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## Voice and Communication Change for Gender Nonconforming Individuals: Giving Voice to the Person Inside

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**ABSTRACT.** In the seventh version of their Standards of Care, WPATH recognizes that, as each person is unique, so is the person's gender identity. The goal of speech-language therapists/pathologists is to help transgender people develop voice and communication that reflects their unique sense of gender. When outer expression is congruent with an inner sense of self, transgender people may find increased comfort, confidence, and improved function in everyday life. Transgender voice and communication is a relatively new area of practice within speech-language pathology/therapy and this document is intended to support clinicians and researchers working in this field. It begins with a review of the evidence-based literature in transgender voice and communication. The paper then discusses these clinical topics: trans-specific voice-and-communication assessment, voice feminization protocols and voice feminizing surgeries. There is also a section on speech and voice masculinization—an area that has received little previous attention. As minimal standards have yet to be established in this field the paper concludes with recommendations for good clinical care.

**KEYWORDS.** Communication, transgender, voice

This companion document discusses in more detail the position outlined by WPATH's Standing Committee for Voice and Communication. In the seventh version of the Standards of Care, WPATH recognizes that, as each person is unique, so is the person's gender identity. The role of speech-language pathologists/therapists<sup>1</sup> is to help individuals find and develop voice and communication that reflects the

individual's sense of gender, so the outside expression reflects the person inside. A discrepancy between outward gender presentation and the felt sense of gender is not trivial; it can impair confidence in communication, comfort with gender presentation, and function in the everyday world. A number of studies indicate that speech-therapy intervention is useful in helping gender nonconforming individuals

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portray their gender identity through speech (Carew, Dacakis, & Oates, 2007; Dacakis, Oates, & Douglas, 2012; Gelfer & Tice, 2013; Hancock & Garabedian, 2013; Mészáros et al., 2005). Such changes to communication are not simply superficial; they can reduce gender dysphoria and improve mental health and quality of life.

The goal of the Standing Committee on Voice and Speech is to encourage the highest standards of research and practice in the field of transgender voice and communication. In creating this document we wish to make current evidence available to speech-language therapists internationally and foster excellence in this field around the world. However, research and practice constantly evolve, and by the time this document is published, our knowledge will already have advanced beyond it. We hope simply to provide guidance for current practice and stimulate more and better guidelines and research in the future.

### **SCOPE**

This document is intended for speech-language therapists who have already taken transgender sensitivity/awareness training or have experience working with the transgender community and are seeking more advanced guidance on how to be clinically effective in working with transgender-specific aspects of voice and communication. Gender nonconforming people who feel that their speech and voice are not congruent with their gender do not have voice disorders, and the protocols used to address this issue are not designed to treat voice disorders. However, it is possible to have both a voice disorder and gender incongruence in voice and speech. A discussion of voice disorders in transgender clients is found in the section “Vocal Health, Voice Habilitation and Voice Rehabilitation.”

It is our intention to provide a useful summary and interpretation of the research literature on voice, speech, and communication for transgender people. To do this we consulted the following databases: Medline, CINAHL, LLBA, ERIC, PubMed, and PsycINFO.

With the exceptions noted, this document was based on studies using transgender individuals rather than cisgender (gender-sex congruent) subjects. In some areas we could uncover almost no literature discussing transgender participants. These areas include nonverbal communication (e.g., nodding/shaking head, facial expressions); language and syntactic choices (e.g., more/less emotionally laden word choices, use of tag questions and qualifiers); and body movements, postures and gestures. While we do not dismiss the importance of these aspects of communication, the paucity of evidence using transgender subjects did not allow us to do more than mention these aspects in this document. Besides studies of cisgender participants, this companion document also contains instances of expert opinion about a given topic.

It should be noted that recent studies (both on cis- and transgender participants) highlight the context- and identity-driven variation of these communication parameters and shift the focus on the interaction of the (gendered and nongendered) identities in the communicative situation (cf. Grainger & Dunbar, 2009; Hogg, 1985; Papp & Townsend, 2012; Podesva, 2007, 2011; Townsend & Papp, 2012).

