IVT and TVT groups.

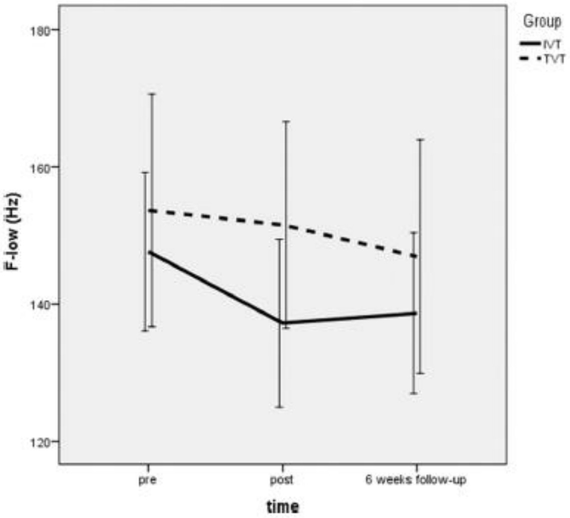


Figure 6.4 Evolution F-low (Hz) over time in the IVT and TVT groups.

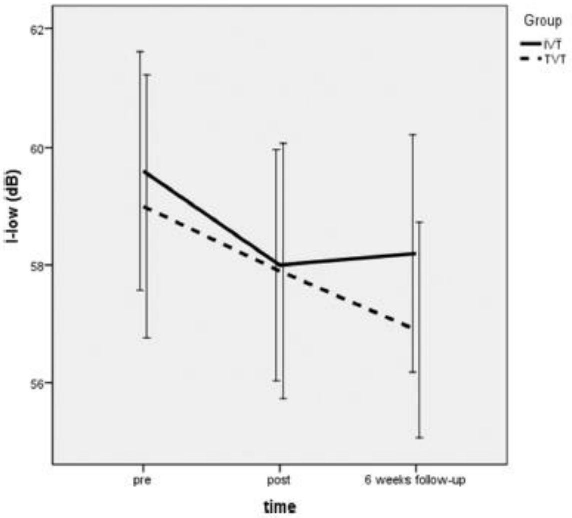


Figure 6.3 Evolution I-low (dB) over time in the IVT and TVT groups.

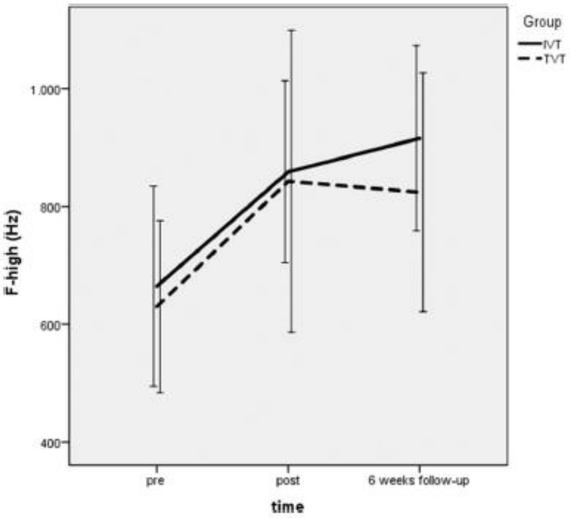


Figure 6.5 Evolution F-high (Hz) over time in the IVT and TVT groups.

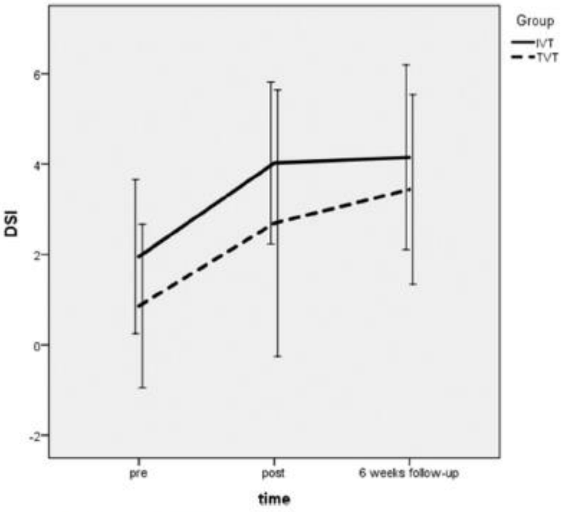


Figure 6.6 Evolution DSI over time in the IVT and TVT groups.

DISCUSSION

The aim of this study was to compare the effect of a short-term IVT with a longer-term TVT on the vocal quality and vocal capacities of vocally healthy non-professional voice users. Earlier shortcomings (Fu et al., 2015a; Wenke et al., 2014; Fischer et al., 2009) were met by using a longitudinal randomized control group design, a voice assessment including both objective measures, auditory-perceptual evaluations and a subjects' self-report, and a standardized and equal training program for both groups. The experiment started with a group of 20 healthy female non-professional voice users. No significant differences were found regarding age, voice-related symptoms, risk factors, vocal abuse and lifestyle habits between the IVT and TVT groups.

Based on the principles of behavioral change and the potential advantages of high-intensity training, the authors hypothesized that a short-term IVT may be equally, or even more, effective than a longer-term TVT. This hypothesis has been supported by the results of the current study. (Generalized) linear mixed models showed no significant time-by-group interactions for any of the outcome measures, indicating no significant differences in evolution over time between the groups. Significant time effects were found for the parameters MPT, I-low, F-low, F-high and DSI, all evolving in the desired directions in both groups. More in-depth within-group analyses indicate a preference for the IVT group regarding the evolution of MPT, F-low and DSI, and a preference for the TVT group regarding the evolution of I-low. In contrast to Fu et al. (2015a), auditory-perceptual evaluations and acoustic perturbation and noise measures showed no significant evolution, probably due to the fact that participants were vocally healthy in this study allowing less significant progress. Visual analogue scales may be more sensitive to measure auditory-perceptual differences in this population. The same applies for the self-reported VHI scores, which, in contrast to the study of Wenke et al. (2014), did not significantly improve in the current study.

Vocally healthy participants were selected for this exploratory study. At first, this selection provided more options for a stronger methodological design with less bias. A randomization procedure and better control of influencing factors can easier be achieved in healthy participants than in dysphonic patients. Second, this is a well-considered study group for the aim of exploring motor learning principles of behavioral change that are totally new in vocology. Every voice user, also a vocally healthy individual, is able to improve his or her vocal quality and vocal capacities. Therefore, learning principles will probably apply to any type of voice user. This may cautiously be compared with a typical motor learning task, such as learning how to play tennis. An intensive tennis program will probably lead to more effective and efficient learning than a less intensive one, regardless of the type of player (age, sex, physical fitness, experience etc.). Of course, it is plausible that a younger player with a higher level of physical fitness and experience will learn even more and faster than an older player with less physical fitness and experience. However, a general trend of more effective and efficient learning in the intensive program will likely exist for both individuals. With this idea in mind, we may hypothesize that the current results in healthy participants will give a first general idea of what the most effective distribution of practice might be in vocology. Of course, further research in the whole field (dysphonic patients, elite vocal performers etc.) is needed to make more profound conclusions.

Suppose that this hypothesis is correct and that a short-term intensive model is indeed equally, or even more, effective than a longer-term traditional one, then this will have its consequences for both the patient/client, the voice therapist/coach and the healthcare system. Time efficiency would be the first advantage for both parties as busy work schedules are no exception these days. Occupational voice users and elite vocal performers are sometimes hindered to work because of their voice problems and want to resume work as soon as possible (Fischer et al., 2009; Fu et al., 2015a). People who live far from the voice center will experience benefits of a short-term intensive model as they do not have to schedule weekly appointments spread overall several weeks to months (Patel et al., 2011). Motivation may increase or be regained as more progress will be noted in a short time frame (Patel et al., 2011; Wenke et al., 2014; Fu et al., 2015a). Although not shown in the current study, Wenke et al. (2014) found higher attendance for the intensive model, which may reduce frustrations for clinicians associated with cancellations and no-shows. Furthermore,

more time efficiency and less dropout will obviously lead to less financial burden on the client and the healthcare system (Patel et al., 2011; Wenke et al., 2014; Fu et al., 2015b).

Besides the many benefits a short-term intensive model has to offer, certain aspects should be kept in mind. At first, the practicality and complexity of scheduling a short-term intensive training or therapy should not be underestimated (Bergan, 2010). As said before, time efficiency will eventually overcome, but in the short-term it requires a strict scheduling for both the patient/client and the voice therapist/coach. Secondly, the potential risk of overdosing laryngeal tissues cannot be excluded (Bergan, 2010; Roy 2012; Behlau et al., 2014). Compared with most medical and pharmaceutical therapies, little is known about the moment or threshold at which vocal training transitions from being beneficial to harmful (Roy, 2012). Extreme vigilance by the voice therapist/coach and otorhinolaryngologist will be indispensable in this trajectory (Roy, 2012). However, earlier findings by Fu et al. (2015a) are promising as patients with vocal nodules showed comparable positive physiological results evaluated with laryngovideostroboscopy (improved ratings of mucosal wave, vocal fold edge smoothness, regularity of vocal fold movement and glottal closure) post-intensive treatment and post-traditional treatment. This indicates no overdose, even for patients with organic voice disorders. Of course, variability will be a key component in the balance between beneficial and harmful dosages (Roy, 2012, Behlau et al., 2014). It is quite possible that the ideal frequency and intensity for one individual may be insufficient or harmful for another (Roy, 2012; Behlau et al., 2014). Despite this variability, we are convinced that a general picture of the most effective and efficient frequency and duration of voice therapy and training is essential. Individualization will be a logical next step.

Limitations of this study are that subjects and experimenters were not blinded to the purpose of the study and that objective measures were only based on sustained vowel samples. Including voice assessments based on both sustained vowels and continuous speech (e.g., acoustic voice quality index; Maryn et al., 2010a) would be a merit in approximating daily speech and voice use patterns. Another possible limitation is that the (although not significantly) higher proportion smokers in the IVT group may have influenced the results. Stricter exclusion criteria and larger sample sizes with a greater success of randomization may be of value in further research. Besides, convenience sampling as a recruitment procedure has its shortcomings. Implementation of a longer-term follow-up and analysis of the subjects' opining regarding the administered frequency and duration can provide valuable information in future. Investigating the role of telepractice in intensive short-term service delivery models may be an interesting goal for further studies. In general, the principal distribution of practice should be further explored over the whole domain of vocology, which will give us an idea of the optimal dosage for different types of voice users (patients with a variety of voice disorders, occupational voice users, elite vocal performers), and undoubtedly be a step forward for both the patient/client, the voice therapist/coach and the healthcare system.

CONCLUSIONS

Results suggest that short-term IVT may be equally, or even more, effective in training vocally healthy non-professional voice users compared with longer-term TVT. Whether similar results may be expected in different types of voice users and patients with a variety of voice disorders is subject for further research.

6.2 Massed versus spaced practice in vocology: effect of a short-term intensive voice therapy versus a long-term traditional voice therapy

Based on: Meerschman, I., D'haeseleer, E., Claeys, S., Bettens, K., Bruneel, L., & Van Lierde, K. Massed versus spaced practice in vocology: Effect of a short-term intensive voice therapy versus a long-term traditional voice therapy. *Submitted to Journal of Speech, Language, and Hearing Research.*

ABSTRACT

Objective. The aim of this study was to compare the effect of a short-term intensive voice therapy (IVT) with a long-term traditional voice therapy (TVT) on the vocal quality, vocal capacities, psychosocial impact, vocal tract discomfort, laryngological anatomy/physiology and adherence of patients with dysphonia. An additional comparison was made between two types of IVT: an individual (IVT-I) and a group treatment (IVT-G).

Methods. A longitudinal, prospective controlled trial with a multiple baseline design was used. Forty-six patients (mean age, 23 years; 44 females, 2 males) diagnosed with dysphonia were assigned to one of the three treatment groups: IVT-I (*n* = 15), IVT-G (*n* = 15), or TVT (*n* = 16). The IVT groups practiced with a frequency of 1h20min a day and a duration of 10 consecutive work days (2 weeks). The TVT group practiced with a frequency of two 30-min sessions a week and a duration of 6 months. Both therapy programs were content-identical and guided by the same voice therapist. A standardized voice assessment consisting of both objective (maximum performance task, aerodynamic measurements, voice range profile, acoustic analysis, Acoustic Voice Quality Index, Dysphonia Severity Index) and subjective (subject's self-report, auditory-perceptual evaluation, flexible videolaryngostroboscopy) vocal measures and determinations was used to evaluate the participants' voice. Assessors were blinded to group allocation and study evolution. Time points of the assessment were at baseline (twice), after 1 week, 2 weeks, 2 months, 3 months, 4 months, 6 months, and 1 year. Additional voice evaluations were performed after each therapy day in the IVT groups.

Results. IVT made an equal progress in only 2 weeks and 12h of therapy compared with TVT that needed 6 months and 24h of therapy. IVT-I and IVT-G showed comparable results. Patient adherence was clearly higher in IVT compared with TVT. Long-term follow-up results (1 year) were positive for the three groups, except for the self-reported psychosocial impact that increased in the IVT-I group.

Conclusions*.* Short-term IVT is at least equally effective in treating patients with dysphonia than long-term TVT. Group treatment seemed as effective as individual treatment. Patient adherence and cost-effectiveness are important advantages of IVT. A potential drawback might be an insufficient psychosocial progression. The golden mean between intensive and traditional treatment might therefore be an achievable, effective and efficient solution for everyday clinical practice.

INTRODUCTION

Unlike most medical and pharmaceutical therapies, the optimal “dosage” for voice therapy is unknown (De Bodt et al., 2015; Roy, 2012). The frequency and duration used today depends on several factors, such as the medical prescription, rules of reimbursement, the vocal pathology and its severity, the type of therapy, and the client’s limitations and expectations (Mueller & Larson, 1992; De Bodt et al., 2008a; Van Lierde et al., 2007; Van Lierde et al., 2010a). Despite these influencing factors, a practice schedule with weekly sessions spread over several weeks, months or years seems to be the standard (Carding et al., 1999; Chen et al., 2007; Fischer et al., 2009; Bergan, 2010; Demmink-Geertman & Dejonckere, 2010; Patel et al., 2011; Behlau et al., 2014; Wenke et al., 2014). This traditional way of practice scheduling is also reflected in the literature. De Bodt et al. (2015) found that published voice therapy lasts an average of 9.25 weeks in which 10.87 sessions of mostly 30 or 60 minutes are provided once are twice a week. However, substantial geographical differences were found.

Traditional voice therapy services are often faced with poor client adherence, cancellations or non-attendance. These factors may lead to frustrations for clinicians, reduced vocal and psychosocial outcomes, chronic or recurrent dysphonia, and eventually high costs for the health care system (Portone et al., 2008; Patel et al., 2011; Wenke et al., 2014). Wenke et al. (2014) found that 25% of the sessions in a traditional voice therapy schedule resulted in cancellations. Portone et al. (2008) showed that 38% (48/125) of patients did not attend a voice evaluation after referral by an otolaryngologist. Of those who attended the voice evaluation, 47% (137/294) did not appear on the first actual therapy session. Furthermore, as much as 65% (95/146) of those who did attend the first therapy session dropped out before therapy completion (Portone et al., 2008; Hapner et al., 2009). Long-term therapy outcome suggests a high rate of chronic and recurrent dysphonia in about 50% (14/27) of the individuals (Van Lierde et al., 2007).

As patient adherence and motivation are key components for successful therapeutic outcomes, research should focus on finding service delivery models that maximize these aspects (Koufman & Blalock, 1982; Hapner et al., 2009; Patel et al., 2011; Wenke et al, 2014). Such research is still in its infancy in voice therapy, but received considerable attention in the fields of neurobiology, exercise physiology, motor learning, psychology and language therapy (Patel et al., 2011). One of the learning principles investigated in these fields is the principle “distribution of practice”, with “massed” and “spaced” practice as two ends of a continuum. In massed practice, sessions are organized very closely together with little or no rest time between sessions, whereas in spaced practice, the time interval between practice sessions is larger (Bergan, 2010). As literature suggests a preference for high-intensity training (i.e. massed practice) to obtain desirable learning and behavioral changes, the traditional spaced practice schedule in voice therapy might by questioned (Patel et al., 2011; Bergan, 2010).

Although the preference for massed practice has not yet broken through our field, it does have its history and was proven effective in specific programs, such as the Lee Silverman Voice Treatment (LSVT®, Ramig et al., 1994) and Vocal Function Exercises (VFE, Stemple et al., 1994). Recently, Patel et al. (2011) highlighted the massed practice approach with their development of a “boot camp” voice therapy, performed in a time frame of 1-4 consecutive days with 4-7 hours of therapy a day. Boot camp is designed for people who have pressing needs to improve their voice (e.g. upcoming vocal performances), who failed traditional voice therapy (e.g. recalcitrant dysphonia), and/or have an inability to schedule weekly appointments (e.g. living at geographical distances far from a voice center). A few years later, Behlau et al. (2014) shared their experience with a similar intensive short-term voice therapy used for a variety of cases, including iatrogenic dysphonia and elite vocal performers suffering from acute dysphonia. Their therapy schedule lasts 3 days to 2 weeks in which 3 to 4 sessions are provided per day.

Clinical trials that actually compare the effect of massed and spaced practice in voice therapy are limited and show some methodological shortcomings. Fu et al. (2015a) investigated the effect of both models (eight 45-minute sessions over 3 weeks versus eight 45-minute sessions over 8 weeks) in 53 women with vocal nodules and found comparable positive perceptual, physiological, and acoustic outcomes. Shortcomings of this study were the lack of long-term follow-up and self-rating questionnaires. Furthermore, subjects were not randomly assigned to the two treatment groups but according to their availability. Wenke et al. (2014) compared the two models (four 1-hour treatment sessions a week for 8 weeks versus one 1-hour treatment session a week for 8 weeks) in voice therapy for patients with functional dysphonia (*n* = 16) and found high satisfaction and a significantly reduced Voice Handicap Index (VHI) after the intensive treatment. Moreover, significantly higher attendance rates were found in the intensive group compared with the traditional group. A major limitation of this study is that the therapy program was not standardized, which means that subjects received different treatment techniques depending on the individual's profile. Therefore, treatment success cannot surely be related to the distribution of practice. Besides, perceptual and objective vocal measures were lacking. A pilot study of Meerschman et al. (2017) explored massed practice in 20 female vocally healthy participants and met earlier shortcomings by using a longitudinal randomized control group design, a voice assessment including both objective measures, auditory-perceptual evaluations and a subjects' self-report, and a standardized and equal training program for both groups. They found that a short-term intensive voice training (2h a day for 3 consecutive days) was at least equally effective in training vocally healthy non-professional voice users compared with a longer-term traditional voice training (two 30-min sessions a week for 6 weeks). Maximum phonation time, lowest intensity, lowest frequency, highest frequency and Dysphonia Severity Index (i.e. multiparametric objective vocal quality index; Wuyts et al., 2000), similarly improved over time in both groups. More in-depth within-group analyses indicated a slight preference for the intensive group regarding the evolution of maximum phonation time, lowest frequency and dysphonia severity index, and a slight preference for the traditional group regarding the evolution of lowest intensity. Follow-up research is needed as the results of this pilot study are not generalizable to a dysphonic population.

The aim of the current study was to compare the effect of a short-term intensive voice therapy (IVT) with a long-term traditional voice therapy (TVT) on the vocal quality, vocal capacities, psychosocial impact, vocal tract discomfort, laryngological anatomy/physiology and adherence of patients with dysphonia. An additional comparison was made between two types of IVT: an individual (IVT-I) and a group treatment (IVT-G). Based on the principles of behavioral change and the results of previous studies (Fu et al., 2015a; Wenke et al., 2014; Meerschman et al., 2017), it was hypothesized that a short-term IVT may be at least equally effective than a long-term TVT. As care and attention can go completely to one person in an individual program, better results were expected after IVT-I compared with IVT-G.

MATERIAL AND METHODS

This study was approved by the Ethics Committee of Ghent University Hospital (EC/2014/1194).

Participants

Participants were recruited at the departments of Speech, Language and Hearing Sciences and Otorhinolaryngology of Ghent University and Ghent University Hospital from October 2014 to January 2017. Inclusion criteria were aged between 18 and 60 years and diagnosed with an organic or functional voice disorder by an otorhinolaryngologist (S.C.) and a speech-language pathologist (SLP) experienced in voice diagnostics (K.V.L, E.D., K.B., L.B., or I.M.). Diagnoses were based on the results of a standardized voice assessment: anamnesis, flexible videolaryngostroboscopy, auditory-perceptual evaluation, maximum performance task, aerodynamic measurements, acoustic analyses, and multiparametric voice indices (based on the European Laryngological Society (ELS) protocol; Dejonckere et al., 2003). Forty-eight patients referred for voice therapy were interested to participate in the study and provided written informed consent. Smoking, pregnancy, mental health conditions, and physically-limiting diseases that might interfere with study completion were selected as exclusion criteria. Two participants were excluded because of pregnancy. The remaining participants were a group of 44 females and 2 males with a mean age of 23 years (SD, 10.1 years; range, 18-60 years).

Design

A longitudinal, prospective, controlled trial with a multiple baseline design was used with the TVT group serving as the control group. Participants were assigned to one of three treatment groups: a short-term intensive voice therapy group receiving individual one-to-one sessions (IVT-I, *n* = 15), a short-term intensive voice therapy group receiving group sessions (IVT-G, *n*

= 15), or a long-term traditional voice therapy group receiving individual one-to-one sessions (TVT, *n* = 16). Thirty-three of the 46 participants were randomly assigned based on the moment of recruitment. The remaining 13 participants were assigned to one of the three groups according to their availability or preference. There were no differences among the three groups in gender (chi-square test; *p* = 0.602) and mean age (Kruskall-Wallis test; *p* = 0.126).

Voice therapy

The two IVT groups received a short-term intensive voice therapy with a frequency of 1h20min a day and a duration of 10 consecutive work days (2 weeks) with no therapy in the weekends and one extra rest day in one of the two weeks (total: 12h). The TVT group served as the control group and received a long-term traditional voice therapy with a frequency of two 30-min sessions a week and a duration of 6 months (total: 24h). The IVT-G group received group sessions, whereas the IVT-I and TVT groups received individual one-to-one sessions. The content of the voice therapy programs was identical for each group and therapy sessions were guided by the same voice therapist (I.M.). A detailed overview of the voice therapy program can be found in Table 6.5 (Arsonson, 1990; Boone et al., 2010; De Bodt et al., 2008a; De Bodt et al., 2008b; Lieberman, 1998; Mailänder et al., 2017; Rosenberg, 2013; Roy & Leeper, 1993; Stemple et al. 1994; Timmermans, 2008; Titze et al., 1995; Verdolini, 2000; Van Lierde et al., 2010a; D’haeseleer et al., 2013).

Voice assessment

A standardized voice assessment based on the ELS protocol (Dejonckere et al., 2003) including both objective (maximum performance task, aerodynamic measurements, voice range profile, acoustic analysis, Acoustic Voice Quality Index, Dysphonia Severity index) and subjective (subject’s self-report, auditory-perceptual evaluation, flexible videolaryngostroboscopy) measures and determinations was used to evaluate the participants’ voice.

Table 6.5 Content of the voice therapy program.

Content	Details
Education and counseling	Explaining the anatomy and functioning of the larynx, indicating the current pathology or dysfunction • use of educational images • use of patient's flexible videolaryngoscoboscopy
Vocal hygiene program	Program proposal based on results questionnaire (risk factors, vocal abuse, vocal load and lifestyle habits) • selection and discussion of vocal hygiene criteria based on impact and feasibility • use of a logbook (e.g. throat clearing, drinking water) • follow-up during the course of the therapy program
Posture	Correct and eutonic posture for phonation in sitting and standing position: • Explanation and demonstration by the therapist, imitation by the subject • Feedback and correction by the therapist during the course of the therapy program (when needed)
Relaxation	Local relaxation of the neck, shoulders, larynx and pharynx • Neck: e.g. moving the head sideways as much as possible so that the ear almost touches the shoulder • Shoulders: e.g. lifting the shoulders as high as possible without movement of the back or trunk for a few seconds, then slowly lower the shoulders • Larynx, pharynx: e.g. pretending to drink out of cupped hands with deep inhalations; introducing a yawn while feeling a slight tension in the palate, lowering of the larynx and widening of the pharynx; yawn-sigh
Respiration	Costo-abdominal respiration type and adequate breath support for phonation • Discussing and demonstrating the different respiration types (clavicular, costal, costo-abdominal, abdominal) • Awareness through tactile-kinesthetic (hand on thorax; hand on abdomen) and visual feedback (mirror) • Laying, sitting and standing position • Practicing on different hierarchical levels: inhaling through the nose and exhaling while producing voiceless fricatives (/f/ and /s/), voiced fricatives (/v/ and /z/), other consonants and vowels, words, automatic sequences, sentences, texts and spontaneous speech • Feedback and correction by the therapist during the course of the therapy program (when needed)
Resonant voice exercises	Obtaining an "easier" phonation and an improved source-filter interaction with aid of resonant voice exercises • Humming nasal consonants /m/, /n/, /ŋ/ • Nasal consonants combined with rounded vowels, unrounded vowels, and consonants • Speech-embedded nasals: words, sentences, texts, spontaneous speech • Gradually reducing resonance levels • Sensory feedback of vibratory sensations in the midfacial region, forward focus
Voice placing, forward focus	Adequate voice placing and forward focus • Awareness through negative practice: alternation between backward and forward focus ("bringing the voice in and out the throat") • Often combined with resonant voice exercises, gradual reduction of excessive resonance but maintenance of forward focus • Sensory feedback: vibratory sensation in the midfacial region, mask resonance • Feedback and correction by the therapist during the course of the therapy program (when needed)

Table 6.5 *(Continued)*

Content	Details
Voice onset	Adequate voice onset • Correction hard onset when applicable • Awareness through negative practice • Adding a /h/ sound before the vowel/diphthong, gradually reducing /h/ production • Words, phrases, sentences, texts, spontaneous speech starting with target vowels • Auditory playback • Feedback and correction by the therapist during the course of the therapy program (when needed)
Semi-occluded vocal tract (SOVT) exercises	Obtaining an "easier" phonation and an improved source-filter interaction with aid of SOVT exercises • Humming, lip trill, tongue trill, LaxVox, straw phonation, finger kazoo, lip-rounded vowels combined with blowing, cork exercise • Focus on warm-up and cool-down (e.g. pitch and loudness exercises), focus on transfer to speech ("reading exercises", use of intonation patterns, variation between SOVT exercises and normal open-mouth phonation)
Laryngeal manipulation	Relaxing tense (peri)laryngeal musculature which inhibits normal vocal function by manual massage techniques • Based on Lieberman (1998), Aronson (1990), Roy & Leeper (1993), Van Lierde et al. (2010a), D'haeseleer et al. (2013) • Laying and sitting position
Pitch and loudness exercises	Strengthening and balancing the laryngeal musculature by exercises on pitch and loudness • Ascending/descending pitch glides, pitch inflections • Crescendo/decrescendo, loudness shifts • Often combined with SOVT exercises
Correction of pitch, loudness, tempo and intonation	Adequate pitch, loudness, tempo and intonation • Correction only if applicable • Texts, spontaneous speech • Feedback by the therapist • Audio and video playback
Generalization and transfer	Combination of all learned techniques: costo-abdominal breathing pattern, adequate breath support, resonant voice, forward focus, adequate voice onset, adequate pitch/loudness/tempo/intonation • Different levels: reading (words, phrases, sentences, texts), semi-spontaneous speech (introducing themselves, describing something), spontaneous speech (answering questions, dialogues), • Creation or imitation of specific contexts (under stress, in loud environment, in front of audience etc.) • Feedback by the therapist, focus on self-correction • Audio and video playback

Logopaedic voice evaluations (maximum performance task, aerodynamic measurements, voice range profile, acoustic analysis, Acoustic Voice Quality Index, Dysphonia Severity index, subject's self-report, auditory-perceptual evaluation) were performed in a sound-treated room at Ghent University Hospital by an SLP experienced in voice diagnostics who was blinded to group allocation and study evolution (E.D., K.B., or L.B.). Time points of the measurements were at baseline (twice), after 1 week, 2 weeks, 2 months, 3 months, 4 months, 6 months, and 1 year (Figure 6.7). Additional logopaedic voice evaluations were performed after each therapy day in the IVT groups.

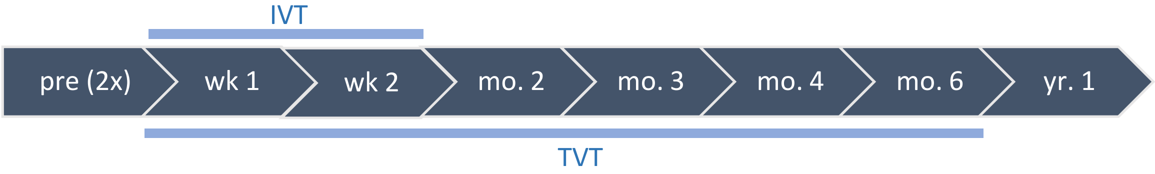


Figure 6.7 Timeline of the longitudinal logopaedic voice assessments performed in the IVT and TVT groups. *Note:* The end point of therapy is 2 weeks for the IVT groups and 6 months for the TVT group. Additional logopaedic voice evaluations were performed after each therapy day in the IVT groups. wk, week; mo., month; yr., year.

Maximum performance task. Maximum phonation time (MPT, in s) was determined by asking the participants to sustain the vowel /a/ at their habitual pitch and loudness after a maximal inspiration, in free field while seated. The production was modeled by the experimenters and the participants received visual and verbal encouragements to produce the longest possible sample. The length of the sustained vowel was measured with a chronometer and the best trials of three attempts was retained for further analysis.

Aerodynamic measurements. A dry spirometer (Riester, Jungingen, Germany) was used for determination of the vital capacity (VC, in cc). The best trial of three attempt was retained for further analysis and used for the calculation of the phonation quotient (PQ, in cc/s), which is the ratio of VC to MPT.

Voice range profile. The voice range profile was obtained using the Computerized Speech Lab (CSL; model 4500, KayPENTAX, Montvale, NY), and a Shure SM-48 microphone (located at a distance of 15 cm from the mouth, angled at 45 degrees). The procedure of Heylen et al. (1998) was used to determine the lowest and highest frequency (F-low, F-high), and the lowest and highest intensity (I-low, I-high). Subjects were instructed to produce the vowel /a/ for at least 2 seconds using, respectively, a habitual pitch and loudness, a minimal pitch, a minimal intensity, a maximal pitch, and a maximal intensity. Each production was modeled by the experimenters and the subjects received visual and verbal encouragement.

Acoustic analysis based on sustained /a/ *vowel.* The fundamental frequency (f_o, in Hz), jitter (in %), shimmer (in %), variation in f_0 (vf_o, in %) and noise-to-harmonic ratio (NHR) were obtained by the Multi Dimensional Voice Program of the CSL and a Shure SM-48 microphone (located at a distance of 15 cm from the mouth, angled at 45 degrees). Participants produced the vowel /a/ at their habitual pitch and loudness following an automatic series (counting to 2). A midvowel segment of 3 seconds registered with a sampling rate of 50 kHz was used for the analysis.

Acoustic analysis based on sustained /a/ *vowel and continuous speech: Acoustic Voice Quality Index (AVQI).* The AVQI is a recently developed objective multiparametric approach to quantify dysphonia severity based on both a sustained vowel and continuous speech (Maryn et al., 2010a). The AVQI consists of a weighted combination of 6 time- [i.e., shimmer local (SL), shimmer local dB (SLdB) and harmonics-to-noise ratio (HNR)], frequency- [i.e., general slope of the spectrum (Slope) and tilt of the regression line through the spectrum (Tilt)] and quefrency-domain [i.e., smoothed cepstral peak prominence (CPPs)] measures (Maryn, De Bodt, & Roy, 2010b). The formula of the index is 2.571 [3.295 - 0.111 CPPs - 0.073 HNR - 0.213 shimmer local + 2.789 shimmer local dB - 0.032 slope + 0.077 tilt] and ranges from 0 to 10. A higher index indicates a worse vocal quality. The threshold score separating normophonic from dysphonic persons in Dutch is 2.95 (Maryn et al., 2010a). AVQI (version 02.03) was calculated on an audio recording of a sustained /a/ vowel and the first two sentences of the Dutch phonetically balanced text “Papa en Marloes” (Van de Weijer and Slis, 1991) using the software program PRAAT version 6.0.14 (Boersma and Weenink).

Dysphonia Severity Index (DSI). The DSI is a multiparametric approach designed to establish an objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000). The index is based on a weighted combination of the following parameters: MPT (in s), highest frequency (F-high, in Hz), lowest intensity (I-low, in dB) and jitter (in %). The DSI is constructed as 0.13 MPT + 0.0053 F-high − 0.26 I-low − 1.18 jitter + 12.4. The index ranges from -5 to +5 for severely dysphonic to normal voices. A more negative index indicates a worse vocal quality. Values higher than 5 are possible in subjects with excellent vocal capacities. A DSI of 1.6 is the threshold separating normophonic from dysphonic persons (Raes et al., 2002).

Subject's self-report. Subjects filled in the Dutch version of the Voice Handicap index (VHI) to evaluate the psychosocial impact of the voice disorder (Jacobson et al., 1997; De Bodt et al., 2000). The VHI is a self-rating questionnaire consisting of 30 statements, evaluating functional (10 statements, F-scale), physical (10 statements, P-scale), and emotional (10 statements, E-scale) restrictions. Every statement is scored on a 5-point Likert scale (0: never, 1: almost never, 2: sometimes; 3: almost always; 4: always). The total VHI-score ranges from 0 to 120 with higher scores indicating greater impacts. Subjects also completed the Dutch version of the Vocal Tract Discomfort Scale (VTDS) (Mathieson et al., 2009; Luyten et al. 2016). This scale consists of eight sensations that can be felt in or around the throat: burning, tight, dry, aching, tickling, sore, irritable and globus. Each item should be scored on frequency (never, seldom, sometimes, more than sometimes, often, very often, always) and severity (no, almost no, limited, more than limited, moderate, more than moderate, severe perception) using a 7-point Likert scale. The total VTDS score (sum of frequency and severity) can range from 0 to 96 with higher scores indicating more discomfort. An additional questionnaire based on the checklists of Russell et al. (2000), De Bodt et al. (2008b) and Van Lierde et al. (2010b, 2010c) was presented at baseline to explore voice-related symptoms, risk factors, vocal abuse, vocal load and lifestyle habits.

Auditory-perceptual evaluation. For the auditory-perceptual evaluation of the subjects' voices, the GRBASI scale was used (Hirano, 1981; completed with an "I" parameter by Dejonckere et al., 1996). The six parameters “overall grade of hoarseness” (G), “roughness” (R), “breathiness” (B), “asthenia” (A), “strain” (S), and “instability” (I) were scored using a 4-point grading scale (0: absent, 1: mild, 2: moderate, 3: severe). Subjects sustained the vowel /a/ for at least 3 seconds and read aloud the Dutch phonetically balanced text “Papa en

Marloes" (Van de Weijer & Slis, 1991) while voice samples were audio recorded using a C01U USB Studio Condenser Microphone (Samson) and the software program PRAAT version 6.0.14 (Boersma & Weenink). Samples were randomized and rated blindly by the same SLP experienced in voice diagnostics (K.B.). To assure interrater reliability, 20% of the samples were judged at random, blindly and independently by another SLP experienced in voice diagnostics (I.M.).

Flexible videolaryngostroboscopic examinations were performed by an otorhinolaryngologist with more than 20 years of experience in voice disorders (S.C.) at the department of Otorhinolaryngology at Ghent University Hospital. Time points of the examinations were at baseline, after 3 months, after 6 months, and after 1 year. An additional flexible videolaryngostroboscopy was performed after two weeks (posttherapy) in the IVT groups. Subjects were asked to produce the sustained vowel /i/ at habitual pitch and loudness followed by a low-to-high glissando. The function and aspect of the vocal folds were evaluated using a standardized evaluation protocol during habitual phonation (Remacle, 1996; Van Lierde et al., 2010d; D'haeseleer et al., 2016). Evaluation was based on the following indicators: symmetry (symmetrical or asymmetrical), regularity (regular, irregular or inconsistent), glottal closure (complete, incomplete or inconsistent), type of gap (longitudinal, posterior, anterior, irregular, oval or hourglass), amplitude (increased, normal, reduced or none), mucosal wave (normal, reduced or none), aspect (normal, organic lesion, and color), and presence and type of organic lesion. Potential supraglottic constrictions were observed in two directions, mediolateral (M-L) and anterior-posterior (A-P), using the SERF protocol (Poburka, 1999). The SERF protocol pictures a laryngeal image with concentric circles. Constrictions were evaluated using a 6-point grading scale (0 = no constriction, 5 = complete constriction). Samples were randomized and rated blindly by the same SLP experienced in voice diagnostics (I.M.). To assure interrater reliability, 20% of the samples were judged at random, blindly and independently by another SLP experienced in voice diagnostics (E.D.).

Statistical analysis

SPSS version 25 (SPSS Corporation, Chicago, IL) was used for the statistical analysis of the data. Analyses were conducted at $\alpha = 0.05$. Fisher's Exact tests were used to compare the groups regarding self-reported voice-related symptoms, risk factors, vocal abuse and lifestyle habits. ICC(3,2) models (two-way mixed, consistency type) and Cohen's κ were run to determine interrater reliability of the ordinal and nominal data, respectively.

Linear mixed models were used to compare groups over time on each continuous outcome measure, using the restricted maximum likelihood estimation and scaled identity covariance structure. Time, group, and time-by-group interaction were specified as fixed factors. A random intercept for subjects was included. Model assumptions were checked by inspecting whether residuals were normally distributed. Generalized linear mixed models were used for the categorical outcome measures. Within-group effects of time were determined using pairwise comparisons.

Due to the high number of outcome parameters, a subset was selected as "primary" outcome parameters, i.e. the multiparametric indices (DSI and AVQI), the auditory-perceptual evaluations (GRBASI), and the patient's self-report (VHI and VTDS). These "primary" outcome parameters were used in all analyses, whereas the other, "secondary" parameters were solely used in the pre- to post-therapy comparisons.

RESULTS

Baseline results

Voice-related symptoms, risk factors, vocal abuse, vocal load and lifestyle habits

Table 6.6 presents the results of the questionnaire on voice-related symptoms, risk factors, vocal abuse, vocal load and lifestyle habits in the IVI-I, IVT-G and TVT groups. Fischer's exact tests showed no significant differences in baseline occurrence between the three groups.

Professions and studies

Participants' professions and studies are summarized per group in Table 6.7. A similar distribution of occupational versus non-occupational voice users and employees versus students were found for the IVT-I and TVT groups. The IVT-G group consisted only of SLP students.

Baseline outcome parameters

The two baseline measures of each outcome parameter did not significantly differ in any group. The mean of the two baseline measures was used for further analyses. Baseline parameters were also not significantly different between the three groups, except for the VHI which was higher in the TVT group compared with the IVT-G group (EM difference: 23, $p < 0.001$).

Table 6.6 Baseline voice-related symptoms, risk factors, vocal abuse, vocal load and lifestyle habits in the IVT-I, IVT-G and TVT groups.

		Occurrence				
	Group	Daily	Weekly	Monthly	Never	*p*-value
Voice-related symptoms						
Hoarseness	IVT-I	3	5	7	0	0.360
	IVT-G	4	2	8	1	
	TVT	6	6	4	0	
Aphonia	IVT-I	0	1	4	10	0.503
	IVT-G	0	0	2	13	
	TVT	0	0	5	11	
Vocal fatigue	IVT-I	5	2	6	2	0.252
	IVT-G	1	1	7	6	
	TVT	6	3	4	3	
Shortness of breath while speaking	IVT-I	1	3	3	8	0.827
	IVT-G	1	1	3	10	
	TVT	3	2	4	7	
Changes in habitual pitch	IVT-I	4	2	4	5	0.222
	IVT-G	0	2	3	10	
	TVT	5	1	4	6	
Reduced pitch range	IVT-I	3	3	4	5	0.248
	IVT-G	2	3	4	6	
	TVT	9	1	3	3	
Globus sensation	IVT-I	2	5	2	6	0.204
	IVT-G	1	0	4	10	
	TVT	2	3	5	6	
Sore throat	IVT-I	1	4	8	2	0.821
	IVT-G	0	2	9	4	
	TVT	1	5	7	3	
Dry throat	IVT-I	1	8	4	2	0.426
	IVT-G	5	4	3	3	
	TVT	4	5	6	1	
Tight throat	IVT-I	3	3	4	5	0.636
	IVT-G	1	1	4	9	
	TVT	3	4	3	6	

Table 6.6 *(Continued)*

		Occurrence				
	Group	Daily	weekly	monthly	Never	*p*-value
Tickling throat	IVT-I	2	2	5	6	0.406
	IVT-G	1	2	7	5	
	TVT	2	7	4	3	
Burning throat	IVT-I	1	2	5	7	0.441
	IVT-G	3	3	2	7	
	TVT	0	5	5	6	
Risk factors						
Reflux	IVT-I	1	1	6	7	0.983
	IVT-G	1	1	4	9	
	TVT	1	1	4	10	
Allergies	IVT-I	2	0	3	10	0.725
	IVT-G	1	0	5	9	
	TVT	2	0	2	12	
Upper respiratory tract infections	IVT-I	1	1	7	6	0.853
	IVT-G	0	1	6	8	
	TVT	1	0	9	6	
Contact with irritating substances (paint, glue etc.)	IVT-I	0	2	4	9	0.687
	IVT-G	0	0	3	12	
	TVT	0	1	3	12	
Stress	IVT-I	2	3	9	1	0.873
	IVT-G	3	5	5	2	
	TVT	4	4	7	1	
Vocal abuse						
Coughing	IVT-I	4	1	6	4	0.753
	IVT-G	2	4	5	4	
	TVT	2	3	8	3	
Throat clearing	IVT-I	4	2	6	3	0.250
	IVT-G	5	2	1	7	
	TVT	3	4	6	3	
Whispering	IVT-I	1	4	9	1	0.351
	IVT-G	3	4	4	4	
	TVT	3	7	4	2	
Screaming or yelling	IVT-I	3	2	7	3	0.139
	IVT-G	0	4	10	1	
	TVT	0	5	6	5	
Imitating voices or sounds	IVT-I	1	2	3	9	>0.999
	IVT-G	1	3	2	9	
	TVT	0	3	3	10	
Hard glottal onset	IVT-I	4	4	1	6	0.158
	IVT-G	3	0	6	6	
	TVT	3	4	5	4	
Singing or acting without technique	IVT-I	1	2	2	10	0.890
	IVT-G	2	2	3	8	
	TVT	0	3	4	9	
Vocal load						
Speaking at inappropriate loudness	IVT-I	4	3	3	5	0.898
	IVT-G	2	4	5	4	
	TVT	3	6	3	4	

Table 6.6 *(Continued)*

	Group	Occurrence Daily	Weekly	Monthly	Never	*p*-value
Speaking at heightened pitch	IVT-I	2	2	3	8	0.737
	IVT-G	0	1	2	12	
	TVT	1	3	2	10	
Strained phonation	IVT-I	3	4	4	4	0.219
	IVT-G	1	2	3	9	
	TVT	6	4	1	5	
Speaking for a large audience	IVT-I	2	3	2	8	0.553
	IVT-G	0	2	1	12	
	TVT	3	2	3	8	
Speaking in large spaces	IVT-I	2	2	1	10	0.424
	IVT-G	0	2	5	8	
	TVT	3	1	3	9	
Speaking in air-conditioned rooms	IVT-I	3	0	3	9	0.570
	IVT-G	0	1	4	10	
	TVT	2	2	4	8	
Speaking in rooms with insufficient humidity	IVT-I	3	1	3	8	0.891
	IVT-G	2	1	2	10	
	TVT	4	0	4	8	
Speaking for a long period of time without vocal rest	IVT-I	4	1	1	9	0.408
	IVT-G	1	3	4	7	
	TVT	4	4	2	6	
Hobbies with high vocal load	IVT-I	1	4	0	10	0.198
	IVT-G	0	7	2	6	
	TVT	0	4	4	8	
Professional voice use	IVT-I	3	0	0	12	0.163
	IVT-G	0	0	0	15	
	TVT	4	0	0	12	
Lifestyle habits						
Eating late and heavy food	IVT-I	5	1	5	4	0.335
	IVT-G	1	2	6	6	
	TVT	1	1	10	4	
Alcohol use	IVT-I	1	7	5	2	0.850
	IVT-G	1	5	6	3	
	TVT	0	8	7	1	
Smoking	IVT-I	0	0	0	10	-
	IVT-G	0	0	0	10	
	TVT	0	0	0	10	
Coffee or tea	IVT-I	9	2	0	4	0.277
	IVT-G	4	4	2	5	
	TVT	7	6	0	3	
Soft drinks, carbonated drinks	IVT-I	4	5	3	3	0.603
	IVT-G	3	6	1	5	
	TVT	5	8	2	1	
Going out	IVT-I	0	7	7	1	0.916
	IVT-G	0	9	5	1	
	TVT	0	7	8	1	
Sleep deprivation	IVT-I	1	8	6	0	0.766
	IVT-G	1	6	7	1	
	TVT	1	4	10	1	

Table 6.7 Professions and studies of the participants in the IVT-I, IVT-G and TVT groups.