### **LIMITATIONS**

We are still in the early stages of understanding gender markers in voice and communication and how to affect their change in transgender people. The corpus of literature is small and many studies involve small numbers of participants and lack of control groups. Some of the literature is based on expert opinion rather than on well-designed studies. Oates reminds us that the evidence for effectiveness of voice therapy for transgender clients is weak, with 83% of the studies being “at the very lowest level on the evidence hierarchy. The remaining 17% of publications in this field provide only marginally stronger evidence” (Oates, 2012, p. 59). No studies compare specific interventions or the effectiveness of targeting

particular parameters of voice and speech. Johnston (2007) notes that “the most compelling information will come from review articles, with or without quantitative meta-analysis” (p. 12). Until recently there have been few review articles that summarize the primary literature on transgender voice and communication.

Currently there are almost no studies that investigate effectiveness of voice-and-communication therapy protocols with transgender people. In the absence of evidence-based studies we have elected to discuss two kinds of protocols: those used with transgender people that include standard outcome measures and those modeled on evidence-based protocols from the voice therapy literature with cisgender people.

The literature we uncovered was found to be further biased in two ways:

1. Research and therapy have been conducted primarily with transsexual women, who are only one subgroup under the umbrella of those who identify as transgender.
2. The literature is chiefly concerned with voice. Oates (2012) references Pasricha et al. (2008), saying, “The voice was of primary concern [for transsexual women] and that it was the feature of their communication with which they were least satisfied” (p. 30).

This lack of strong evidence does not mean the practice is poor but simply that the field has not been fully and rigorously explored. It is important to remember that practice, especially in the medical field, always precedes evidence. In examining the literature on clinical practice, Oates (2012) noticed

- high levels of satisfaction among transgender clients;
- fairly strong consensus among speech-language therapists as to vocal parameters that are strong markers of speaker gender; and
- ways to approach voice therapy with this population.

### **VOICE AND COMMUNICATION IN TRANSGENDER PEOPLE: THE EVIDENCE THAT SUPPORTS THE PRACTICE**

“If we are to provide the highest quality care, our clinical decisions must reflect an integration of current high quality research evidence . . . with practitioner expertise and client preferences and values” (American Speech-Language-Hearing Association, 2005, p. 1). Notwithstanding the limitations discussed earlier, the past 10 years have seen a dramatic expansion of both clinical practice and the collection of evidence in the following areas:

1. We have established that therapy can be effective in feminizing the voice in transsexual women (Dacakis, 2012b; Descloux et al., 2012; Gelfer & Tice, 2013; Hancock & Garabedian, 2013; Mészáros et al., 2005; Söderpalm, Larsson, & Almqvist, 2004).
2. We are beginning to determine the parameters of voice that are most important to target in feminization/masculinization (Adler, Hirsch, & Mordaunt, 2012; Carew et al., 2007; Dacakis et al., 2012; Gelfer & Mikos, 2005; Holmberg, Oates, Dacakis, & Grant, 2010; King, Brown, & McCrea, 2011; Mészáros et al., 2005; Owen & Hancock, 2010; van Borsel & De Maesschalck, 2008; van Borsel, Van Eynde, Cuypere, & Bonte, 2008).
3. Our assessments of goals and outcomes have gone beyond the measurement of acoustic data to include the clients’ own perception of their voice and their experiences of voice in their real lives (Adler, Hirsch, & Mordaunt, 2012; Constansis, 2008; Davies & Goldberg, 2006a; Hancock, Krissinger, & Owen, 2011; McNamara, 2007; McNeill, Wilson, Clark, & Deakin, 2008; Owen, 2009; Owen & Hancock, 2010; Papp, 2011a; Papp & Townsend, 2012; Pasricha et al., 2008; Zimman, 2010, 2012).
4. We are beginning to investigate the protocols in voice surgery and voice therapy for their efficiency and effectiveness (Adler,

Hirsch, & Mordaunt, 2012; Chung, Tsuji, Sennes, & Imamura, 2007; Gelfer & Van Dong, 2013; Gorham-Rowan & Morris, 2006; Hancock & Garabedian, 2013; Kocak et al., 2010; Orloff, Mann, Damrose, & Goldman, 2006; Palmer, Dietsch, & Searl, 2012; Remacle, Matar, Mor-somme, Verduyck, & Lawson, 2011; Wagner, Fugain, Monneron-Girard, Cordier, & Chabolle, 2003).