	IVT-I	IVT-G	TVT
Professions			
Teacher	2	0	1
Nurse	1	0	0
Home care	0	0	1
Assistant medical staff	0	0	1
Supervisor living group patients with dementia	0	0	1
Studies			
Speech-language pathology	10	15	10
Linguistics & literature	0	0	1
Physical education	1	0	0
Civil engineering	0	0	1
Business engineering	1	0	0

Pre- to post-therapy evolution

Primary outcome parameters

Multiparametric indices. Table 6.8 shows the evolution of the multiparametric indices DSI and AVQI pre- to post-therapy in the three groups. No significant time-by-group interactions were found, which indicates no significant differences in evolution between the three groups. More-in depth within-group analyses showed that the DSI significantly improved after therapy in all three groups (IVT-I: +3.1; IVT-G: +3.2; TVT: +3.0; $p < 0.001$). The AVQI did improve in the three groups as well, although not significantly (IVT-I: -0.64; IVT-G: -0.46; TVT: -0.55). A graphical representation of the evolution of DSI and AVQI can be found in Figures 6.8 and 6.9, respectively.

Patient's self-report. The pre- to post-therapy evolution of VHI and VTDS is presented in Table 6.9. A significant time-by-group interaction was found for VHI, that only significantly improved in the TVT group (-13, $p = 0.001$). The VTDS, on the contrary, only significantly improved in the IVT-I group (-8, $p = 0.003$) but showed no significant interaction effect. A graphical representation of the evolution of VHI and VTDS can be found in Figures 6.10 and 6.11, respectively.

Auditory-perceptual evaluation. No significant time-by-group interactions were found for the auditory-perceptual evaluation (Table 6.10). Within-group analyses showed a significantly improved grade after both IVT-I and TVT. Roughness evolved in advantage of both IVT groups, strain evolved in advantage of the IVT-I group and asthenia in advantage of the TVT group. Excellent degrees of interrater reliability were found for G, S and I with average measure ICC's of 0.85, 0.84, and 0.78. Good degrees of interrater reliability were found R, B and A with average measure ICC's of 0.72, 0.64, and 0.68, respectively.

Flexible videolaryngostroboscopic evaluation. Results of the flexible videolaryngostroboscopic evaluation are presented in Table 6.11. Positive trends were found for the three groups. Occurrence of organic lesions significantly decreased with 40% (4/15) in the IVT-G group (p = 0.031). Excellent degrees of interrater reliability were found for "presence and type of organic lesion" with κ = 0.80, and "degree of anteroposterior supraglottic activity" with ICC = 0.84. Good degrees of interrater reliability were found for "symmetry", "presence and type of incomplete glottal closure", "amplitude" and "degree of mediolateral supraglottic activity" with κ = 0.65, κ = 0.57, κ = 0.67, and ICC = 0.71, respectively. Moderate degrees of reliability were found for "regularity" and "mucosal wave", with κ = 0.52, and κ = 0.68, respectively.

<u>Secondary outcome parameters</u>

Table 6.12 shows the evolution of the secondary outcome parameters. No significant time-by-group interactions were found for the parameters MPT, VC, PQ, jitter, shimmer, vf$_o$, CPPS, HNR, shimmerlocal (%), shimmerlocal (dB), slope of LTAS, tilt of trendline through LTAS, I-low, I-high and F-low, meaning that the evolution of these parameters did not significantly differ between the three groups. More in-depth within-group analyses showed that the evolution of MPT is in advantage of the TVT group (+3.8, p = 0.008), whereas the acoustic measures jitter, shimmer, vF$_o$, CPPS, HNR and shimmerlocal (%) evolved in advantage of the IVT groups. Jitter significantly improved in both the IVT-I and IVT-G groups (IVT-I: -0.88, p = 0.018; IVT-G: -0.93, p = 0.013). Shimmer and vf$_o$ significantly improved in the IVT-G group (shimmer: -1.45, p = 0.013; vf$_o$: -0.81, p = 0.032); CPPS, HNR and shimmerlocal(%) significantly improved in the IVT-I group (CPPS: +1.32, p = 0.006; HNR: +1.46, p = 0.049; shimmerlocal(%): -1.61, p = 0.047). The voice range measure I-low significantly improved in all three groups with a preference for the IVT groups (IVT-I: -4.7, p < 0.001; TVT: -4.0, p < 0.001; TVT: -2.7, p = 0.010).

A significant time-by-group interaction was found for the parameters NHR and F-high. NHR significantly improved in the IVT-G (-0.04, $p = 0.002$) but not in the other two groups. F-high significantly improved in all three groups with a preference for the IVT-G and TVT groups (IVT-I: +111.2, $p = 0.005$; IVT-G: +184.5, $p < 0.001$; TVT: +185.2, $p < 0.001$). The TVT group caught up with the other two groups by making the largest improvement starting from the lowest baseline.

Table 6.8 Evolution of the multiparametric indices DSI and AVQI pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

		Baseline 1	Baseline 2	Post	Time*Group	Evolution mean baseline - post
Parameter	Group	EM [95% CI]	EM [95% CI]	EM [95% CI]	*p*-value	EM difference
DSI	IVT-I	-1.0 [-2.2, +0.2]	-0.9 [-2.1, +0.3]	+2.1 [+0.9, +3.3]		**+3.1 (*)**
	IVT-G	+0.1 [-0.9, +1.4]	+0.3 [-0.7, +1.6]	+3.4 [+2.3, +4.7]	0.975	**+3.2 (*)**
	TVT	-1.3 [-2.5, -0.2]	-0.8 [-2.0, +0.3]	+1.9 [+0.6, +3.1]		**+3.0 (*)**
AVQI	IVT-I	4.65 [4.05, 5.23]	4.29 [3.75, 4.84]	3.83 [3.28, 4.38]		**-0.64**
	IVT-G	4.07 [3.48, 4.67]	4.11 [3.57, 4.64]	3.63 [3.09, 4.17]	0.916	**-0.46**
	TVT	4.75 [4.24, 5.36]	4.65 [4.07, 5.13]	4.15 [3.58, 4.73]		**-0.55**

Note: EM, estimated mean; CI, confidence interval; DSI, Dysphonia Severity Index; AVQI, Acoustic Voice Quality Index. * indicates a significant effect.

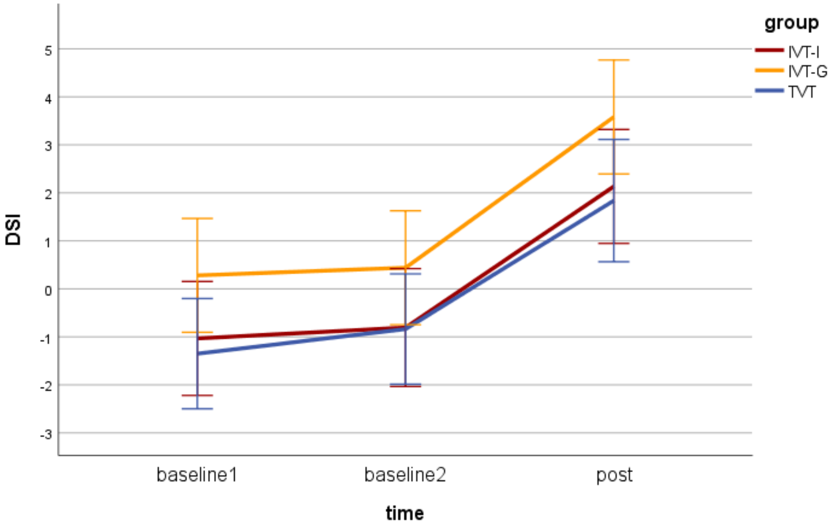


Figure 6.8 Evolution of DSI pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

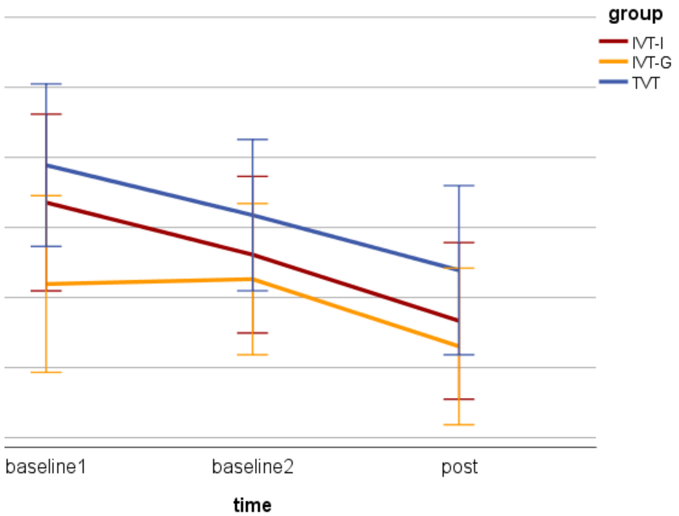


Figure 6.9 Evolution of AVQI pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

Table 6.9 Evolution of the self-reported VHI and VTDS pre- to post-therapy in the IVT-I, IV-G and TVT groups.

		Baseline	**Post**	**Time*Group**	**Evolution baseline - post**
Parameter	Group	EM [95% CI]	EM [95% CI]	*p*-value	EM difference
VHI	IVT-I	26 [18, 35]	22 [16, 33]	0.018*	**-4**
	IVT-G	13 [5, 22]	9 [1, 18]		**-4**
	TVT	36 [28, 45]	23 [16, 34]		**-13 (*)**
VTDS	IVT-I	29 [21, 37]	21 [13, 29]	0.314	**-8 (*)**
	IVT-G	22 [15, 30]	19 [12, 27]		**-3**
	TVT	34 [27, 42]	30 [23, 38]		**-4**

Note: EM, estimated mean; CI, confidence interval; VHI, Voice Handicap Index; VTDS, Vocal Tract Discomfort Scale. * indicates a significant effect.

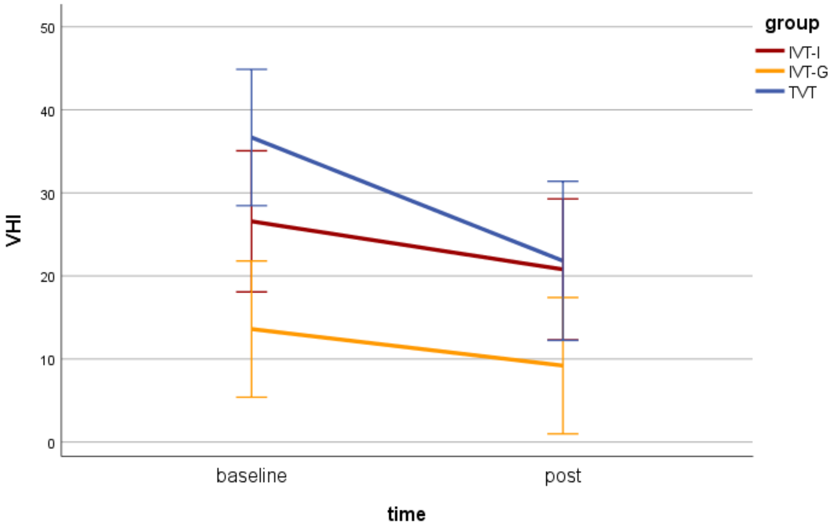


Figure 6.10 Evolution of VHI pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

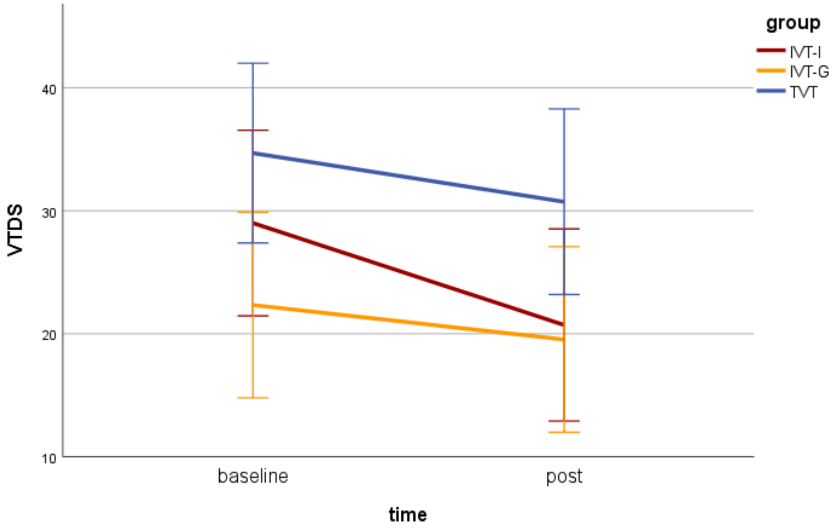


Figure 6.11 Evolution of VTDS pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

Table 6.10 Auditory-perceptual evolution pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

		Baseline 1		**Baseline 2**		**Post**		**Time*group**	**Wilcoxon Signed Ranks test**
Parameter	Group	Median [IQR)	Mean [SD]	Median [IQR]	Mean [SD]	Median [IQR]	Mean [SD]	*p*-value	*p*-value
G	IVT-I	1 [1, 2]	1.4 [0.7]	1 [1, 1]	1.1 [0.5]	1 [0, 1]	0.8 [0.8]	0.204	0.025 (*)
	IVT-G	1 [0, 1]	0.8 [0.6]	1 [1, 1]	0.9 [0.5]	1 [1, 1]	0.8 [0.4]		0.783
	TVT	1 [1, 2]	1.4 [0.7]	1 [1, 2]	1.3 [0.7]	1 [1, 1]	0.9 [0.5]		0.007 (*)
R	IVT-I	1 [0.75, 1.25]	1.1 [0.9]	1 [1, 2]	1.1 [0.7]	1 [0, 1]	0.6 [0.5]	0.990	0.022 (*)
	IVT-G	0.5 [0, 1]	0.6 [0.7]	1 [0.75, 1]	0.8 [0.4]	0 [0, 1]	0.3 [0.5]		0.009 (*)
	TVT	0 [0, 1]	0.5 [0.8]	0 [0, 1]	0.6 [0.7]	0 [0, 0]	0.2 [0.4]		0.071
B	IVT-I	1 [0, 1]	0.8 [0.6]	1 [0, 1]	0.7 [0.6]	1 [0, 1]	0.8 [0.8]	0.741	0.581
	IVT-G	0 [0, 1]	0.5 [0.7]	0 [0, 1]	0.5 [0.8]	1 [0, 1]	0.7 [0.5]		0.107
	TVT	1 [0.5, 1.5]	1.0 [0.7]	1 [0.25, 1]	0.9 [0.6]	1 [0, 1]	0.8 [0.7]		0.633
A	IVT-I	1 [0, 1]	0.6 [0.5]	0 [0, 1]	0.3 [0.5]	0 [0, 1]	0.3 [0.5]	0.654	0.527
	IVT-G	0 [0, 0.25]	0.2 [0.4]	0 [0, 0.25]	0.2 [0.4]	0 [0, 0]	0.1 [0.4]		0.480
	TVT	1 [0, 1]	0.9 [0.9]	0.5 [0, 1]	0.7 [0.7]	0 [0, 1]	0.3 [0.6]		0.031 (*)
S	IVT-I	0.5 [0, 1]	0.5 [0.5]	0 [0, 1]	0.5 [0.5]	0 [0, 0]	0.1 [0.4]	0.876	0.015 (*)
	IVT-G	0 [0, 1]	0.3 [0.5]	0 [0, 0.25]	0.3 [0.6]	0 [0, 0]	0.1 [0.4]		0.257
	TVT	0 [0, 1.5]	0.5 [0.9]	0 [0, 1]	0.6 [0.8]	0 [0, 1]	0.4 [0.7]		0.389
I	IVT-I	0 [0, 0.25]	0.3 [0.7]	0 [0, 0]	0.1 [0.4]	0 [0, 0]	0.1 [0.3]	0.908	0.461
	IVT-G	0 [0, 0]	0 [0]	0 [0, 0]	0.1 [0.3]	0 [0, 0]	0.1 [0.4]		0.564
	TVT	0 [0, 1]	0.4 [0.7]	0 [0, 1]	0.3 [0.5]	0 [0, 0]	0.3 [0.6]		0.892

Note: IQR, interquartile range; G, grade; R, roughness; B, breathiness; S, strain; I, instability. * indicates a significant effect.

Table 6.11 Videolaryngostroboscopic evolution pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

			Baseline	**Post**	**Evolution baseline - post**	**McNemar Test**
Parameter		Group	% (ratio)	% (ratio)	% (ratio)	*p*-value
Asymmetrical vocal fold vibration		IVT-I	33.3 (3/9)	11.1 (1/9)	-22.2 (-2/9)	0.625
		IVT-G	44.4 (4/9)	11.1 (1/9)	-33.3 (-3/9)	0.125
		TVT	36.4 (4/11)	36.4 (4/11)	0	>0.999
Irregular vocal fold vibration		IVT-I	11.1 (1/9)	11.1 (1/9)	0	>0.999
		IVT-G	22.2 (2/9)	0 (0/9)	-22.2 (-2/9)	0.500
		TVT	18.2 (2/11)	9.1 (1/11)	-9.1 (-1/11)	>0.999
Incomplete glottal closure		IVT-I	90.9 (10/11)	81.8 (9/11)	-9.1 (-1/11)	0.625
		IVT-G	100 (12/12)	66.7 (8/12)	-33.3 (-4/12)	0.125
		TVT	100 (12/12)	83.3 (10/12)	-16.7 (-2/12)	0.500
Type of glottal gap	Longitudinal	IVT-I	9.1 (1/11)	0 (0/11)	-9.1 (-1/11)	
		IVT-G	9.1 (1/11)	0 (0/11)	-9.1 (-1/11)	
		TVT	8.3 (1/12)	0 (0/12)	-8.3 (-1/12)	
	Posterior	IVT-I	27.3 (3/11)	18.2 (2/11)	-9.1 (-1/11)	
		IVT-G	36.4 (4/11)	45.5 (5/11)	+9.1 (+1/11)	
		TVT	41.7 (5/12)	0 (0/12)	-41.7 (-5/12)	
	Anterior	IVT-I	9.1 (1/11)	9.1 (1/11)	0	
		IVT-G	0 (0/11)	0 (0/11)	0	
		TVT	0 (0/12)	0 (0/12)	0	
	irregular	IVT-I	9.1 (1/11)	0 (0/11)	-9.1 (-1/11)	
		IVT-G	9.1 (1/11)	0 (0/11)	-9.1 (-1/11)	
		TVT	16.7 (2/12)	8.3 (1/12)	-8.4 (-1/12)	
	Oval	IVT-I	0 (0/11)	0 (0/11)	0	
		IVT-G	0 (0/11)	0 (0/11)	0	
		TVT	0 (0/12)	0 (0/12)	0	
	Hourglass	IVT-I	36.4 (4/11)	9.1 (1/11)	-27.3 (-3/11)	
		IVT-G	54.5 (6/11)	27.3 (3/11)	-27.2 (-3/11)	
		TVT	33.3 (4/12)	16.7 (2/12)	-16.6 (-2/12)	
Reduced amplitude		IVT-I	22.2 (2/9)	0 (0/9)	-22.2 (-2/9)	0.250
		IVT-G	33.3 (3/9)	0 (0/9)	-33.3 (-3/9)	0.500
		TVT	45.5 (5/11)	18.2 (2/11)	-27.3 (-3/11)	0.250
Reduced mucosal wave		IVT-I	44.4 (4/9)	11.1 (1/9)	-33.3 (-3/9)	0.250
		IVT-G	33.3 (3/9)	0 (0/9)	-33.3 (-3/9)	0.250
		TVT	45.5 (5/11)	36.4 (4/11)	-9.1 (-1/11)	>0.999

Table 6.11 *(Continued)*

		Baseline	Post	Evolution baseline - post	McNemar Test
Parameter	Group	% (ratio)	% (ratio)	% (ratio)	*p*-value
Organic lesion	IVT-I	46.7 (7/15)	40.0 (6/15)	-6.7 (-1/15)	>0.999
	IVT-G	66.7 (10/15)	26.7 (6/15)	-40 (-4/15)	0.031 (*)
	TVT	61.5 (8/13)	53.8 (7/13)	-7.7 (-1/13)	>0.999
Type of organic lesion					
Irritation and mucus stasis anterior 1/3 true vocal fold	IVT-I	13.3 (2/15)	26.6 (4/15)	+13.3 (+2/15)	
	IVT-G	6.7 (1/15)	6.7 (1/15)	0	
	TVT	7.7 (1/13)	15.4 (2/13)	+7.7 (+1/13)	
Beginning vocal fold nodules (“soft” nodules)	IVT-I	13.3 (2/15)	13.3 (2/15)	0	
	IVT-G	26.7 (4/15)	13.3 (2/15)	+13.3 (+2/15)	
	TVT	38.5 (5/13)	30.8 (4/13)	-7.7 (-1/13)	
Vocal fold nodules (“hard” nodules)	IVT-I	13.3 (2/15)	0	-13.3 (-2/15)	
	IVT-G	0	0	0	
	TVT	0	0	0	
Edema	IVT-I	6.7 (1/15)	0	-6.7 (-1/15)	
	IVT-G	26.7 (4/15)	6.7 (1/15)	-20 (-3/15)	
	TVT	15.4 (2/13)	7.7 (1/13)	-7.7 (-1/13)	
Polyp	IVT-I	0	0	0	
	IVT-G	6.7 (1/15)	0	-6.7 (-1/15)	
	TVT	0	0	0	
Supraglottic activity	IVT-I	61.5 (8/13)	53.8 (7/13)	-7.7 (-1/13)	>0.999
	IVT-G	53.8 (7/13)	53.8 (7/13)	0	>0.999
	TVT	63.6 (7/11)	54.5 (6/11)	-9.1 (1/11)	>0.999

* indicates a significant effect.

Table 6.12 Evolution of the secondary outcome parameters pre- to post-therapy in the IVT-I, IVT-G and TVT groups.

		Baseline 1	**Baseline 2**	**Post**	**Time*Group**	**Evolution mean baseline - post**
Parameter	Group	EM [95% CI]	EM [95% CI]	EM [95% CI]	*p*-value	EM difference
Maximum performance task						
MPT (s)	IVT-I	15.9 [12.4, 19.5]	16.1 [12.5, 19.7]	18.3 [14.8, 21.9]	0.592	**+2.3**
	IVT-G	17.6 [14.1, 21.1]	17.7 [14.2, 21.2]	18.7 [15.2, 22.1]		**+1.1**
	TVT	15.1 [11.7, 18.5]	15.6 [12.1, 19.0]	19.1 [15.5, 22.7]		**+3.8 (*)**
Aerodynamic assessment						
VC (cc)	IVT-I	2449 [2161, 2736]	2551 [2296, 2807]	2517 [2276, 2757]	0.893	**+17**
	IVT-G	2544 [2298, 2791]	2519 [2282, 2756]	2512 [2271, 2753]		**-20**
	TVT	2403 [2170, 2636]	2371 [2139, 2605]	2313 [2062, 2563]		**-74**
PQ (cc/s)	IVT-I	179.2 [146.4, 211.9]	167.0 [137.9, 196.0]	156.6 [129.3, 183.8]	0.438	**-16.5**
	IVT-G	154.4 [126.5, 182.4]	152.0 [125.1, 178.9]	144.4 [117.0, 171.8]		**-8.8**
	TVT	184.6 [158.2, 211.0]	170.1 [143.7, 196.5]	141.2 [112.7, 169.6]		**-36.2 (*)**
Acoustic analysis (/a/ vowel, MDVP, Kay)						
f_o (Hz)	IVT-I	194.0 [181.2, 206.9]	191.7 [178.7, 204.7]	194.3 [181.5, 207.2]	0.290	**+1.5**
	IVT-G	204.3 [191.8, 216.9]	203.7 [191.2, 216.3]	211.6 [199.0, 224.1]		**+7.6 (*)**
	TVT	202.9 [190.1, 215.6]	206.1 [193.7, 218.6]	202.9 [190.1, 215.6]		**-1.6**
Jitter (%)	IVT-I	2.69 [2.15, 3.23]	2.67 [2.12, 3.23]	1.80 [1.26, 2.34]	0.723	**-0.88 (*)**
	IVT-G	2.10 [1.56, 2.64]	2.19 [1.65, 2.72]	1.22 [0.68, 1.76]		**-0.93 (*)**
	TVT	2.97 [2.45, 3.50]	2.49 [1.97, 3.01]	2.13 [1.55, 2.71]		**-0.60**
Shimmer (%)	IVT-I	6.11 [5.16, 7.07]	5.49 [4.50, 6.48]	5.13 [4.17, 6.09]	0.722	**-0.67**
	IVT-G	6.30 [5.34, 7.25]	6.13 [5.17, 7.08]	4.77 [3.81, 5.72]		**-1.45 (*)**
	TVT	5.83 [4.90, 6.76]	5.92 [4.99, 6.85]	4.93 [3.91, 5.94]		**-0.95**
vf_o (%)	IVT-I	2.68 [2.16, 3.19]	2.40 [1.86, 2.93]	1.80 [1.29, 2.32]	0.830	**-0.74**
	IVT-G	1.95 [1.43, 2.47]	2.10 [1.59, 2.62]	1.22 [0.70, 1.74]		**-0.81 (*)**
	TVT	2.75 [2.23, 3.27]	2.33 [1.83, 2.83]	1.86 [1.31, 2.42]		**-0.68**
NHR	IVT-I	0.15 [0.13, 0.18]	0.14 [0.13, 0.16]	0.15 [0.14, 0.16]	0.023 (*)	**+0.01**
	IVT-G	0.16 [0.14, 0.18]	0.16 [0.14, 0.18]	0.12 [0.11, 0.14]		**-0.04 (*)**
	TVT	0.15 [0.13, 0.17]	0.15 [0.13, 0.16]	0.14 [0.13, 0.16]		**-0.01**
Acoustic analysis (/a/ vowel + continuous speech, Praat, AVQI)						
CPPS	IVT-I	10.52 [9.67, 11.36]	11.02 [10.24, 11.79]	12.09 [11.32, 12.87]	0.664	**+1.32 (*)**
	IVT-G	11.46 [10.63, 12.30]	11.53 [10.78, 12.28]	12.33 [11.56, 13.09]		**+0.84**
	TVT	10.72 [9.93, 11.51]	10.64 [9.89, 11.38]	11.40 [10.59, 12.21]		**+0.72**

Table 6.12 *(Continued)*

		Baseline 1	**Baseline 2**	**Post**	**Time*Group**	**Evolution mean baseline - post**
Parameter	Group	EM [95% CI]	EM [95% CI]	EM [95% CI]	*p*-value	EM difference
HNR (dB)	IVT-I	15.36 [14.04, 16.68]	15.91 [14.71, 17.11]	17.09 [15.89, 18.29]	0.832	**+1.46 (*)**
	IVT-G	16.22 [14.91, 17.54]	15.67 [14.51, 16.83]	17.04 [15.85, 18.23]		**+1.10**
	TVT	16.08 [14.85, 17.31]	15.67 [14.52, 16.83]	17.05 [15.78, 18.32]		**+1.18**
Shimmer Local (%)	IVT-I	7.45 [6.27, 8.63]	6.23 [5.18, 7.29]	5.23 [4.18, 6.29]	0.149	**-1.61 (*)**
	IVT-G	5.57 [4.39, 6.75]	6.19 [5.16, 7.21]	4.73 [3.67, 5.78]		**-1.15**
	TVT	6.17 [5.08, 7.26]	7.32 [6.30, 8.34]	5.90 [4.77, 7.04]		**-0.85**
Shimmer Local (dB)	IVT-I	0.69 [0.58, 0.79]	0.59 [0.50, 0.69]	0.52 [0.43, 0.62]	0.405	**-0.12**
	IVT-G	0.54 [0.43, 0.64]	0.58 [0.49, 0.68]	0.46 [0.37, 0.56]		**-0.10**
	TVT	0.63 [0.54, 0.73]	0.70 [0.61, 0.79]	0.59 [0.49, 0.69]		**-0.08**
Slope of LTAS (dB)	IVT-I	-21.99 [-24.38, -19.60]	-20.51 [-22.72, -18.31]	-19.61 [-21.81, -17.41]	0.834	**+1.64**
	IVT-G	-20.40 [-22.77, -18.03]	-19.13 [-21.26, -17.00]	-19.17 [-21.35, -17.00]		**+0.60**
	TVT	-21.26 [-23.51, -19.02]	-19.79 [-21.92, -17.76]	-20.58 [-22.89, -18.28]		**+0.06**
Tilt of trendline through LTAS (dB)	IVT-I	-9.64 [-10.37, -8.91]	-9.90 [-10.56, -9.23]	-9.82 [-10.49, -9.15]	0.486	**-0.05**
	IVT-G	-10.04 [-10.76, -9.31]	-9.75 [-10.40 -9.10]	-9.74 [-10.41, -9.08]		**+0.16**
	TVT	-9.05 [-9.73, -8.36]	-9.45 [-10.10, -8.80]	-9.73 [-10.43, -9.02]		**-0.48**
Voice Range Profile						
I-low (dB)	IVT-I	60.9 [59.3, 62.6]	59.8 [58.1, 61.5]	55.7 [54.1, 57.4]	0.336	**-4.7 (*)**
	IVT-G	59.0 [57.3, 60.6]	59.2 [57.6, 60.9]	55.1 [53.4, 56.7]		**-4.0 (*)**
	TVT	58.8 [57.1, 60.4]	59.1 [57.4, 60.7]	56.3 [54.6, 58.1]		**-2.7 (*)**
I-high (dB)	IVT-I	99.2 [96.6, 101.8]	98.4 [95.7, 101.0]	101.1 [98.5, 103.7]	0.354	**+2.3**
	IVT-G	97.0 [94.4, 98.6]	98.9 [96.4, 101.5]	100.5 [98.0, 103.1]		**+2.6**
	TVT	98.9 [96.4, 101.5]	98.7 [96.2, 101.2]	101.0 [98.3, 103.7]		**+2.2**
F-low (Hz)	IVT-I	145.9 [133.8, 158.0]	146.5 [134.3, 158.8]	142.4 [130.3, 154.5]	0.891	**-3.8**
	IVT-G	155.6 [143.7, 167.5]	157.6 [145.7, 169.4]	149.9 [138.0, 161.7]		**-6.7**
	TVT	152.5 [140.8, 164.2]	153.5 [141.8, 165.2]	152.0 [139.8, 164.1]		**-1.0**
F-high (Hz)	IVT-I	643.5 [551.7, 735.4]	592.9 [500.0, 685.8]	729.4 [637.6, 821.3]	0.037 (*)	**+111.2 (*)**
	IVT-G	613.7 [523.5, 703.8]	665.4 [590.3, 755.6]	824.0 [734.0, 913.9]		**+184.5 (*)**
	TVT	559.0 [470.1, 648.0]	554.5 [465.6, 643.5]	741.9 [649.6, 834.2]		**+185.2 (*)**

Note: EM, estimated mean; CI, confidence interval; MPT, maximum phonation time; VC, vital capacity; PQ, phonation quotient; f_o, fundamental frequency; vf_o, variation in fundamental frequency; NHR, noise-to-harmonic ratio; CPPS, smoothed cepstral peak prominence; HNR, harmonics-to-noise ratio; LTAS, long-term average spectrum; I-low, lowest intensity; I-high, highest intensity; F-low, lowest frequency; F-high, highest frequency. * indicates a significant effect.

Evolution at time points with an equal number of therapy hours

Table 6.13 presents the evolution of the multiparametric indices DSI and AVQI at time points with an equal number of therapy hours: 1 day for the IVT groups versus 1 week for the TVT group, 2 days for the IVT groups versus 2 weeks for the TVT group, 6 days for the IVT groups versus 2 months for the TVT group and 9 days for the IVT groups versus 3 months for the TVT group. A borderline significant time-by-group interaction was found for DSI, with a preference for the IVT groups. No significant time-by-group interactions were found for AVQI, indicating no significant difference in evolution between the three groups. Graphical representations of the evolution of DSI and AVQI can be found in Figures 6.12 and 6.13, respectively.

Longitudinal evolution till 1 year follow-up

Multiparametric indices. The evolution posttherapy till 1 year follow-up of DSI and AVQI can be found in Table 6.14. No significant time-by-group interactions were found. More in-depth within group analyses showed that the improved post DSI remained stable till 1 year follow-up in all groups. AVQI further improved after therapy in the IVT-I group (-0.66), although not significantly. The score approximately remained stable in the TVT group (+0.13) and non-significantly worsened (+0.52) in the IVT-G group. Figures 6.14 and 6.15 present the longitudinal evolution of DSI and AVQI with all follow-up time points (baseline, 1 week, 2 weeks, 2 months, 3 months, 4 months, 6 months and 1 year).

Patient's self-report. A significant time-by-group interaction was found for VHI, which significantly worsened (+15, $p < 0.001$) after therapy in the IVT-I group, whereas VHI remained stable in the IVT-G and TVT groups. No significant time-by-group interaction was found for VTDS (Table 6.15). Within-group analysis showed a significant improvement of VTDS after therapy in the TVT group (-12; $p = 0.023$), whereas VTDS remained stable in the IVT-I and IVT-G groups.

Auditory-perceptual evaluation. A significant time-by-group interaction was found for breathiness, characterized by a non-significant increase in the TVT group and a non-significant decrease in the IVT-I group. Roughness significantly increased after therapy till 1 year follow-up in both the IVT-I and TVT groups (Table 6.16).

Flexible videolaryngostroboscopic evaluation. Figure 6.16 presents the longitudinal evolution of the videolaryngostroboscopic evaluation with all follow-up time points: baseline, 2 weeks (only for the IVT groups), 3 months, 6 months and 1 year.

Cancellations and drop-out

Average cancellation rates were 1.5% (range: 0-11%) in the IVT-I group, 0% (range: 0-0%) in the IVT-G group and 17% (range: 6-38%) in the TVT groups. Dropout rates were 0% (0/30) in the IVT groups and 19% (3/16) in the TVT group. Reasons for dropout were: need for phonosurgery, lack of therapy progress, or medical (no voice related) reasons. Dropout took place after 2 to 3 months of traditional therapy.

Need for continuation of voice therapy

Three patients (20%) of the IVT-I group, 3 patients (20%) of the IVT-G group and 1 patient of the TVT (6%) group continued voice therapy after the 2 weeks/6 months and during the follow-up measurements. These follow-up data were not used for the above analyses.

Table 6.13 Evolution of the multiparametric indices DSI and AVQI at time points with an equal number of therapy hours in the IVT-I, IVT-G and TVT groups.

		Baseline 1	**Baseline 2**	**1 day (IVT)** **1 week (TVT)**	**2 days (IVT)** **2 weeks (TVT)**	**6 days (IVT)** **2 months (TVT)**	**9 days (IVT)** **3 months (TVT)**	**Group*Time**
Parameter	Group	EM [95% CI]	EM [95% CI]	EM [95% CI]	EM [95% CI]	EM [95% CI]	EM [95% CI)	*p*-value
DSI	IVT-I	-1.0 [-2.2, +0.2]	-0.9 [-2.1, +0.3]	-0.7 [-1.9, +0.5]	+0.7 [-0.5, +2.0]	+1.3 [+0.1, +2.5]	+2.1 [+0.9, +3.3]	
			+0.3	+1.4	+0.6	+0.8		
							Total: +3.1 (*)	
	IVT-G	+0.1 [-0.9, +1.4]	+0.3 [-0.7, +1.6]	+0.2 [-1.0, +1.4]	+1.5 [+0.3, +2.7]	+3.2 [+2.0, +4.4]	+3.4 [+2.3, +4.7]	
			+ 0.0	+1.3	+1.7	+0.2		0.063
							Total: +3.2 (*)	
	TVT	-1.3 [-2.5, -0.2]	-0.8 [-2.0, +0.3]	-0.1 [1.3, +1.1]	+1.1 [-0.1, +2.2]	+0.5 [-0.7, +1.7]	+1.4 [+0.2, +2.5]	
			+ 1.0	+1.2	-0.6	+0.9		
							Total: +2.5 (*)	
AVQI	IVT-I	4.65 [4.05, 5.23]	4.29 [3.75, 4.84]	4.72 [4.20, 5.24]	4.26 [3.74, 4.78]	4.19 [3.67, 4.71]	3.83 [3.28, 4.38]	
			+0.25	-0.46	-0.07	-0.36		
							Total: -0.64	
	IVT-G	4.07 [3.48, 4.67]	4.11 [3.57, 4.64]	4.45 [3.93, 4.97]	3.95 [3.43, 4.46]	3.51 [2.99, 4.02]	3.63 [3.09, 4.17]	
			+0.36	-0.50	-0.44	+0.12		0.704
							Total: -0.46	
	TVT	4.75 [4.24, 5.36]	4.65 [4.07, 5.13]	4.55 [3.93, 4.97]	4.57 [4.06, 5.08]	4.20 [3.67, 4.74]	4.35 [3.83, 4.86]	
			-0.15	+0.02	-0.37	+0.15		
							Total: -0.35	

Note: EM, estimated mean; CI, confidence interval; DSI, Dysphonia Severity Index; AVQI, Acoustic Voice Quality Index. * indicates a significant effect.

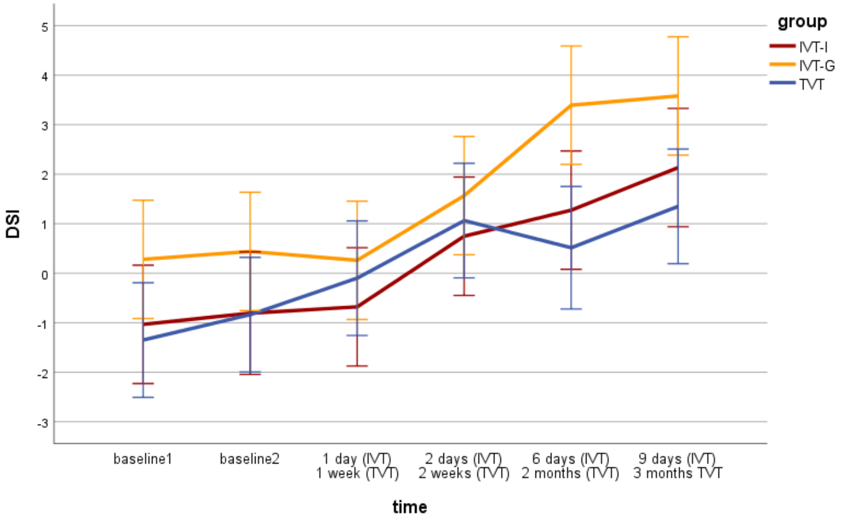


Figure 6.12 Evolution of DSI at time points with an equal number of therapy hours in the IVT-I, IVT-G and TVT groups.

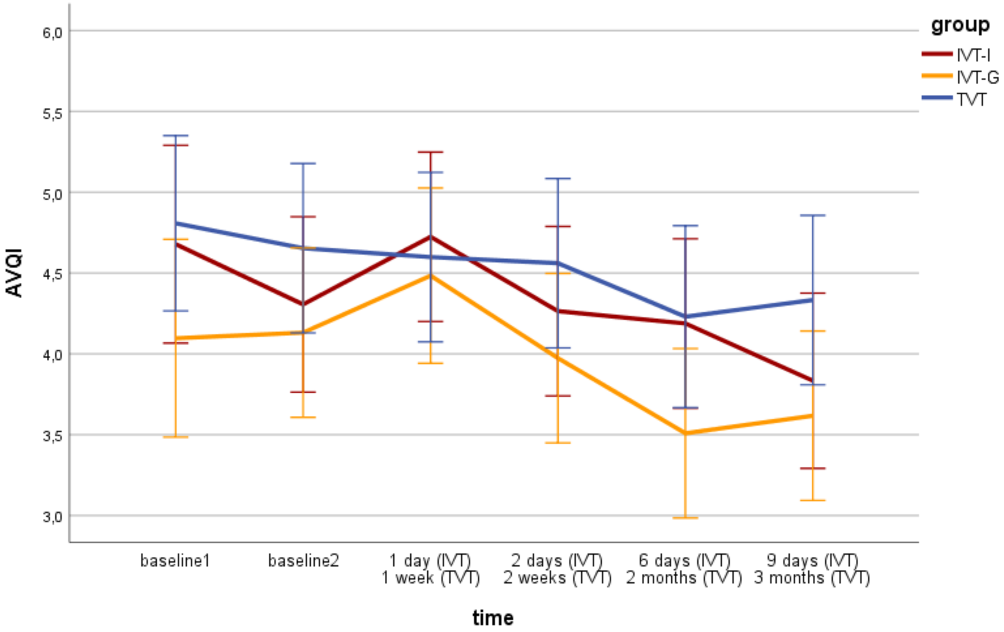
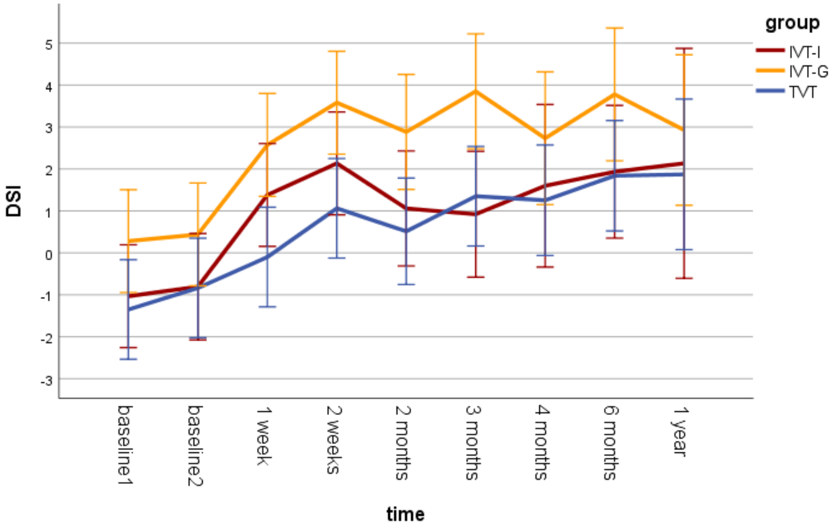


Figure 6.13 Evolution of AVQI at time points with an equal number of therapy hours in the IVT-I, IVT-G and TVT groups.

Table 6.14 Evolution post-therapy till 1 year follow-up of the multiparametric indices DSI and AVQI in the IVT-I, IVT-G and TVT groups.

		Post	1 year follow-up	Time*Group	Evolution post – 1 year follow-up
Parameter	Group	EM [95% CI)	EM [95% CI]	*p*-value	EM difference
DSI	IVT-I	+2.1 [+0.9, +3.3]	+2.5 [+0.2, +4.7]		**+0.4**
	IVT-G	+3.4 [+2.3, +4.7]	+3.3 [+1.7, +4.8]	0.983	**-0.1**
	TVT	+1.9 [+0.6, +3.1]	+1.8 [+0.3, +3.3]		**-0.1**
AVQI	IVT-I	3.83 [3.28, 4.38]	3.17 [2.13, 4.20]		**-0.66**
	IVT-G	3.63 [3.09, 4.17]	4.15 [3.44, 4.87]	0.283	**+0.52**
	TVT	4.15 [3.58, 4.73]	4.28 [3.57, 4.99]		**+0.13**

Note: EM, estimated mean; CI, confidence interval; DSI, Dysphonia Severity Index; AVQI, Acoustic Voice Quality Index.



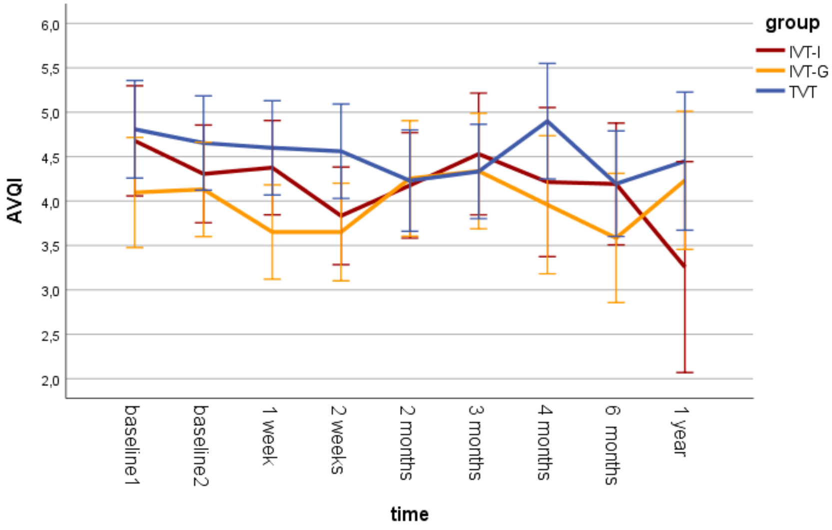


Figure 6.14 Longitudinal evolution with follow-up of the DSI in the IVT-I, IVT-G and TVT groups. *The end point of therapy is 2 weeks for the IVT groups and 6 months for the TVT group.*

Figure 6.15 Longitudinal evolution with follow-up of the AVQI in the IVT-I, IVT-G and TVT groups. *The end point of therapy is 2 weeks for the IVT groups and 6 months for the TVT group.*

Table 6.15 Evolution post-therapy till 1 year follow-up of the self-reported VHI and VTDS in the IVT-I, IVT-G and TVT groups.

		Post	**1 year follow-up**	**Time*Group**	**Evolution post – 1 year follow-up**
Parameter	Group	EM [95% CI]	EM [95% CI]	p-value	EM difference
VHI	IVT-I	22 [16, 33]	37 [24, 50]	0.006*	**+15 (*)**
	IVT-G	9 [1, 18]	9 [0, 20]		**0**
	TVT	23 [16, 34]	24 [14, 36]		**+1**
VTDS	IVT-I	21 [13, 29]	22 [11, 33]	0.302	**+1**
	IVT-G	19 [12, 27]	15 [6, 24]		**-4**
	TVT	30 [23, 38]	18 [9, 27]		**-12 (*)**

Note: EM, estimated mean; CI, confidence interval; VHI, Voice Handicap Index; VTDS, Vocal Tract Discomfort Scale. * indicates a significant effect.

Table 6.16 Evolution post-therapy till 1 year follow-up of the auditory-perceptual evaluation in the IVT-I, IVT-G and TVT groups.