A full review of the history of research in transgender voice and communication is beyond the scope of this document. Extensive reviews of the literature from 1978 to the present are found in Freidenberg (2002), Pickering and Baker (2012), and Oates and Dacakis (1983). Much of the early literature focused on single-case studies or small-group studies that report the outcomes of speech therapy and phonosurgery. Parameters of change targeted in speech therapy included pitch, resonance, inflections, loudness, articulation, and voice quality; speaking rate; and nonverbal communication (Bralley, Bull, Gore, & Edgerton, 1978; Coleman, 1983; Günzburger, 1989, 1993; Oates & Dacakis, 1983; Spencer, 1988; Wolfe, Ratusnik, Smith, & Northrop, 1990). Oates and Dacakis (1997) expanded the discussion beyond research and therapy outcomes to discuss philosophy of treatment. They discuss the importance of working in a collaborative process with the client and outline the importance of designing a treatment plan that takes into account the client's changing gender identity, goals, and real life communicative situations.

During this period there was a concurrent literature looking at issues of communication and gender in nontransgender people. They include studies on average speaking fundamental frequency (Andrews, 1999; Biemans, 2000; Hudson, de Jong, McDougall, Harrison, & Nolan, 2007; Iseli, Shue, & Alwan, 2007; Traunmüller & Eriksson, 1995); voice quality (Andrews & Schmidt, 1997; Mendoza, Valencia, Munoz, & Trujillo, 1996; van Borsel, Janssens, & de Bodt, 2009); resonance and resonance-source interactions (Smith & Patterson, 2005; Turner & Patterson, 2003); language and syntax (Eckert &

McGonnell-Ginet, 1999, 2003; MacAulay, 2001; Mondorf, 2002; Schumann & Ross, 2010); phonetics (Diehl, Lindblom, Hoemeke, & Fahey, 1996; Robb, Gilbert, & Lerman, 2005; Simpson, 2009); and nonverbal aspects of communication (Briton & Hall, 1995; Hall, Coats, & Smith, 2005; Hess, Adams, & Kleck, 2004; LaFrance, Hecht, & Paluck, 2003). Further references on cisgender-based studies are found in the references in the appropriate chapters of Adler, Hirsch, and Mordaunt (2012).

As the understanding of issues in transgender voice and communication grew the literature became more refined. Comprehensive summaries of recent work are found in Dacakis et al. (2012); Gelfer and Tice (2013); Hancock and Garabedian (2013); and Pickering and Baker (2012).

### ***ACROSS THE GENDER SPECTRUM***

Many people identify as being under the gender nonconforming “umbrella” and there is great variation in the extent to which voice and communication changes are undertaken or desired by gender nonconforming individuals. Some gender nonconforming persons seek to develop two speech patterns (one more masculine and one more feminine) either because they identify as bigendered or because external pressures (family, employment, cultural community, friends) prevent living full time in a way that is consistent with their felt sense of self. Some people may have a sense of gender that is not at either pole of the cismale/cisfemale scale but is on the continuum of masculine and feminine. They would like a more flexible gender presentation to reflect this gender identity.

Further, most current transgender speech and voice protocols do not support bimodal speech as a treatment goal, based on the belief that to achieve maximal change it is necessary to have a consistent single speech pattern. Switching back and forth between two speech/voice patterns may be too difficult for some clients and inconsistent use decreases practice opportunities to acquire the new speech/voice habits.

However, the human capacity to learn and speak more than two languages or dialects, develop a specific accent for an acting role, and develop a singing voice that is different from the speaking voice suggests it may be possible to develop bigender speech/voice. We encourage speech-language therapists to be open to this possibility and not to routinely exclude clients who have two speech/voice patterns as their treatment goal. We recommend that speech services be made available to the full spectrum of the gender nonconforming community.

As was discussed earlier, the majority of gender nonconforming clients seeking speech therapy services are transsexual women wishing to maximize their feminine voice and communication. Speech and voice feminization is widely recognized as a vital component of care for transgender women (Adler, Hirsch, & Mor-daunt, 2012; Andrews, 1999; Kalra, 1977; Neumann & Welzel, 2004; Wollitzer, 1994). The weighting of studies in transgender communication is far from balanced, with almost all research being on transsexual women.

Much less attention has been paid to speech masculinization (Oates & Dacakis, 1997; van Borsel, Cuypere, Rubens, & Destaerke, 2000) and this lack of investigation may be obscuring concerns of transgender men. The study by van Borsel et al. (2000) of 16 female-to-male (FtM) transsexuals found that 88% of participants considered masculinization of communication to be as important or more important than sex reassignment surgery. While many transgender men find that they develop an acceptably masculine voice as a result of androgen therapy, some do encounter difficulties. We will discuss voice-and-communication change for transgender men in the section "Masculinizing Speech: Physiology and Identity."