		Post		**1 year follow-up**		**Time*Group**	**Wilcoxon Signed Ranks test**
Parameter	Group	Median [IQR]	Mean [SD]	Median [IQR]	Mean [SD]	*p*-value	*p*-value
G	IVT-I	1 [0, 1]	0.8 [0.8]	1 [0, 1]	1.0 [0.5]	0.497	0.414
	IVT-G	1 [1, 1]	0.8 [0.4]	1 [1, 1]	0.8 [0.6]		>0.999
	TVT	1 [1, 1]	0.9 [0.5]	1 [1, 2]	1.3 [0.5]		0.083
R	IVT-I	1 [0, 1]	0.6 [0.5]	1 [1, 1]	1.0 [0.5]	0.167	0.046 (*)
	IVT-G	0 [0, 1]	0.3 [0.5]	0 [0, 1]	0.3 [0.5]		>0.999
	TVT	0 [0, 0]	0.2 [0.4]	1 [0, 1]	0.7 [0.5]		0.046 (*)
B	IVT-I	1 [0, 1]	0.8 [0.8]	0 [0, 1]	0.3 [0.5]	0.041(*)	0.083
	IVT-G	1 [0, 1]	0.7 [0.5]	1 [0, 1]	0.8 [0.6]		>0.999
	TVT	1 [0, 1]	0.8 [0.7]	2 [0.75, 2]	1.5 [0.8]		0.257
A	IVT-I	0 [0, 1]	0.3 [0.5]	0 [0, 0]	0.1 [0.3]	0.168	0.317
	IVT-G	0 [0, 0]	0.1 [0.4]	0 [0, 1]	0.5 [0.7]		0.157
	TVT	0 [0, 1]	0.3 [0.6]	0 [0, 1]	0.3 [0.5]		>0.999
S	IVT-I	0 [0, 0]	0.1 [0.4]	0 [0, 0]	0.1 [0.3]	0.935	0.564
	IVT-G	0 [0, 0]	0.1 [0.4]	0 [0, 0]	0.2 [0.4]		>0.999
	TVT	0 [0, 1]	0.4 [0.7]	0 [0, 1]	0.3 [0.5]		0.157
I	IVT-I	0 [0, 0]	0.1 [0.3]	0 [0, 0]	0 [0]	0.823	0.317
	IVT-G	0 [0, 0]	0.1 [0.4]	0 [0, 0]	0.2 [0.6]		0.655
	TVT	0 [0, 0]	0.3 [0.6]	0 [0, 0]	0 [0]		0.317

Note: IQR, interquartile range; G, grade; R, roughness; B, breathiness; A, asthenia; S, strain; I, instability. * indicates a significant effect.

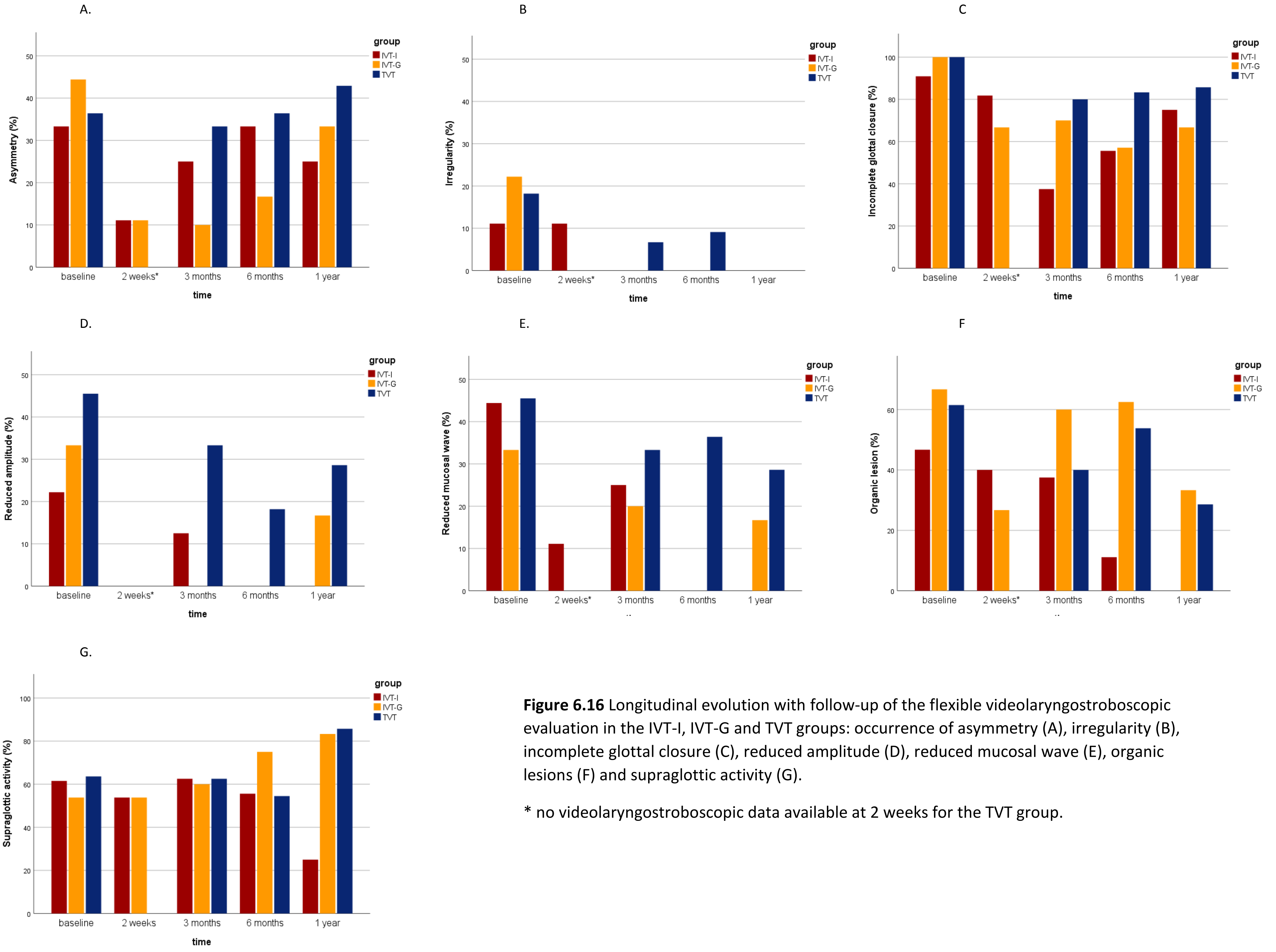


Figure 6.16 Longitudinal evolution with follow-up of the flexible videolaryngostroboscopic evaluation in the IVT-I, IVT-G and TVT groups: occurrence of asymmetry (A), irregularity (B), incomplete glottal closure (C), reduced amplitude (D), reduced mucosal wave (E), organic lesions (F) and supraglottic activity (G).

* no videolaryngostroboscopic data available at 2 weeks for the TVT group.

DISCUSSION

Research should focus on finding service delivery models that maximize effectiveness and efficiency of therapy. To date, the most optimal “dosage” for voice therapy is unknown (De Bodt et al., 2015; Roy, 2012). Therefore, this study aimed to compare the effect of a short-term IVT with a long-term TVT on the vocal quality, vocal capacities, psychosocial impact, vocal tract discomfort, laryngological anatomy/physiology and adherence of patients with dysphonia. As treating patients intensively and individually may lead to quickly filled week schedules for the clinician, a group IVT was compared with an individual one. Results of this study support the hypothesis that IVT is at least equally effective in treating patients with dysphonia compared with TVT. Somehow less expected, the group treatment showed comparable results as the individual one.

To get a clear impression of therapy outcomes, voice assessments should include both objective and subjective measures. The most valid and clinically useful objective approaches recognize the multidimensionality of the voice. DSI and AVQI are two such multiparametric indices that have been proven responsive to vocal quality changes (Wuyts et al., 2000; Maryn et al., 2010b). DSI significantly and similarly improved pre- to post-therapy in the IVT-I (+3.1), IVT-G (+3.2) and TVT (+3.0) groups. Strikingly, IVT made an equal progress in only 2 weeks and 12h of therapy compared with TVT that needed 6 months and 24h of therapy. The same progress was not completely achieved after identically 12h of traditional treatment (3 months, DSI +2.5). Furthermore, improvements were not only limited to short-term effects as DSI scores remained stable till 1 year follow-up in the three groups. These findings were particularly surprising for subjects of the IVT groups who received only two weeks of actual treatment. Positive follow-up indicates that patients were capable of progressive vocal self-management in the absence of active rehabilitation (Kleemola et al., 2011; Wenke et al., 2014). Motor and cognitive learning probably continued to occur after treatment and reinforced behaviors taught during this short but intensive period (Wenke et al., 2014, Fu et al., 2015a).

AVQI also equally improved pre- to post-therapy in the three groups, although not significantly (IVT-I: -0.64; IVT-G: -0.46; TVT: -0.55). The score provides an “ecologically valid” outcome that is representative of daily speech and voice use patterns through the inclusion of continuous speech samples (Maryn et al., 2010b). The fact that AVQI improvements were less dominant than DSI improvements, might indicate a limited transfer of learned skills to daily voice use. Nevertheless, this potential lack of transfer cannot be due to the shortness of IVT because similar results were found after 6 months TVT. On the contrary, when comparing time points with an equal number of therapy hours (2 weeks versus 3 months), a new advantage for the IVT groups arose (-0.64 or -0.46 for the IVT-I and IVT-G groups compared with -0.35 for the TVT group). DSI probably showed more sensitivity to treatment due to the weighted combination of both vocal quality and capacity measures. Besides the positive and parallel progress on multiparametric indices, IVT groups performed better on isolated acoustic measures and equally well on voice range profile measures. In general, IVT gave excellent objective results that are at least comparable with TVT, and required only 2 weeks and 12h of active rehabilitation.

Objective determination of vocal quality can lose its strength if there is no agreement with the gold standard of voice assessment, i.e. the auditory-perceptual evaluation (Wuyts et al., 2000). Dysphonia grade significantly improved after both IVT-I and TVT, but not after IVT-G. Roughness’ pre- to post-therapy evolution showed a preference for both IVT groups, strain for the IVT-I group and asthenia for the TVT group. Again, reassuring results for both intensive and traditional treatment were found. Group therapy, on the other hand, may have less impact on auditory-perceptual dysphonia.

Besides objective and auditory-perceptual evaluations, patients’ self-report is indispensable in high-quality assessment of therapy outcome. Unfortunately, the first drawback for IVT arises here. The psychosocial impact of the voice disorder significantly improved after TVT (VHI -13) but not after IVT (VHI -4). Two weeks might be too short to experience an impact on daily life. As improved vocal quality remained stable till 1 year follow-up, we might expect that participants gradually encounter less psychosocial problems. However, VHI inconsequently deteriorated in the IVT-I group at follow-up (VHI +15), whereas VHI remained stable in the TVT and IVT-G groups. Progressive vocal-self management in real-life situations apparently became more difficult after a while. Therefore, follow-up sessions or potential refurbishment of learned skills by boost therapies will be important in future. However, differences in baseline measurements between the IVT and TVT groups should be taken into account when interpreting these results. The TVT group showed higher VHI scores at baseline and may therefore allow more progress. Relief of vocal tract discomfort seemed to occur in both groups. Participants of the IVT group experienced an immediate relief, whereas participants of the TVT group encountered it later at follow-up.

In summary, IVT seems a promising service delivery model to improve the voice of patients with dysphonia on a multidimensional level, although the psychosocial evolution should be kept in mind. Cost-effectiveness can be one of the convincing factors to actually select IVT over TVT. The reimbursement system in Belgium prescribes 80 sessions of 30 minutes over maximum 2 years with a free choice of practice frequency (De Bodt et al., 2014). Traditionally, weekly 30 min sessions are spread over 1 or 2 years till refund is no longer disposable. Problems arise when dysphonia is chronic or patients relapse after treatment (Van Lierde et al, 2007). Therefore, reorganizing the distribution of sessions can be useful. With a short-term IVT, sessions can be saved for follow-up or potential restart of treatment. An individualized plan can be made per patient and pathology and reevaluation is important depending on the individual's evolution. In this manner, the exact number of sessions will be adapted to the specific case in front of the clinician and not to the absolute maximum written on the prescription. Consequently, less burden on the health care system might be expected (Wenke et al., 2014).

More cost-effectiveness can also be obtained by maximizing patient adherence and motivation. These factors are keys for successful outcomes and turned out to be achievable in the short-term IVT. Cancellation and dropout were remarkably less common in IVT than in TVT. Average cancelation rates were only 1.5% in the IVT-I group and 0% in the IVT-G group compared with 17% in the TVT group. The latter approximates the 25% found in traditional treatment by Wenke et al. (2014). Furthermore, no dropout existed in the IVT groups, whereas 19% (3/16) of the patients in the TVT group dropped out before therapy completion.

Possible reasons for greater attendance and compliance in IVT are the urge to get the maximum out of a short treatment period with a clear end sight (“now or never”), being in the flow with full focus on voice and less distractions, and experiencing greater motivation due to short-term improvements (Patel et al., 2011; Wenke et al., 2014). Therapy in group may additionally give that extra social control and support for showing up every session.

The group IVT did not only score excellent on adherence, but also evolved equally in terms of objective vocal quality and capacities as the individual groups. Factors that stimulate learning in a group environment have been explored in the domain of psychotherapy, rather than voice therapy. One of the described advantages in that domain is observing and learning from each other (Guttmacher & Birk, 1971). Evaluating another patient is often easier and may unconsciously reflect information to you as observer. Secondly, group treatment provides a miniature real-life situation with more opportunities for transfer (e.g. group conversations) (Mishna, 1996). At last, participants feel supported and realize that others have similar problems which may relief shame (Guttmacher & Birk, 1971). Groups were formed homogeneous in terms of vocal pathology and severity to avoid frustration and obtain an adjusted pace. Nevertheless, those factors were not always avoidable and sometimes led to extra individual needs. Although the group results of the current study are promising, two factors may have influenced them: participants started with a somewhat milder baseline dysphonia severity and were all SLP students. Further research is needed to confirm if group treatment can be as effective as individual treatment.

Possible disadvantages of short-term IVT should not be underestimated. Scheduling intensive therapy sessions might be complex as it should fit both the patient’s and the clinician’s schedule (Bergan, 2010). Based on the current results, a group IVT program might offer opportunities for the clinician to treat more patients in such an intensive way. Secondly, the potential risk of “overdose” cannot be excluded (Bergan, 2010; Roy, 2012; Behlau et al., 2014). Just like in medicine or pharmacy, the threshold at which voice therapy transitions from being beneficial to harmful should be explored (Roy, 2012). Signs of vocal fatigue must be detected and otorhinolarngologists should be available for additional check-up if necessary. Nevertheless, flexible videolaryngostroboscopic results of the current study are reassuring. Occurrence of organic lesions did not increase after 2 weeks IVT. On the contrary, decreases of 6.7% after IVT-I and no less than 40% after IVT-G were found. These impressive results give food for thought as we know that the decline was only 7.7% after 6 months of TVT. Earlier findings by Fu et al. (2015a) support the current results. The authors found comparable positive videolaryngostroboscopic outcomes post-intensive and -traditional treatment for patients with vocal nodules. This indicates no overdose, even for patients with organic voice disorders. Of course, variability will play a role in the balance between beneficial and harmful dosages (Roy, 2012; Behlau et al., 2014). It is possible that the ideal frequency and intensity for one individual may be insufficient or harmful for another (Roy, 2012; Behlau et al., 2014).

Although not methodologically verified, signs of vocal fatigue were indeed often orally reported in the IVT groups, especially in the first week of treatment. The body and mind should get used to the sudden intensive work-out and especially to the new motor and cognitive processes required for efficient and economic voice use (Mcllwaine et al., 2010; Patel et al., 2011; Fu et al., 2015a). The main goal of voice therapy is to obtain a definite behavioral change by rebalancing and strengthening the vocal system as a result of practice (Roy, 2012). Fatigue is a logical side effect in this learning process. Inserting vocal rest pauses and alternating high- and low-loaded vocal exercises are important to keep the sessions pleasant and less tiring.

This clinical trial is situated in between a pragmatic and explanatory trial and therefore has its specific strengths and limitations (Roland & Torgerson, 1998; Tosh et al., 2011; Patsopoulos, 2011). Strict and ideal methodological circumstances are not always achievable or ethical in clinical trials (Tosh et al., 2011). A first pragmatic element can be seen in the study population that reflects variations between patients as in real life clinical practice (Roland & Torgerson, 1998). A heterogeneous group of female and male patients, aged between 18 and 60 years, with different studies/professions and variations in dysphonia type and severity was selected. Homogeneous study populations may provide less bias (more internal validity) but meanwhile lose some generalizability to everyday practice (less external validity) (Patsopoulos, 2011; Kleemola et al., 2010). A second pragmatic element is the absence of a placebo group. In pragmatic trials, the outcome is the total difference between two interventions, including both treatment and associated placebo effects, as this will best reflect the clinical response in daily practice (Roland & Torgerson, 1996). Furthermore, it would be impossible and unethical to follow-up patients with placebo treatment for 1 year (Kleemola et al., 2011). A third pragmatic element can be found in the subgroup assignment, which was based on availability and preference in 28% (13/46) of the participants. However, randomization occurred for the majority (72%, 33/46) of the participants, which is a typical explanatory strength. Other explanatory strengths were the standardized and content-identical treatment guided by the same voice therapist for any participant, the blinded assessors to group allocation and study evolution,, and the extensive and standardized follow-up voice assessments till 1 year follow-up. Explanatory and pragmatic trials can sometimes lead to different conclusions about the benefit of a treatment, either because a treatment that is effective in ideal settings may not work in real life or vice versa (Roland & Torgerson, 1996). Clinicians should therefore judge the relevance of the findings to their own clinical practice.

The golden mean between intensive and traditional treatment might be an achievable, effective and efficient solution for everyday clinical practice. Based on the results of the current study, voice therapy should definitely start more intensively and more transiently. Once the patient is ready for progressive vocal self-management in real life and transfer of learned skills (Wenke et al., 2014; Fu et al., 2015a), one of three different paths can be picked. The first path is a gradual reduction of the frequency of active treatment till eventually only a follow-up program is required. The second path involves an immediate transition from active treatment to follow-up. A boost short-term IVT can then be given at any moment in this follow-up process. The third possibility is a combination of the above two paths: starting with a gradual reduction of frequency, followed by a follow-up program and a boost IVT when needed. Telepractice might be a useful tool in follow-up (Mashima et al., 2003; Fu et al., 2015b; Rangarathnam et al., 2015). Further research is needed to confirm whether these innovative service delivery models should be the new standard for voice therapy.

CONCLUSIONS

Short-term IVT is at least equally effective in treating patients with dysphonia than long-term TVT. IVT made an equal progress in only 2 weeks and 12h of therapy compared with TVT that needed 6 months and 24h of therapy. Group treatment seemed as effective as individual treatment. Improved vocal quality and capacities remained stable till 1 year follow-up, suggesting transfer of learned skills. Only the psychosocial well-being inconsequently deteriorated in the IVT-I group at follow-up. Patient adherence was clearly higher in IVT compared with TVT, a factor that is indispensable for successful therapy. Cost-effectiveness is an important advantage of IVT. The golden mean between intensive and traditional treatment might be an achievable, effective and efficient solution for everyday clinical practice.

General discussion

CHAPTER 7

General discussion and conclusion

The high prevalence and the psychosocial impact of voice disorders, together with the limited success rates of traditional voice therapy, highlight the need for evidence-based practice. Research should focus on finding the most effective and efficient voice training and therapy models. To date, efficacy or effectiveness studies of voice training and therapy are limited and the research methodology is usually poor (Speyer, 2008; Ruotsalainen et al., 2008; Ruotsalainen et al., 2010; Hazlett et al., 2011; Bos-Clark & Carding, 2011). Therefore, the main objective of this doctoral thesis was to investigate the effect of **voice training** and **voice therapy**, both on the **content** and **dosage** level.

7.1 Effect of vocal techniques (content)

Whether a training or therapy program using vocal facilitating techniques or semi-occluded vocal tract (SOVT) exercises leads to enhanced phonation and improved vocal quality on the short or long time is not yet confirmed. Therefore, the first objective of this thesis was to investigate the effect of training or therapy programs using vocal facilitating techniques **(chapter 4)** or SOVT exercises **(chapter 5)** on the phonation of vocally healthy future occupational voice users or patients with dysphonia.

7.1.1. Vocal facilitating techniques

In this thesis, the effect of five **vocal facilitating techniques** was investigated: chewing, chant talk, pitch inflections, glottal fry and yawn-sigh. A summary of the effect of each technique on the objective voice assessment in vocally healthy future occupational voice users is presented in Table 7.1.

Chewing seems to be the most effective vocal facilitating technique for optimizing the voice of vocally healthy future occupational voice users. It is the only technique that had a positive effect on both acoustic perturbation and noise measures (jitter, NHR), the voice range profile (I-low, F-low, I-high, F-high) and the Dysphonia Severity Index (DSI). The DSI is a multiparametric index designed to establish an objective and quantitative correlate of the perceived vocal quality (Wuyts et al., 2000). It ranges from –5 to +5 for severely dysphonic to normal voices. Higher values are possible in subjects with very good vocal capacities. The index can detect small changes in vocal quality, which makes it suitable for evaluating the effect of training/therapy in vocally healthy and dysphonic subjects. Another promising vocal facilitating technique is *yawn-sigh* for which improvements in acoustic perturbation and noise measures (shimmer, NHR) and the voice range parameter I-high were found.

Table 7.1 Summary of the effect of the vocal facilitating techniques on the objective voice assessment in vocally healthy future occupational voice users (chapter 4).

Vocal facilitating technique	Effect in future occupational voice users
Chewing	Increased f_o Decreased jitter Decreased NHR Decreased I-low, F-low Increased I-high, F-high Increased DSI
Chant talk	Increased f_o Decreased NHR
Pitch inflections	Decreased NHR
Glottal fry	Decreased I-low Decreased I-high
Yawn-sigh	Increased f_o Decreased shimmer Decreased NHR Increased I-high

Note: f_o, fundamental frequency; NHR, noise-to-harmonic ratio: I-low, lowest intensity; F-low, lowest frequency; I-high, highest intensity; F-high, highest frequency; DSI, Dysphonia Severity Index.

Both chewing and yawn-sigh are assumed to facilitate "relaxed" phonation by reducing muscle tension in the vocal tract (Froeschels, 1943; Froeschels, 1952; Beebe, 1956; Brodnitz, 1968; Moncur & Brackett, 1974; Wilson, 1979; Pershall & Boone, 1985; Casper et al., 1990; Colton & Casper, 1990; Moore, 1990; Boone, 1991; Boone & McFarlane, 1993; Dworkin et al., 2000; Shrivastav et al., 2000; Holmberg et al., 2001; Roy, 2003a; Schneider & Sataloff, 2007; Boone et al., 2010; Duan et al., 2010). It should be noted that the vocal tract configuration associated with yawn-sigh is the exact opposite of that associated with SOVT exercises (chapter 2.1.2). Vocal tract widening is now achieved instead of vocal tract narrowing. The reason why two opposite strategies are used to obtain a common goal needs some further discussion. Recall from chapter 2.1.2 that economic and efficient voice production can be achieved by source-vocal tract impedance matching (Titze, 2006; Titze, 2008). One way to obtain this impedance matching is by semi-occluding the vocal tract during phonation. However, it is hypothesized that a match with a wide vocal tract is also possible in specific phonatory gestures. Titze & Verdolini Abbott (2012) describe that a sigh is characterized by a source with low impedance and slightly abducted focal folds. Therefore, it might perfectly match a "yawny" (i.e. wide) vocal tract impedance. Based on this reasoning, it might be hypothesized that yawn-sigh is specifically effective for patients with hyperfunctional dysphonia who use a pressed voice. This dysphonic population was indeed originally suggested by Boone et al. (2010). However, efficacy and effectiveness studies in patients with a variety of voice disorders are needed to confirm these assumptions.

The ultimate goal of practicing vocal techniques is to increase the vocalist's awareness of this source-vocal tract impedance matching (Titze, 2006), regardless of whether this is achieved by vocal tract narrowing or widening. It might even be possible that maximum awareness can be achieved by combining the two strategies as in chewing (i.e. constant alternation between vocal tract narrowing and widening). What works best for a specific vocalist will probably depend on several factors including the natural glottal resistance, vocal pathology, gender, vocal awareness, etc. (Titze, 2002a; Titze, 2002b; Maxfield et al., 2015). Further research is needed to find the best matched configurations for specific vocalists and pathologies.

Chant talk and *pitch inflections* training also led to a decrease in NHR, which indicates less noise in the acoustic voice signal. Noise can arise from turbulent airflow generated by inadequate closure or aperiodic vibrations of the vocal folds (Ferrand, 2002). Therefore, a decrease in NHR might indicate a better conversion of aerodynamic energy into acoustic energy. The reason why chant talk and pitch inflections might improve vocal efficiency is unknown. Bovo et al. (2007) and Boone et al. (2010) assumed obtaining "relaxed" voicing and elimination of hard glottal attacks. However, these assumptions are rather vague and lack substantiation. Furthermore, the performance of both techniques is contradictory. A monotonic phonation is stimulated during chant talk, whereas adequate intonation is stimulated during pitch inflections (Boone et al., 2010). These ambiguities and vague assumptions highlight the need for studies that investigate the techniques' underlying mechanisms and the exact reason for a possible effect. It should be noted that improvements in NHR after chant talk and pitch inflections were statistically significant, although relatively small (mean differences of -0.014 and -0.022). Besides, no other vocal parameters improved after the training programs. Therefore, the clinical relevance of this finding is limited.

Glottal fry seems less suitable for training the voice of vocally healthy future occupational voice users. No improvements in acoustic measures or in the multiparametric vocal quality index were found. Furthermore, the decrease in I-low was associated with an even greater decrease in I-high, which led to a small truncation of the intensity range. The use of glottal fry as a vocal training or therapy technique has frequently been debated. Some authors consider glottal fry a diagnostic and harmful parameter (Blomgren et al., 1998; Gottliebson et al., 2007; Cielo et al., 2011), some describe it as a specific speech pattern in healthy (young) adult American-English speakers (Slifka, 2006; Yuesa, 2010; Wolk et al., 2012; Abdelli-Beruh et al., 2014; Abdelli-Beruh et al., 2016; Oliveira et al., 2016), whereas others recognize its potential training or therapeutic effect (Bolzan et al., 2008; Boone et al., 2010; Cielo et al., 2011; Pimenta et al., 2013). Also notable is the debate regarding the underlying physiological mechanisms of glottal fry. The minimal subglottal pressure and reduced friction between the vocal folds originally described by Boone & McFarlane (1988) has later been contradicted by authors who mentioned an increase in subglottal pressure and tightly adducted vocal folds (Blomgren et al., 1998; Doellinger et al., 2005; Cielo et al., 2011). As an increase in subglottal pressure is associated with higher impact stress (Jiang & Titze, 1994), the therapeutic benefit of glottal fry for hyperfunctional dysphonia might be questioned. Such ambiguities confirm the need for studies that investigate the underlying mechanisms of glottal fry and it effect in patients with a variety of voice disorders.

At last, both chewing, chant talk and yawn-sigh training led to an increase in fundamental frequency (f_o). This phenomenon of increased f_o after voice training in healthy subjects has earlier been identified by Van Lierde et al. (2011). A heightened f_o is often associated with increased tension in the vocal folds, which is controlled by activation of the thyroarytenoid and cricothyroid muscles (Titze, 2000a; De Bodt et al., 2008a). More tension in the intrinsic laryngeal muscles is often considered unfavorable. However, it does not necessarily indicate a less economic or efficient phonation (on the condition that the vocalist does not strain the laryngeal framework – such as cartilages, joints, and ligaments – to maintain adequate vocal fold tension and length) (Titze, 2000a). Further investigation in this area can give more clarity in future.

7.1.2 Semi-occluded vocal tract exercises

The second group of vocal techniques discussed in this thesis are the **SOVT exercises**. Each exercise (resonant voice training using nasal consonants, straw phonation, lip trill and water-resistance therapy) showed its own positive effect on one or more parameters of the multidimensional voice assessment. A summary of these results can be found in Table 7.2.

Straw phonation showed the most promising results for rehabilitating the voice of patients with dysphonia. It is the only SOVT exercise that led to improvements in both acoustic parameters (jitter, vf_o), auditory-perceptual vocal quality (grade, roughness) and the multiparametric vocal quality index DSI. In vocally healthy future occupational voice users, straw phonation led to an increment in intensity range (decrease I-low, increase I-high). Based on the above results, straw phonation has the unique ability to improve the voice on all multidimensional facets. However, the improved vocal quality and capacities did not (yet) have an impact on daily life (no changes in VHI after straw phonation).

The reason why straw phonation led to significant vocal improvements might be related to the physics behind an SOVT. Straw phonation is the SOVT exercise that creates the highest resistance to airflow, and therefore the highest supraglottal pressure and inertive reactance in the vocal tract. This leads to an optimal non-linear source-vocal tract interaction wherein the vocal tract enhances the vocal fold vibration, which might in turn improve vocal quality (Titze, 2006; Titze & Verdolini Abbott, 2012; Gaskill & Quinney, 2012; Maxfield et al., 2015). The decrease in I-low may be explained by a lower phonation threshold pressure associated with an SOVT. Because acoustic energy is reflected back to the vocal folds, less subglottal pressure is required to induce vocal fold vibration (i.e. vocal efficiency) (Titze & Verdolini

Abbott, 2012; Guzman et al., 2013; Kapsner-Smith et al., 2015; Guzman et al., 2017a). The increased I-high fits within the hypothesis of obtaining greater vocal output with less physical effort (i.e. vocal economy) (Titze, 2006; Gaskill & Quinney, 2012; Maxfield et al., 2015; Croake et al., 2017; Mills et al., 2017).

Table 7.2 Summary of the effect of the SOVT exercises on the multidimensional voice assessment in vocally healthy future occupational voice users or patients with dysphonia (chapter 5).

SOVT exercise	Effect in future occupational voice users	Effect in patients with dysphonia
Resonant voice training using nasal consonants	Increased DSI	*- not investigated -*
Straw phonation	Decreased I-low Increased I-high	Decreased jitter Decreased vf_o Increased DSI Decreased grade, roughness Worse self-perceived vocal quality immediately after a session
Lip trill	*- not investigated -*	Decreased I-low Increased DSI Decreased VHI (E-scale) Worse self-perceived vocal quality immediately after a session
Water-resistance therapy (WRT)	*- not investigated -*	Decreased VHI (P-scale) Better self-perceived vocal quality immediately after a session

Note: DSI, Dysphonia Severity Index; I-low, lowest intensity; I-high, highest intensity; vf_o, variation in fundamental frequency; VHI, Voice Handicap Index.

Lip trill also seems a promising SOVT exercise by showing improvements in I-low and DSI. Lower flow resistance is achieved during lip trill compared with straw phonation (Titze, 2006), which might be the reason for the lack of improvements in acoustic parameters or auditory-perceptual vocal quality. Lip trill therapy had the extra advantage of decreasing the emotional restrictions associated with dysphonia (VHI-E).

Surprisingly, *WRT* showed no improved objective or auditory-perceptual outcomes, despite the relatively high flow resistance. It can be hypothesized that the effect of WRT depends on the used materials, diameters and water depths. In this thesis, a flexible soft-walled tube with a diameter of 10mm and a water depth of 2cm was used. This choice was based on the general guidelines for initiating WRT with a so-called Lax Vox tube (Sihvo, 2006; Tyrmi et al., 2017). Water depth was restricted to 2cm throughout the entire experiment to guarantee a comfortable phonation for each subject and to keep treatment conditions and methodology as strict as possible. Smaller diameters and/or more water depth will increase flow resistance (Andrade et al., 2016) and might therefore lead to better results. However, recent results of Guzman et al. (2017a, 2017b) do not support our hypothesis. They combined a straw with small diameter (5 mm) and more water depth (5cm) and did not find improvements in acoustic or auditory-perceptual outcomes. There is need for further research to find the best matched materials, diameters and water depths for individual vocalists who all have unique glottal resistances (Titze, 2002a; Titze, 2002b; Maxfield et al., 2015).

Resonant voice training using nasal consonants led to an improved DSI in vocally healthy future occupational voice users. Although it is the SOVT exercise with the lowest flow resistance (Titze, 2006; Maxfield et al., 2015), increases in objective vocal quality were found. Furthermore, higher baseline DSI scores in a healthy population probably allowed less progress. In an earlier study, De Bodt et al. (2012) found a better vocal fold closure during humming (resonance on /m/) in vocally healthy future occupational voice users. This better vocal fold closure might lead to more vocal economy and efficiency, and consequently, a better vocal quality. Furthermore, resonant voice training has the extra advantage of being speech-embedded (Kapsner-Smith et al., 2015). The nasal consonants can easily be combined with vowels and other consonants in words, sentences, texts and spontaneous speech, which might positively affect transfer. Resonant voice exercises were not investigated in a dysphonic population in this thesis. Therefore, a comparison with the other SOVT exercises is difficult. Earlier studies showed improvements in voice range profile, auditory-perceptual parameters and VHI after resonant voice therapy in people with vocal symptoms or voice disorders (Verdolini-Marston et al., 1995; Roy et al., 2003b; Chen et al., 2007).

Results of chapter 5.2 revealed important new insights regarding how subjects experience SOVT therapy. Noteworthy, these self-perceptions are contradictory to the results described so far. Despite the assessed vocal quality improvements, subjects reported a worse sounding voice immediately after the straw phonation and lip trill sessions. The exact opposite applied to WRT. Although no improvements in vocal quality were found, subjects experienced a better voice sound immediately after the WRT sessions. We hypothesize that the perception of a worse or better voice sound was related to a sensation rather than a sound. SOVT phonation is associated with higher flow resistance and more pressure in the vocal tract. Therefore, subjects need to familiarize with this unnatural phonation and might experience discomfort or vocal fatigue after practicing SOVT exercises for 30min (Titze, 2006; Gaskill & Quinney, 2012). The reason why subjects in the WRT group did not experience a worsening in voice sound and/or sensation, might be related to the double source of vibration (i.e. vocal fold vibration and water bubbling). A secondary vibratory source at the distal part of the vocal tract produces a fluctuating intraoral pressure, which is hypothesized to create a "massage-like" effect on the vocal folds and the vocal tract with a reduction of vocal tract discomfort and muscle tension (Andrade et al., 2014; Guzman et al., 2017b). This "massage-like" effect possibly balanced the unnatural feeling of higher supraglottal pressure. Two results found in the WRT group support our hypothesis. First, subjects literally reported a more comfortable voice production after the WRT sessions. Second, the physical subscale of the VHI (P-VHI) significantly decreased, which indicates less physical vocal discomfort (e.g., "I use a great deal of effort to speak," "I feel as though I have to strain to produce my voice") (Guzman et al., 2017b). Furthermore, similar decreases in P-VHI were found after water-resistance therapy in patients with hyperfunctional dysphonia (Guzman et al., 2017a) and in healthy teachers (Mailänder et al., 2017). In contrast to the results of Guzman et al. (2017b), this thesis showed no changes in Vocal Tract Discomfort Scale (VTTDS) after WRT. This contradictory finding may be due to differences in inclusion criteria. Self-reported vocal complaints, including vocal fatigue and muscle tension perception, were specified as inclusion criteria in the study of Guzman et al. (2017b) but not in this thesis. It is possible that the VTDS is not sensitive enough to detect changes in a population with limited baseline discomfort. Further exploration of the impact of secondary vibratory sources on vocal tract discomfort is needed. The reason why lip trilling did not lead to the same phonatory comfort as water bubbling is subject for further research.

In general, each SOVT exercise showed a positive effect on one or more facets of voice. Those results suggest transfer of the heightened source-vocal tract interaction achieved during

SOVT-phonation to normal open-mouth phonation (/a/ vowel and continuous speech). The underlying mechanisms for transfer are not yet completely understood. However, it is hypothesized that the epilarynx, also known as the laryngeal vestibule, plays a crucial role in that process. The epilarynx, which is a tube just above the glottis, can narrow during SOVT exercises (Titze, 2006; Titze & Verdolini Abbott, 2012). The oral semi-occlusion is then accompanied with a semi-occlusion at the back end of the vocal tract, further reinforcing the source-vocal tract interaction. The hypothesis is that vocalists wants to hold on to the sensation of resistance and back pressure associated with SOVT exercises, and therefore retain (or create) some epilarynx narrowing when transferring to normal open-mouth phonation (Titze, 2006). The vocal tract configuration evolves from an inverted megaphone shape during SOVT exercises to a megaphone shape after SOVT exercises (Titze, 2006) (Figure 7.1). In other words, the epilarynx could serve as an impedance matcher between the vocal folds and the vocal tract in trained vocalists, and SOVT exercises may assist in the awareness of this impedance matching (Titze & Story, 1997; Titze, 2006; Titze & Laukkanen, 2007).

Based on the theory and physics behind an SOVT, training or therapy should start with the greatest resistance to airflow and thus the highest source-vocal tract interaction, and proceed hierarchically through less resistive and more naturel SOVT exercises (Titze, 2006; Gaskill & Quinney, 2012). For the SOVT exercises discussed in the current thesis, the following theoretical order could be proposed: (1) straw phonation using stirring straws, (2) straw phonation using drinking straws, (3) WRT, (4) lip trill, and (5) nasal consonants. The position of straw phonation using drinking straws and WRT might be switched depending on the used water depth. However, it should be acknowledged that this scientifically strong order is not obviously a clinically strong order. As shown in chapter 5.2, vocalists often need time to get used to the higher resistance to airflow during SOVT exercises. It can be assumed that this familiarization time will depend on the type of vocalist. For example, patients with (hyperfunctional) voice disorders will probably need more time than healthy and experienced singers. Therefore, an individualized trajectory based on comfort and ease of phonation will be necessary (Titze, 2006; Gaskill & Quinney, 2012). It is the task of the vocologist to check whether the exercises are correctly performed in terms of sufficient breath support and abdominal muscle use. Furthermore, the most suitable SOVT exercise for a specific vocalist depends on his or her natural glottal resistance. People with more restricted tissue motion in the vocal folds tend to have smaller amplitudes of vibration with more adduction, which increases their glottal resistance (Titze, 2002a; Maxfield et al., 2015). Highly resistant SOVT exercises, such as phonation through stirring straws will probably be the best match for them. Further research is needed to find the most optimal SOVT exercises for each individual, which will probably depend on multiple factors such as sex, age, type of voice user, history of voice training or therapy, vocal fold pathology, etc. In summary, a hierarchical and individualized SOVT training or therapy program, including a variety of techniques and a good balance between transfer and comfort, seems advisable for clinical practice.

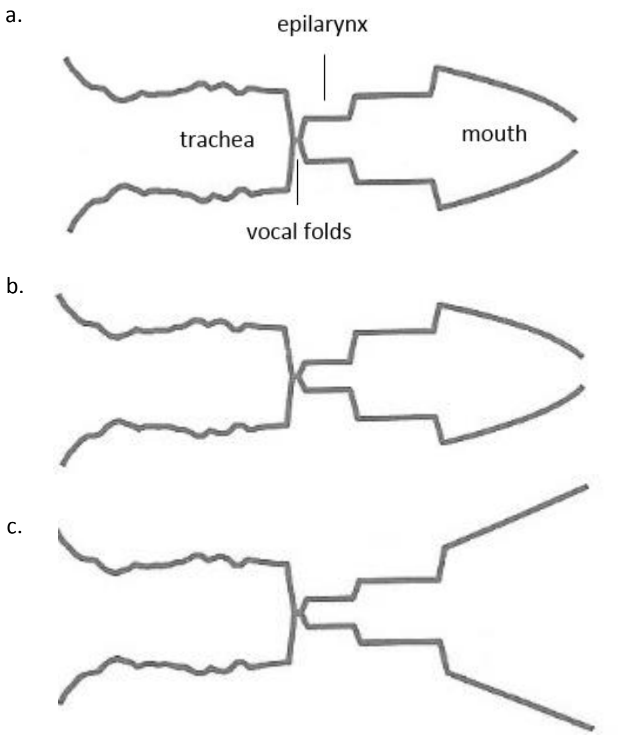


Figure 7.1 Vocal tract configurations associated with SOVT exercises. Inverted megaphone vocal tract configuration without epilarynx narrowing (a), inverted megaphone vocal tract configuration with epilarynx narrowing (b), megaphone vocal tract configuration with epilarynx narrowing (c) (Titze & Verdolini Abbott, 2012)

7.1.3 How to make a clinical decision based on these results?

Clinicians are encouraged to critically interpret the results summarized in Tables 7.1 and 7.2. First of all, it should be acknowledged that the results found in vocally healthy subjects cannot be generalized to a dysphonic population, and vice versa. The EBP model (Figure 2.1) is a good starting point to make a clinical decision. A training or treatment program should be developed for each *specific* vocalist based on the best available *research evidence*. This program should progressively be evaluated and adjusted based on the *clinician's expertise* and the *vocalist's preferences* (Sackett et al., 1996; McKibbon, 1998; De Bodt et al., 2008a).

For example, a female kindergarten teacher is referred for voice therapy because of a hyperfunctional voice disorder (muscle tension dysphonia). In the anamnesis, the patient mentioned the following complaints: (1) "children do not hear or understand me in class due to my hoarseness", (2) "people ask if I am sick or tired the moment they hear my voice" and (3) "I am not able to sing". Auditory-perceptual evaluation shows a mild dysphonia characterized by roughness and strain. Acoustic analyses shows increased jitter, shimmer and NHR and a truncated frequency range. The DSI is -1.0 and the AVQI is 4.66. The psychosocial impact is significant (VHI 76). One possible process of clinical decision making is elaborated below.

Based on the anamnesis and the voice assessment, you decide that the primary aim of your treatment is to decrease the patient's hoarseness (complaint 1 and 2), and the secondary aim is to expand her frequency range (complaint 3). If you look at Table 7.1, chewing and yawn-sigh seemed the most promising vocal facilitating techniques to decrease acoustic perturbation and noise measures in vocally healthy SLP students. You have a preference for yawn-sigh because of previous positive *clinical experiences* with the use of this technique in patients with hyperfunctional dysphonia. However, yawn-sigh was only investigated in vocally healthy subjects in this thesis, wherefore you decide to search for additional *research evidence* applicable to the specific patient. In the scientific literature, you find that several authors describe a reduction of muscle tension in the vocal tract due to a lowering of the larynx and widening of the pharynx (Brodnitz, 1968; Moncur & Brackett, 1974; Wilson, 1979;

Pershall & Boone, 1985; Boone & McFarlane, 1988; Casper et al., 1990; Colton & Casper, 1990; Boone, 1991; Moore, 1990; Boone & McFarlane, 1993; Dworkin et al., 2000; Shrivastav et al., 2000; Holmberg et al., 2001; Roy, 2003a; Schneider & Sataloff, 2007; Boone et al., 2010; Duan et al., 2010). You also find that yawn-sigh might lead to a good impedance match between the vocal tract and the vocal folds (Titze & Verdolini Abbott, 2012). More specifically, a yawn is performed with e wide vocal tract which matches the glottal configuration of a sigh, i.e. slightly abducted vocal folds. Because the otorhinolaryngologist observed hyperadduction of the vocal folds during flexible videolaryngostroboscopy, you assume that yawn-sigh might be a suitable technique for this case. The *patient* feels comfortable with the performance of the technique, so you decide to add it to your treatment program.

If you now observe Table 7.2, straw phonation shows the best *research evidence* in patients with dysphonia. Improvements in both auditory-perceptual parameters, acoustic parameters and DSI were found. Based on these results, you decide to add this technique to your treatment program. However, the *patient* does not seem to get used to the higher resistance to airflow and the back pressure associated with straw phonation. She is worried that it will worsen her voice. Therefore, you decide to switch to water-resistance therapy because results of this thesis showed that patients reported a better self-perceived vocal quality and less physical discomfort after the technique. This might reassure your patient. Because lip trill and resonant voice therapy show more *research evidence* for improving the vocal quality, you gradually introduce these exercises too. Although resonant voice training was only investigated in vocally healthy subjects in this thesis, earlier studies showed promising underlying mechanisms of the technique and positive effects in patients with dysphonia (Verdolini-Marston et al., 1995; Roy et al., 2003b; Chen et al., 2007; De Bodt et al., 2012).

Once the patient is familiar with the exercises, pitch variations during SOVT exercises can be introduced to potentially increase her frequency range. This hypothesis is not supported by the results found in this thesis. However, other *research evidence* shows that SOVT exercises are the ideal vocal warm-up because phonation with high subglottal pressure and high pitch is possible without risking injury to the vocal fold mucosa (Titze, 2000b, Titze, 2002a, Titze, 2006; Guzman et al,. 2013b; Ogawa et al., 2014; Hampaia et al., 2015; Smith & Titze, 2017).

Of all the techniques studied, only chewing led to an actual increase in highest frequency. Again, this was only investigated in vocally healthy subjects in this thesis and other research evidence is lacking. Based on the weight of the other two pillars (*clinician's* expertise and *patient's* needs/preferences), chewing may or may not be added to the treatment program.

7.2 Effect of frequency and duration of practice (dosage)

Estimating the optimal dosage for training or treatment is an unsolved challenge in the field of vocology (Roy, 2012; De Bodt et al., 2015). The second purpose of this thesis was to explore the motor learning principle “distribution of practice” in voice training **(chapter 6.1)** and voice therapy **(chapter 6.2)**. A comparison was made between a short-term intensive voice training/therapy (IVT, “massed” practice) and a long-term traditional voice training/therapy (TVT, “spaced” practice). As treating patients intensively and individually may lead to quickly filled week schedules for the clinician, an additional comparison was made between an individual (IVT-I) and a group IVT (IVT-G) (chapter 6.2).

In the voice training study **(chapter 6.1)**, similar positive results were found for the parameters MPT, I-low, F-low, F-high and DSI for both IVT and TVT. Furthermore, the improved parameters remained stable till 6 weeks follow-up in both groups. More in-depth within-group analyses indicated a preference for the IVT group regarding the evolution of MPT, F-low and DSI, and a preference for the TVT group regarding the evolution of I-low. Both groups also showed a positive trend for the parameters I-high and VHI. In contrast to the study of Fu et al. (2015a), auditory-perceptual evaluations and acoustic outcomes showed no significant evolution, probably due to the fact that participants were vocally healthy in this study allowing less significant progress.

This population of vocally healthy participants was a well-considered study group for a first exploration of a motor leaning principle that is new in vocology. Every voice user, also a vocally healthy individual, is able to learn economic and efficient voice use (Titze, 2006; Gaskill & Quinney, 2012; Titze et al., 2016; Croake et al., 2017; Mills et al., 2017). Therefore, learning principles will probably apply to any type of voice user. This may cautiously be compared with a typical motor learning task, such as learning how to play tennis. An intensive tennis program will probably lead to more effective and efficient learning than a less intensive one, regardless of the type of player (age, sex, physical fitness, experience etc.). Of course, it is plausible that a younger player with a higher level of physical fitness and experience will learn even more and faster than an older player with less physical fitness and experience.

However, a general trend of more effective and efficient learning in the intensive program will likely exist for both individuals. With this idea in mind, we hypothesized that the results in healthy participants would give a first general idea of what the most effective distribution of practice might be in vocology. Furthermore, this selection provided more options for a stronger methodological design with less bias. A randomization procedure and better control of influencing factors can easier be achieved in healthy participants than in dysphonic patients.

Results of the voice therapy study **(chapter 6.2)** supported our hypothesis and showed positive results for the objective vocal outcomes (acoustic parameters, voice range profile and multiparametric indices) and the auditory-perceptual evaluations for both IVT and TVT. DSI significantly and similarly improved pre- to post-therapy in the IVT-I (+3.1), IVT-G (+3.2) and TVT (+3.0) groups. Strikingly, IVT made an equal progress in only 2 weeks and 12h of therapy compared with TVT that needed 6 months and 24h of therapy. The same progress was not completely achieved after identically 12h of traditional treatment (3 months, DSI +2.5). Furthermore, improvements were not only limited to short-term effects as DSI scores remained stable till 1 year follow-up in the three groups. These findings were particularly surprising for subjects of the IVT groups who received only two weeks of actual treatment. Positive follow-up indicates that patients were capable of progressive vocal self-management in the absence of active rehabilitation (Kleemola et al., 2011; Wenke et al., 2014). Motor and cognitive learning probably continued to occur after treatment and reinforced behaviors taught during this short but intensive period (Wenke et al., 2014; Fu et al., 2015).

Besides objective and auditory-perceptual evaluations, patient’s self-report is indispensable in a multidimensional assessment of therapy outcome. Unfortunately, the first potential drawback for IVT arises here. The psychosocial impact (VHI) of the voice disorder significantly improved after TVT but not after IVT. Two weeks might be too short to experience an impact on daily life. As improved vocal quality remained stable till 1 year follow-up, we might expect that participants gradually encountered less psychosocial problems. However, VHI inconsequently deteriorated in the IVT-I group at follow-up, whereas VHI remained stable in the TVT and IVT-G groups. Progressive vocal-self management in real-life situations apparently became more difficult after a while. Therefore, follow-up sessions or potential refurbishment of learned skills by boost therapies will be important in future. Further research should implement additional self-reports to have a full picture of the patient's opinion and satisfaction regarding the administered distribution of practice.

Introducing IVT in everyday clinical practice will have its consequences for both the vocalist, the vocologist and the health care system. Time efficiency is a first advantage for both parties as busy work schedules are no exception these days. Occupational voice users and elite vocal performers are sometimes hindered to work because of their voice problems and want to resume work as soon as possible (Fischer et al., 2009; Fu et al., 2015a). Secondly, people who live far from the voice center will experience benefits of an IVT model as they do not have to schedule weekly appointments spread overall several weeks to months (Patel et al., 2011). Therefore, it will also be a much "greener" and ecological method. Third, motivation may increase or be regained as more progress will be noted in a short time frame (Patel et al., 2011; Wenke et al., 2014; Fu et al., 2015a). A higher motivation was clearly noticeable when observing patient adherence. Average cancelation rates were only 1.5% in the IVT-I group and 0% in the IVT-G group compared with 17% in the TVT group. The latter approximates the 25% found in traditional treatment by Wenke et al. (2014). Furthermore, no dropout existed in the IVT groups, whereas 19% (3/16) of the patients in the TVT group dropped out before therapy completion. Other possible reasons for greater adherence in IVT are the urge to get the maximum out of a short treatment period with a clear end sight ("now or never") and being in the flow with full focus on voice and less distractions (Patel et al., 2011; Wenke et al., 2014). Therapy in group may additionally give that extra social control and support for showing up every session.

Cost-effectiveness will be a last and important advantage. The reimbursement system in Belgium prescribes 80 sessions of 30 minutes over maximum 2 years with a free choice of practice frequency (De Bodt et al., 2014). Traditionally, weekly 30-min sessions are spread over 1 or 2 years till refund is no longer disposable. Problems arise when dysphonia is chronic or patients relapse after treatment (Van Lierde et al., 2007). Therefore, reorganizing the distribution of sessions can be useful. With a short-term IVT, sessions will be saved for follow-up or potential restart of treatment. An individualized plan can be made per patient and pathology and re-evaluation is important depending on the individual's evolution. In this manner, the exact number of sessions will be adapted to the specific case in front of the clinician and not to the absolute maximum written on the prescription. Consequently, less burden on the health care system might be expected (Wenke et al., 2014). However, it should be noted that practice sessions longer than 30 minutes are nowadays not refunded in Belgium. This makes scheduling intensive treatments (e.g. 1h a day) not yet feasible in clinical practice. Given the promising results of massed practice found in this thesis, the rules of reimbursement might be reconsidered.

Besides the many benefits a massed practice model has to offer, certain aspects should be kept in mind. At first, the potential risk of "overdose" cannot be excluded (Bergan, 2010; Roy, 2012; Behlau et al., 2014). Just like in medicine or pharmacy, the threshold at which voice training or therapy transitions from being beneficial to harmful should be explored (Roy, 2012). Signs of vocal fatigue must be detected and otorhinolarngologists should be available for additional check-up if necessary. Nevertheless, flexible videolaryngostroboscopic results, presented in chapter 6.2, are reassuring. Occurrence of organic lesions did not increase after 2 weeks IVT. On the contrary, decreases of 6.7% after IVT-I and no less than 40% after IVT-G were found. These impressive results give food for thought as we know that the decline was only 7.7% after 6 months of TVT. Earlier findings by Fu et al. (2015a) support the current results. The authors found comparable positive videolaryngostroboscopic outcomes post-intensive and -traditional treatment for patients with vocal nodules. Of course, variability will play a role in the balance between beneficial and harmful dosages (Roy, 2012; Behlau et al., 2014). It is possible that the ideal frequency and intensity for one individual may be insufficient or harmful for another (Roy, 2012; Behlau et al., 2014). Second, scheduling intensive sessions might be complex as it should fit both the vocalist's and vocologist's schedule (Bergan, 2010). Based on the current results, a group program might offer opportunities for the clinician to treat more patients in such an intensive way. The group IVT evolved equally in terms of objective vocal quality and capacities as the individual groups. Factors that stimulate learning in a group environment have been explored in the domain of psychotherapy, rather than voice therapy. One of the described advantages in that domain is observing and learning from each other (Guttmacher & Birk, 1971). Evaluating another person is often easier and may unconsciously reflect information to you as observer. Secondly, group treatment provides a miniature real-life situation with more opportunities for transfer (e.g. group conversations) (Mishna, 1996). At last, participants feel supported and realize that others have similar problems which might relief shame (Guttmacher & Birk, 1971). In the current IVT study, groups were formed homogeneous in terms of vocal pathology and severity to avoid frustration and obtain an adjusted pace. Nevertheless, those factors were not always avoidable and sometimes led to extra individual needs. Although the group results of were promising, two factors may have influenced them: participants started with a somewhat milder baseline dysphonia severity and were all SLP students. Further research is needed to confirm if group treatment can be as effective as individual treatment.

In summary, short-term IVT is a new and promising service delivery model to optimize the healthy voice and rehabilitate the disordered voice. The number of benefits associated with IVT clearly exceeds the potential drawbacks (Table 7.3). Group treatment might be a solution for the complexity of scheduling an IVT in everyday clinical practice.

Table 7.3 Benefits (+) and potential drawbacks (-) of short-term intensive voice training/therapy.

+	-
time efficiency	risk of “overdose”
distance	complexity of scheduling
ecological	
motivation	
adherence	
focus	
cost-effectiveness	

7.2.1 How to make a clinical decision based on these results?

Clinicians are encouraged to make a clinical decision based on the EBP model (Figure 2.1). Each training or treatment program should be developed for a *specific* vocalist based on the best available *research evidence*. This program should progressively be evaluated and adjusted based on the *clinician's expertise* and the *vocalist's preferences* (Sackett et al., 1996; McKibbon, 1998; De Bodt et al., 2008a).

For example, you decide to try a short-term intensive voice therapy for a patient with a hypofunctional voice disorder (glottal insufficiency) based on the promising *research evidence*. Your *patient* agrees with this practice schedule, but is only available on Mondays, Thursdays and Fridays (*context*). Therefore, you decide to practice 1h30 min a day, 3 days a week. Some progress was achieved after week 1. However, on Monday of week 2, the *patient* suffers from vocal fatigue and has a very asthenic voice. The session is too intensive and you decide to shorten it (*clinician's expertise*). By Wednesday, the patient's voice has recovered and a session of 1h30 min is again possible. At the end of week 2, clear progress is noted. The *patient* is satisfied and very motivated to continue treatment. Based on your *clinical expertise*, you decide that continuation of treatment is indeed necessary before transfer of learned skills can be expected. In agreement, you continue with a more traditional practice frequency. After another 3 weeks of traditional treatment, the *patient* is familiar with all techniques and progressive vocal self-management is expected (*clinician's expertise*). An appointment with the otorhinolaryngologist shows a better vocal fold closure and the voice assessment significantly improved. Therefore, you decide to start a home practice program for your patient. Skype sessions are scheduled every 2 weeks for check-up. After 3 months, you see the patient for follow-up in the clinic. The vocal quality of your patient is stable and the psychosocial impact clearly improved. After 6 months, the *patient* contacts you because of increased vocal complaints. Therefore, you decide to schedule a boost short-term intensive treatment of 1 week.

7.3 Strengths and limitations

Investigating the effect of an intervention involves a search for a good balance between efficacy and effectiveness. *Efficacy* is the effect that is observed under ideal study conditions (i.e. *explanatory* trial), whereas *effectiveness* is the effect detected under real-life conditions (i.e. *pragmatic* trial) (Roland & Torgerson, 1996; Patsopoulos, 2011; Tosh et al., 2011; Porzsolt et al., 2015). An explanatory trial has high internal validity (i.e. the ability to determine cause-effect relationships, less risk of bias), but this can hamper its external validity (i.e. ability to generalize the results to a clinical setting) (Patsopoulos, 2011; Barnish & Turner, 2017). Both trials can sometimes lead to different conclusions about the benefit of an intervention, either because a training or treatment that is effective in ideal settings may not work in real life or vice versa. Generally, trials will be situated somewhere on a continuum between these two extremes (Patsopoulos, 2011; Tosh et al., 2011; Porzsolt et al., 2015).

This thesis shows an evolution in the search for a balance between efficacy and effectiveness. Each study has its own explanatory strengths and limitations which are summarized in Table 7.4. When observing the table, it should be kept in mind that an explanatory limitation can sometimes be interpreted as a pragmatic strength.

Randomization is a first explanatory strength, which is ideal to guarantee similar distribution of risk factors in the groups of an experimental trial and so reduce selection bias (Roland & Togerson, 1998; Porzsolt et al., 2015). This tool was used in all studies, except for chapter 6.2. Randomization is sometimes unethical to apply in a clinical setting as it will compete with the patient’s expectations (Tosh et al., 2011; Porzsolt et al., 2015). Patients expect a shared decision making concerning their treatment options. Therefore, in chapter 6.2, 28% (13/46) of the participants were assigned to the groups based on availability or preference. This manner of assignment is applicable to real-life everyday clinical practice and this explanatory limitation is therefore at the same time a pragmatic strength (Porzsolt et al., 2015). Reduction of selection bias through randomization can only be assured with large enough sample sizes. Given the relatively small sample size used in chapter 5.2, blocked randomization was used to assure equal contribution in age, gender, studies and occupation.

Table 7.4 Summary of explanatory strengths (+) and limitations (-) in chapters 4.1 – 6.2.

	Chapter						
Explanatory strength	4.1	4.2	4.3	5.1	5.2	6.1	6.2
Randomized study design	+	+	+	+	+/-	+	+/-
Control group	+	+	+	+	+	+	+
Sham- (placebo-) controlled trial	-	-	-	-	+	-	-
Large sample sizes	-	-	-	-	-	-	-
Homogeneous study population	+	+	+	+	-	+/-	-
Technique in isolation instead of a broader training/therapy program	+	+	+	+	+	N/A	N/A
Complete and well-described training/therapy program	+	+	+	+	+	+	+
Home practice information	-	-	-	+	+	-	-
Voice experts a trainers/therapists	-	-	-	-	-	-	+
Avoidance of trainer/therapist bias	+	+	+	+	+	+	+
Avoidance of observer bias	-	-	-	+/-	+	-	+
Standardized and multidimensional voice assessment	+/-	+/-	+/-	+	+	+	+
Long-term follow-up	-	-	-	-	-	+/-	+

Note: N/A, not applicable; Titles of chapters 4.1 – 6.2 can be found below:

4.1 Effect of the vocal facilitating technique chewing on the phonation of future occupational voice users
4.2 Effect of the vocal facilitating techniques chant talk and pitch inflections on the phonation of future occupational voice users
4.3 Effect of the vocal facilitating techniques glottal fry and yawn-sigh on the phonation of future occupational voice users
5.1 Effect of two semi-occluded vocal tract training programs on the phonation of future occupational voice users: resonant voice training using nasal consonants versus straw phonation
5.2 Effect of three semi-occluded vocal tract therapy programs on the phonation of patients with dysphonia: lip trill, water-resistance therapy or straw phonation
6.1 Massed versus spaced practice in vocology: effect of a short-term intensive voice training versus a longer-term traditional voice training
6.2 Massed versus spaced practice in vocology: effect of a short-term intensive voice therapy versus a long-term traditional voice therapy

A second explanatory strength used in each study is the inclusion of a **control group**. In randomized controlled-trials, differences in outcome between experimental and control groups can be attributed to the tested intervention (Porzsolt et al., 2015). In chapters 4.1, 4.2, 4.3 and 5.1, the results of subjects that practiced a vocal technique were compared to the results of controls receiving no voice training or therapy. In chapters 6.1 and 6.2, the traditional voice training and therapy groups served as control groups for the new tested massed practice intervention. In chapter 5.2, an additional explanatory power was added as subjects in the control group received a **sham (placebo) treatment**. Unlike drug trials and some medical interventions, voice therapy trials cannot easily blind participants to the treatment they receive or trigger placebo effects (Bos-Clark & Carding, 2011). In pragmatic trials, the outcome is the total difference between two interventions, including both treatment and associated placebo effects, as this will best reflect the clinical response in daily practice (Roland & Torgerson, 1996). However, sham-controlled trials are explanatory strong designs that should be used whenever possible. To our knowledge, the study discussed in chapter 5.2 is one of the first voice therapy trials that meets this strength.

Besides the use of randomized controlled trials, it is important to include **large enough sample sizes** as this will assure desired statistical power and generalizability of results (Chow, 2011). In this thesis, sample sizes varied between 8 and 16 participants per group. Recruiting large sample sizes is often difficult in clinical trials. All studies of this thesis used multigroup designs in which several interventions and a control group were compared. This led to a total inclusion number of 234 subjects for the entire thesis. Besides, pre-/post-test designs were used with at least two assessments for each participant. In chapter 6.2, the use of a longitudinal design even led to a minimum of 9 assessments per participant. Furthermore, all participants received training or therapy which is time consuming for the experimenters. However, despite these difficulties, larger sample sizes based on power analysis of previous studies are needed in future (Hazlett et al., 2011).

Another characteristic of an explanatory approach is the recruitment of a **homogeneous population**. Pragmatic trials, on the other hand, reflect variability between patients that occur in real-life clinical practice (Roland & Togerson, 1998; Barnish & Turner, 2017). In chapters 4.1, 4.2, 4.3 and 5.1, a homogeneous group of vocally healthy speech-language pathology students, aged between 17 and 22 years, were included. In chapter 6.1, we included all vocally healthy female participants, aged between 20 and 24 years, but with different studies and professions. Chapter 5.2 and 6.2 included the most heterogeneous groups consisting of female and male patients, aged between 17 and 60 years, with different studies and professions, and variations in dysphonia type and severity. Homogeneous study populations may provide less bias (more internal validity) but meanwhile lose some generalizability to everyday clinical practice (less external validity) (Kleemola et al., 2010; Patsopoulos, 2011). An overview of the participants included in each chapter can be found in Table 7.5.

When including a heterogeneous study population in terms of studies/occupation, gender etc., it is important to aim for a similar distribution of these factors over the different groups. In chapter 6.2, for example, the IVT-I and TVT groups included a similar number of SLP students (*n* = 10), other students (*n* = 2) and employees (*n* = 3 or 4) and a similar distribution of men (*n* = 1) versus women (*n* = 14 or 15). However, the IVT-G group consisted solely of female SLP students. Because SLP students might potentially react differently on voice therapy, the group IVT results should be interpreted with caution.

In the “content” part of this thesis, all vocal techniques were investigated **in isolation** and were compared with other techniques in one design (except for chewing). To date, this explanatory strength has been insufficiently used in the literature which made comparisons between different training or therapy approaches impossible (Ruotsalainen et al., 2010; Bos-Clark & Carding, 2011). Furthermore, this thesis focused on the effect of **longer training or therapy programs** instead of a one-time performance, which is mainly a pragmatic strength. The **detailed description of the content** of the voice training and therapy programs used in this thesis is both an explanatory and pragmatic strength. It assures replication in future studies and general clinical practice (Bos-Clark & Carding, 2011).

Table 7.5 Overview of the participants included in chapters 4.1 - 6.2.

Chapter	*n*	Voice	Gender	Mean age (range)	Studies	Professions
4.1	27	Healthy	Female	18 yrs. (17-21 yrs.)	Speech-language pathology (SLP)	-
4.2	40	Healthy	Female	18 yrs. (17-21 yrs.)	SLP	-
4.3	36	Healthy	Female	18 yrs. (17-21 yrs.)	SLP	-
5.1	30	Healthy	Female	19 yrs. (17-22 yrs.)	SLP	-
5.2	35	Dysphonia	33 Females 2 Males	21 yrs. (17-44 yrs.)	SLP (*n* = 23) Communication management (*n* = 2) Podology (*n* = 1) Educational sciences (*n* = 1) Pharmaceutical sciences (*n* = 1) Social work & welfare (*n* = 1) Dental care (*n* = 1) High school (human sciences) (*n* = 1)	Teacher (*n* = 2) Animator nursing home (*n* = 1) Occupational therapist (*n* = 1)
6.1	20	Healthy	Female	22 yrs. (20-24 yrs.)	Medicine (*n* = 3) Law school (*n* = 2) Social work & welfare (*n* = 1) Political sciences (*n* = 1) International relations & diplomacy (*n* = 1) Nursing (*n* = 1) Rehabilitation sciences & physiotherapy (*n* = 1) Educational sciences (*n* = 1) Linguistics & literature (*n* = 1) Multilingual professional communication (*n* = 1) Sociology (*n* = 1) Applied economic sciences (*n* = 1)	Nurse (*n* = 1) Midwife (*n* = 1) Process operator (*n* = 1) Pedagogue (*n* = 1) Sales manager (*n* = 1)
6.2	46	Dysphonia	44 Female 2 Males	23 yrs. (18-60 yrs.)	SLP (*n* = 35) Linguistics & literature (*n* = 1) Physical education (*n* = 1) Civil engineering (*n* = 1) Business engineering (*n* = 1)	Teacher (*n* = 3) Nurse (*n* = 1) Home care (*n* = 1) Assistant medical staff (*n* = 1) Supervisor living group (*n* = 1)

Note: Four SLP students with dysphonia included in chapter 5.2 were earlier included in chapter 6.2. Data collection (including long-term follow-up) was completely finished before the experiment of chapter 5.2 started.

.

In efficacy and effectiveness studies, it is important to have information regarding **home practice**. Despite the encouragement for home practice, compliance was not questioned in chapters 4.1, 4.2 and 4.3. In chapters 5.1 and 5.2, home practice compliance was questioned and showed no significant differences between the training/therapy groups. In chapters 6.1 and 6.2, no instructions or encouragements concerning home practice were provided to maintain a clear view on practice frequency in the IVT and TVT groups. If the TVT group would practice more frequently at home than the IVT groups, the difference in practice frequency would diminish between the groups, which might in turn bias the results. However, gathering home practice information after the experiment could provide valuable information and should therefore be implemented in further research.

In chapters 4.1 - 6.1, master SLP students were the trainers/therapists of the sessions. They were intensively coached, guided and supervised by voice experts (K.V.L., E.D. and I.M.). The master students had adequate theoretical and practical knowledge to guide the sessions. However, it should be acknowledged that a lack of expertise in treatment may have influenced the results. Future research should preferably select only **voice experts as trainers/therapists**. A voice expert did treat all participants of chapter 6.2 (I.M.). Furthermore, three other experienced and blinded clinicians performed the longitudinal assessments (E.D., K.B. and L.B). Because data collection of this main study was intensive and time consuming (± 2.5 years with ± 624 active treatment hours and at least 9 assessments per subject), assistance of master students for the other experiments was required.

Biased outcomes can occur due to trainer/therapist bias or observer bias. **Trainer or therapist bias** was avoided in all studies. In chapters 4.1, 4.2, 4.3, 5.2, and 6.1, trainer or therapist bias was avoided because each session was guided by the same two trainers/therapists for every group. In chapter 5.1, trainer bias was avoided by splitting each training group in two and each trainer guided half of the groups. In chapter 6.2, therapist bias was avoided because the same therapist guided all sessions for all patients. **Observer bias** can occur if the assessor is aware of group allocation and study evolution (Roland & Togerson, 1998). Again, this thesis shows a clear evolution in taking observer bias into account. In chapters 4.1, 4.2 and 4.3, trainers were the assessors and vice versa. In these chapters, only objective outcome measures determined with computer software, were used. However, these objective assessments are still performed by humans in terms of instructions, encouragement etc. Therefore, observer bias cannot be excluded in these studies. In chapter 6.1, trainers were also the assessors and vice versa. However, the subjective auditory-perceptual evaluations were performed by two blinded assessors and an interrater reliability was determined. In chapter 5.1, observer bias was partly avoided by splitting each training group in two, so that four training groups were formed: resonant voice training 1 (R1), resonant voice training 2 (R2), straw phonation 1 (SP1) and straw phonation 2 (SP2). Experimenter 1 guided R1 and SP1, experimenter 2 guided R2 and SP2. The other experimenter performed the objective voice assessment (e.g. experimenter 1 performed the voice assessments of group R2 and SP2). Furthermore, auditory-perceptual evaluations were again performed by two blinded assessors and interrater reliability was determined. In chapter 5.2 and 6.2, assessors were blinded to group allocation and study evolution and observer bias was therefore completely avoided.

Because voice is a multidimensional phenomenon, it cannot be measured with a single scale or test (Ruotsalainen, 2008). A **voice assessment** should reflect this **multidimensionality** to enable a full description of therapy outcome. Different outcome measures do not always correlate and reliance on one particular outcome can therefore be misleading (Bos-Clark & Carding, 2011). Explanatory trials mostly focus on clearly measurable objective outcomes (e.g. acoustic measures), whereas pragmatic trials mostly determine patient-centered outcomes (e.g. psychosocial impact) (Roland & Togerson, 1998; Patsopoulos, 2011).

In this thesis, a clear evolution in the multidimensionality of the voice assessment can be observed. In chapters 4.1, 4.2 and 4.3, only objective vocal outcomes, determined during sustained /a/ phonation, were used (maximum performance task, acoustic measures, voice range profile, Dysphonia Severity Index). The multiparametric Dysphonia Severity index (DSI) reflects the multidimensionality of voice and is based on a weighted combination of the following parameters: maximum phonation time (MPT, in s), highest frequency (F-high, in Hz), lowest intensity (I-low, in dB) and jitter (in %). The index is designed to establish an objective and quantitative correlate of the perceived vocal quality and is sensitive to detecting small changes in vocal quality (Wuyts et al., 2000).

In chapters 5.1, 5.2 and 6.2, the objective outcome assessment was expanded with a second multiparametric approach, the Acoustic Voice Quality Index (AVQI). This index quantifies dysphonia severity based on both a sustained /a/ vowel and continuous speech (Maryn et al., 2010a). The AVQI consists of a weighted combination of 6 time- [i.e., shimmer local (SL), shimmer local dB (SLdB) and harmonics-to-noise ratio (HNR)], frequency- [i.e., general slope of the spectrum (Slope) and tilt of the regression line through the spectrum (Tilt)] and quefrency-domain [i.e., smoothed cepstral peak prominence (CPPs)] measures (Maryn et al., 2010b).

Furthermore, in chapters 5.1, 5.2, 6.1 and 6.2, subjective vocal outcomes were added to the voice assessment. First, the subjects' voices were auditory-perceptually evaluated using the GRBASI scale. Second, a subject's self-report was used, evaluating the psychosocial impact of potential voice problems or disorders with the Voice Handicap Index (Jacobson et al., 1997; De Bodt et al., 2000). The Vocal Tract Discomfort Scale was added to that self-report in chapters 5.2 and 6.2 (Mathieson et al., 2009; Luyten et al. 2016). An additional questionnaire to check the subject's opinion regarding the received SOVT therapy programs was used in chapter 5.2. In chapter 6.2, a flexible videolaryngostroboscopic evaluation was performed by an experienced otorhinolarngologist to evaluate laryngeal anatomic and physiologic changes related to therapy outcome.

At last, the implementation of **long-term follow-up** is both an explanatory and pragmatic strength that is often lacking in efficacy/effectiveness studies. In a review of Ruotsalainen et al. (2008), it was highlighted that no studies provide follow-up data beyond several months after treatment. Long-term follow-up is often difficult to achieve in clinical trials because of dropout. However, it remains crucial as dysphonia is often chronic or recurrent (Van Lierde et al., 2007). In chapter 6.1, follow-up data were available till 6 weeks after training; in chapter 6.2, follow-up data were available till 1 year after therapy. No sham treatment could be included in chapter 6.2 as it would be unethical to follow-up patients with sham treatment for 1 year (Kleemola et al., 2011).

7.4 Future perspectives

The search for efficacy and effectiveness of voice training and therapy should definitely be continued in future. To demonstrate the effect of an intervention, it will be important to first determine efficacy by explanatory trials and afterwards effectiveness by pragmatic trials (Porzsolt et al., 2015; Desjardins et al., 2017). Only then, both internal and external validity can be assured. In general, larger sample sizes based on power analysis are needed. Multicentric studies can be organized to access more participants (Ruotsalainen et al., 2008; Bos-Clark & Carding, 2011). Whenever ethically possible, randomized sham-controlled trials with long-term follow-up should be the standard design for further studies.

Regarding the content of voice training and therapy, both the vocal facilitating techniques and SOVT exercises need further investigation. First, the effect of the vocal facilitating techniques can be investigated in patients with dysphonia. Second, other SOVT therapy programs, such as tongue trill, raspberry, hand-over-mouth, finger kazoo and cup phonation should be investigated. Third, it can be further explored whether speech-embedded SOVT exercises (such as resonant voice training/therapy and cup phonation) are more effective than nonspeech-embedded SOVT exercises (such as straw phonation and tongue trill), or whether SOVT exercises with a double source of vibration (such as water-resistance therapy and tongue trill) are more effective than exercises with a single source of vibration (such as straw phonation and finger kazoo). Fourth, it will be important to determine the most optimal vocal facilitating technique or SOVT exercise for a specific vocalist or disorder and possible factors that might influence these matches. Fifth, programs in isolation can be compared with combined therapy programs to check the advantage of potential cumulative effects. At last, anatomical or physiological laryngeal and pharyngeal changes after therapy programs including vocal facilitating techniques or SOVT exercises can be subject for further research.

Based on the results of the dosage studies, it can be hypothesized that the golden mean between short-term intensive therapy and long-term traditional therapy might be an achievable, effective and efficient solution for everyday clinical practice. Voice therapy should definitely start more intensively and more transiently. Once the patient is ready for progressive vocal self-management in real life and transfer of learned skills (Wenke et al., 2014; Fu et al., 2015a), one of three different paths can be proposed. The first path is a gradual reduction of the frequency of active treatment till eventually only a follow-up program is required (“massed-spaced” practice). The second path involves an immediate transition from active treatment to follow-up. A boost intensive treatment can then be given at any moment in this follow-up process (“massed-massed” practice). The third possibility is a combination of the above two paths: starting with a gradual reduction of frequency, followed by a follow-up program and a boost intensive treatment when needed (“massed-spaced-massed” practice). Exploration of the most effective and efficient “massed practice” paths is subject for further research. Other aspects that can be implemented in future studies are the patient’s and therapist’s opining regarding the administered frequency and duration, and an investigation of the usefulness of group sessions and telepractice in short-term intensive treatments (Mashima et al., 2003; Fu et al., 2015b; Rangarathnam et al., 2015). A combination of massed practice, group sessions and follow-up with telepractice can lead to a cost-effective and ecological service delivery model.

Finally, a comparison and summary of well-designed, high-quality efficacy and effectiveness studies will provide a list of effective “ingredients” for voice training and therapy. SLPs active in clinical practice will then have the important task to prepare an individualized “menu” for every specific vocalist, or in other words, perform **evidence-based practice**.

7.5 Conclusion

Given the high prevalence and psychosocial impact of voice disorders, research should focus on finding the most effective and efficient voice training and therapy models. Therefore, the main objective of this doctoral thesis was to investigate the effect of voice training and therapy, both on the content and dosage level. Based on the studies described in this thesis, the following conclusions can be drawn:

Content

- Chewing seems to be the most effective vocal facilitating technique for optimizing the voice of vocally healthy future occupational voice users as both acoustic perturbation and noise measures, the voice range profile and the multiparametric vocal quality index DSI improved. Yawn-sigh is also a promising vocal facilitating technique that led to improved acoustic perturbation and noise measures and an increase in highest intensity. Chant talk and pitch inflections only led to decreased noise levels.
- Glottal fry, on the other hand, is less suitable for optimizing the voice of vocally healthy future occupational voice users as no vocal parameters improved.
- Straw phonation and lip trill are effective semi-occluded vocal tract exercises for rehabilitating the voice of patients with dysphonia. Straw phonation therapy led to both improved acoustic parameters, auditory-perceptual vocal quality and the objective vocal quality index DSI. Lip trill therapy positively affected the lowest intensity, DSI and the psychosocial impact associated with dysphonia.
- Water-resistance therapy showed no improvements in objective or auditory-perceptual parameters, although the self-perceived vocal quality and psychosocial impact associated with dysphonia improved.

Dosage

- A short-term intensive voice training/therapy is a promising service delivery model for optimizing the healthy voice and rehabilitating the disordered voice.
- A similar progress was made in only 2 weeks (12h) of intensive therapy compared with 6 months (24h) of traditional therapy.

- Advantages of a short-term intensive model are obtaining higher time efficiency, motivation, adherence, focus and cost-effectiveness. Furthermore, it is a much "greener" (ecological) method.
- Group sessions might be a solution for the complexity of scheduling short-term intensive programs in everyday clinical practice.

In conclusion, the results of this thesis contribute to evidence-based practice in vocology. It is a step forward in the process of providing a list of effective "ingredients" for clinical practice. To complete the list, the search for efficacy and effectiveness of voice training and therapy should definitely be continued in future.

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CURRICULUM VITAE

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Education

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2010-2013	Bachelor Logopaedic and Audiological Sciences – Logopaedics Ghent University Graduated with greatest distinction
2008-2010	1st and 2nd Bachelor Pharmaceutical Sciences Ghent University Reorientation due to greater interest in Logopaedics
2002-2008	General Secondary Education, Science-Mathematics Lyceum O.L.V. Vlaanderen, Kortrijk

Additional Education

2017	Personal effectiveness Doctoral School of Life Sciences and Medicine, Ghent University
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2015	Advanced Academic English writing skills Doctoral Schools of Life Science and Medicine, Ghent University
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2014	Statistics module 4: Introductory Statistics Institute for Continuing Education in Science, Ghent University

International Education & Training

2015	Summer Vocology Institute The National Center for Voice and Speech, University of Utah, U.S.
2013-2014	Erasmus exchange (master Logopaedics) Technologiko Ekpaideutiko Idrima, Patras, Greece

Publications: A1

- Meerschman, I., Van Lierde, K., Van Puyvelde, C., Bostyn, A., Claeys, S., D'haeseleer, E. (2018). Massed versus spaced practice in vocology: Effect of short-term intensive voice training versus a longer-term traditional voice training. *International Journal of Language & Communication Disorders,* 53(2), 393-404.
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SUBMITTED

- Meerschman, I., Van Lierde, K., Ketels, J., Coppieters, C. Claeys, S., & D'heaseleer, E. Effect of three semi-occluded vocal tract therapy programs on the vocal quality of patients with dysphonia: straw phonation, water-resistance therapy or Lip trill. Submitted to *International Journal of Language & Communication Disorders.*
- Meerschman I., Claeys, S., Bettens, K., Bruneel, L., D'haeseleer, E., & Van Lierde, K. Massed versus spaced practice in vocology: effect of a short-term intensive voice therapy versus a long-term traditional voice therapy. Submitted to *Journal of Speech, Language, and Hearing Research.*
- Narges, J., Ebadi, A., Meerschman, I., Izadi, F., Dabirmoghadam, P., D'haeseleer, E., Saeed, T., Salehi, A., Van Lierde, K., & Khoddami, S. M. A novel laryngeal palpatory scale (LPS) in patients with muscle tension dysphonia. Submitted to *Journal of Voice.*

Publications: B2

- Meerschman, I., & Van Lierde, K. (2016). Diagnostiek en behandeling van stemplooidysfunctie. In *Spanning in en rond de larynx: stand van zaken.* ISBN-nummer 9789491170225, p87-100.
- Van Lierde, K., D'haeseleer, E., Meerschman, I., De Bodt, M., & Claeys, S. (2015). Het effect van vocale stemopwarmingsoefeningen op de objectieve stemkwaliteit van vrouwelijke toekomstige professionele stemgebruikers (logopedisten in opleiding). In *Werken met je stem: spreken en zingen!* ISBN-nummer: 9789491170201, p75- 87.
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Presentations at International Conferences

- The Voice Foundation's 47th Annual Symposium: Care of the Professional Voice, Philadelphia, U.S., May 30 - June 3, 2018. Meerschman, I., Claeys, S., Bettens, K., Bruneel, L., D'haeseleer, E., & Van Lierde, K. Massed versus spaced practice in vocology: effect of a short-term intensive voice therapy versus a long-term traditional voice therapy (oral presentation).
- The Voice Foundation's 47th Annual Symposium: Care of the Professional Voice, Philadelphia, U.S., May 30 - June 3, 2018. Meerschman, I., Van Lierde, K., Ketels, J., Coppieters, C., Claeys, S., & D'haeseleer, E. Effect of three semi-occluded vocal tract therapy programs on the vocal quality of patients with dysphonia: Lax Vox, Straw Phonation, and Lip Trill (oral presenation).
- 10th European Congress of Speech and Language Therapy, Cascais, Portugal, May 10 - 12, 2018. Meerschman, I., Claeys, S., Bettens, K., Bruneel, L., D'haeseleer, E., & Van Lierde, K. Massed versus spaced practice in vocology: effect of a short-term intensive voice therapy versus a long-term traditional voice therapy (oral presentation).
- 10th European Congress of Speech and Language Therapy, Cascais, Portugal, May 10 - 12, 2018. Meerschman, I., Van Lierde, K., Ketels, J., Coppieters, C., Claeys, S., & D'haeseleer, E. Effect of three semi-occluded vocal tract therapy programs on the vocal quality of patients with dysphonia: Lax Vox, Straw Phonation, and Lip Trill (oral presenation).
- Minisymposium Nederlandse Vereniging voor Stem-, Spraak- en Taalpathologie, Utrecht, the Netherlands, March 23, 2018. Meerschman, I., Claeys, S., Bettens, K., Bruneel, L., D'haeseleer, E., & Van Lierde, K. Duur en frequentie van stemtherapie: intensief versus traditioneel (oral presentation).
- Pan-European Voice Conference (PEVOC12), Ghent, Belgium, August 30 - September 1, 2017. Meerschman, I., Van Lierde, K., Van Puyvelde, C., Bostyn, A., Claeys, S., & D'haeseleer, E. Massed versus distributed practice in vocology: Effect of a short-term intensive voice training versus a longer-term traditional voice training (oral presentation).
- Pan-European Voice Conference (PEVOC12), Ghent, Belgium, August 30 - September 1, 2017. Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. Short-term effect of two semi-occluded vocal tract training programs on the vocal quality of future professional voice users: “resonant voice training using nasal continuants” versus “straw phonation” (oral presentation).
- Pan-European Voice Conference (PEVOC12), Ghent, Belgium, August 30 - September 1, 2017. Meerschman, I., D'haeseleer, E., De Cock, E., Neyens, H., Claeys, S., & Van Lierde, K. Effect of chewing technique on the phonation of female speech-language pathology students: a pilot study (poster presentation).
- Pan-European Voice Conference (PEVOC12), Ghent, Belgium, August 30 - September 1, 2017. Meerschman, I., Bettens, K., Dejagere, S., Tetaert, L., D'haeseleer, E., Claeys, S., & Van Lierde, K. Effect of two isolated vocal facilitating techniques Chant Talk and Pitch

Inflections on the phonation of female speech-language pathology students: a pilot study (poster presentation).

- Pan-European Voice Conference (PEVOC12), Ghent, Belgium, August 30 - September 1, 2017. Meerschman, I., Bettens, K., Dejagere, S., Tetaert, L., D'haeseleer, E., Claeys, S., & Van Lierde, K. Effect of two isolated vocal facilitating techniques Glottal Fry and Yawn-Sigh on the phonation of female speech-language pathology students: a pilot study (poster presentation).
- The Voice Foundation's 46th Annual Symposium: Care of the Professional Voice, Philadelphia, U.S., May 31 - June 4, 2017. Meerschman, I., Van Lierde, K., Van Puyvelde, C., Bostyn, A., Claeys, S., & D'haeseleer, E. Massed versus distributed practice in vocology: Effect of a short-term intensive voice training versus a longer-term traditional voice training (oral presentation).
- The Voice Foundation's 46th Annual Symposium: Care of the Professional Voice, Philadelphia, U.S., May 31 - June 4, 2017. Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. Short-term effect of two semi-occluded vocal tract training programs on the vocal quality of future professional voice users: "resonant voice training using nasal continuants" versus "straw phonation" (oral presentation).
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- The Voice Foundation's 46th Annual Symposium: Care of the Professional Voice, Philadelphia, U.S., May 31 - June 4, 2017. Meerschman, I., Bettens, K., Dejagere, S., Tetaert, L., D'haeseleer, E., Claeys, S., & Van Lierde, K. Effect of two isolated vocal facilitating techniques Chant Talk and Pitch Inflections on the phonation of female speech-language pathology students: a pilot study (poster presentation).
- 30th World Congress of the I.A.L.P., Dublin, Ireland, August 21 - 25, 2016. Meerschman, I., D'haeseleer, E., De Cock, E., Neyens, H., Claeys, S., & Van Lierde, K. Effect of Chewing technique on the phonation of female speech-language pathology students: a pilot study (poster presentation).
- 30th World Congress of the I.A.L.P., Dublin, Ireland, August 21 - 25, 2016. Meerschman, I., D'haeseleer, E., Catry, T., Ruigrok, B., Claeys, S., & Van Lierde, K. Effect of two isolated vocal facilitating techniques Glottal Fry and Yawn-Sigh on the phonation of female speech-language pathology students: a pilot study (poster presentation).
- The Voice Foundation's 44th Annual Symposium: Care of the Professional Voice, Philadelphia, U.S., May 26 - 31, 2015. Meerschman, I., Van Lierde, K., De ley, S., & D'haeseleer, E. Effectiveness of a new intensive short-term voice treatment: a pre-experimental single subject design (oral presentation).

Presentations at National Conferences

- Research Day & Student Research Symposium, FFW Ghent, April 19, 2018. Meerschman, I., Claeys, S., Bettens, K., Bruneel, L., D'haeseleer, E., & Van Lierde, K. Massed versus spaced practice in vocology: effect of a short-term intensive voice therapy versus a long-term traditional voice therapy (oral presentation).
- 39th Congress Vlaamse Vereniging voor Logopedisten, ICC Ghent, March 16, 2018. Meerschman, I., Claeys, S., Bettens, K., Bruneel, L., D'haeseleer, E., & Van Lierde, K. Duur en frequentie van stemtherapie: intensief versus traditioneel (oral presentation).
- 18th symposium Logopedie en Audiologie, Het Pand Ghent, October 20, 2017. Meerschman, I., Van Lierde, K., Van Puyvelde, C., Bostyn, A., Claeys, S., & D'haeseleer, E. Duur en frequentie van stemtherapie: intensief versus traditioneel (oral presentation).
- Research Day – Student Research Symposium, FFW Ghent, April 20, 2017. Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. Kortetermijneffect van twee semi-occluded vocal tract trainingprogramma's op de stemkwaliteit van toekomstige professionele stemgebruikers: resonantietraining versus straw phonation training (oral presentation).
- Herfstsymposium Stem, Gentse Alumni Logopedie & Audiologie, Ghent University, November 30, 2016. Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. Semi-occluded vocal tract oefeningen: effectieve training voor stem? (oral presentation).
- 38th Congress Vlaamse Vereniging voor Logopedisten, ICC Ghent, March 10, 2017. Meerschman, I., Van Puyvelde, C., Bostyn, A., Meersman, E., Claeys, S., & D'haeseleer, E. Effect van duur en frequentie in vocologie: een intensieve kortdurende stemtraining versus een langer durende traditionele stemtraining (oral presentation).
- 38th Congress Vlaamse Vereniging voor Logopedisten, ICC Ghent, March 10, 2017. Meerschman, I., Van Lierde, K., Peeters, K., Meersman, E., Claeys, S., & D'haeseleer, E. Kortetermijneffect van twee semi-occluded vocal tract trainingsprogramma's op de stemkwaliteit van toekomstige professionele stemgebruikers: resonantietraining versus straw phonation training (oral presentation).
- 16th symposium Logopedie en Audiologie, Het Pand Ghent, October 16, 2015. Meerschman, I., D'haeseleer, E., Bettens, K., Dejagere, S., Tetaert, L., Catry, T., Ruigrok, B., De Cock, E., Neyens, H., Claeys, S., & Van Lierde, K. Effect of the vocal facilitating techniques Chewing, Chant Talk, Pitch Inflections, Glottal Fry and Yawn-Sigh on the phonation of female speech-language pathology students: a pilot study (oral presentation).
- Student Research Symposium, FFW Ghent, May 4, 2015. Meerschman, I., Van Lierde, K., & D'haeseleer, E. Effectiveness of a new intensive short-term voice treatment: a pre-experimental single subject design (poster presentation).
- 36th Congress Vlaamse Vereniging voor Logopedisten, Flanders Expo Ghent, March 20, 2015. Meerschman, I., Van Lierde, K., & D'haeseleer, E. Effectiveness of a new intensive short-term voice treatment: a pre-experimental single subject design (poster presentation).

- Science Day Faculty of Medicine and Health Science, Het Pand Ghent, March 5, 2015. Meerschman, I., Van Lierde, K., & D'haeseleer, E. Effectiveness of a new intensive short-term voice treatment: a pre-experimental single subject design (oral presentation).

Teaching Experience

- Participation in the course "Research stem"
  master Logopaedic and Audiological Sciences, Ghent University
- Guidance of practical workshops in the course "Logopedische vaardigheden"
  2nd bachelor Logopaedic and Audiological Sciences, Ghent University
- Participation in the course "Spraak- en taalvaardigheden"
  1st bachelor Logopaedic and Audiological Sciences, Ghent University

Guidance of Theses

2017-2018	Ketels Julie & Coppieters Charlotte, Effect of three semi-occluded vocal tract therapy programs on the vocal quality of patients with dysphonia: "Lax Vox", "straw phonation" and "lip trill" Promotor: D'haeseleer E., Copromotor: Meerschman I.
2016-2017	Raes Hannelore & Corveleyn Shana, Effectiveness of voice therapy in patients with organic or functional dysphonia Promotor: D'haeseleer E., Copromotor: Meerschman I.
2015-2016	Peeters Karen & Meersman Eline, Effect of two semi-occluded vocal tract training programs on the vocal quality of future occupational voice users: "resonant voice training" versus "straw phonation" Promotor: D'haeseleer E., Copromotor: Meerschman I.
2015-2016	Vergauwe Evelien, Effectiveness of voice therapy in patients with organic dysphonia Promotor: D'haeseleer E., Copromotor: Meerschman I., Van Lierde K.
2015-2016	Carlu Charlotte, Effectiveness of voice therapy in patients with functional dysphonia Promotor: D'haeseleer E., Copromotor: Meerschman I., Van Lierde K.
2014-2015	Bostyn Astrid & Van Puyvelde Caro, Effect of a short-term intensive voice training versus a longer-term traditional voice training Promotor: D'haeseleer E., Copromotor: Meerschman I., Van Lierde K.

Dankwoord

The human voice is the instrument we all play.
It is the most powerful sound in the world.
- Julian Treasure –

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