## **VOICE AND COMMUNICATION THROUGH THE LIFE SPAN AND GENDER TRANSITION**

### ***Childhood and Adolescence***

Speech and voice feminization in adolescents was first examined in 2012 in a

single-subject study by Hancock and Helenius. They found that voice therapy based on principles established with adults was effective but caution that the implications of age on the therapy effectiveness have not been examined. As the need to transition is now being recognized earlier, more research into helping youth develop gender-appropriate communication is needed. We may wish to consider whether there is a role for the speech-language therapist in monitoring the communication needs of transgender adolescents.

### ***Through the Gender Transition Process***

Transsexual people's perception of both their gender identity and their voice may change as they move through transition. In her doctoral thesis, Byrne (2007) notes that some transsexual women feel less pressure to feminize their voice after gender reassignment surgery has been completed. She hypothesizes that once there is congruence between the physical body and gender identity, the need to sound completely female may be less important. It is important for speech-language therapists to remain sensitive to their clients' (possibly changing, evolving) wishes rather than follow their own assumptions about voice-and-communication goals.

### ***Voice, Speech, and Sense of Self***

Initial studies on the transgender voice looked chiefly at speaking fundamental frequency. More recently the scope of study has expanded to explore the intimate and complex relationship between voice/communication, sense of self, and function in the world. It is important to understand the client's perspective around speech and voice change (Andrews, 1999; Byrne, 2007; Dacakis, 2002; Dacakis, Davies, Oates, Douglas, & Johnston, 2013; Gelfer, 1999; McNeill et al., 2008; Oates & Dacakis, 1997; Owen & Hancock, 2010; Söderpalm et al., 2004). A study by McNeill et al. (2008) found that in male-to-female (MtF) transsexual clients, the happiness with voice was not directly related to speaking fundamental frequency. Another 2008 study

looked at 12 MtF transsexuals and found that happiness with voice was not directly related to speaking fundamental frequency, but rather was significantly correlated with perception of femininity—both the participants' self-perceptions and the perceptions of listeners (McNeill et al., 2008). In 2010, in a study of 20 transgender women, Owen and Hancock confirmed this finding. In their study they found that the speaker's perception of her own femininity was strongly correlated to both the mean fundamental frequency of the voice and to her own feeling of femininity. Speakers who rated themselves as more feminine were also judged as more feminine by listeners. Another study by Hancock, Krissing, and Owen (2011) extends the investigation, suggesting that exploring the client's own perception of the voice may be useful for evaluating the effectiveness of voice therapy. This is an important corroboration and verification that outcome measurements need to expand beyond the evaluation of acoustic parameters, such as speaking fundamental frequency.

In an attempt to gather information on the effect of voice in everyday life, Davies adapted the Vocal Handicap Index (Jacobson et al., 1997) to be trans-specific and created the Transsexual Self-Evaluation of Voice Questionnaire (Davies & Goldberg, 2006a). This questionnaire was further developed, and psychometric evaluation was undertaken by Dacakis, Davies, et al., resulting in the TVQ<sup>MtF</sup> (Transsexual Voice Questionnaire, Male to Female) (Dacakis et al., 2013). This is the first instrument with established psychometric properties that assesses a transsexual woman's experience of her own voice in real-life situations. The version for female to male transsexuals is still under development. The TVQ<sup>MtF</sup> is available as a free download from [www.shelaghdavies.com](http://www.shelaghdavies.com) or by contacting Georgia Dacakis at [G.Dacakis@latrobe.edu.au](mailto:G.Dacakis@latrobe.edu.au). The questionnaire has been translated into Swedish, Portuguese, German, and Danish and these versions are also available on the website. Translations into a number of other languages are ongoing and, when finished, will be added to the website and available for downloading at no cost.

## ***GENDERED VOICE AND COMMUNICATION***

The following is a discussion of feminization in voice, speech, and communication. The process of masculinization is discussed in the section "Masculinizing Speech: Physiology and Identity."

### ***Feminizing Voice, Speech and Other Aspects of Communication***

Current evidence suggests that the largest feminization effects come from changing both the speaking fundamental frequency and the resonance of the voice. Other parameters that have been targeted for change are inflectional patterns and excursions, voice quality, speech-sound articulation and duration, average speaking intensity, and speech rate.

### ***Average Speaking Fundamental Frequency***

Söderpalm, Larsson, and Almquist (2004) established that MtF transsexuals were able to raise their speaking fundamental frequency without strain or vocal damage. This is reassuring but there is no consensus in the literature as to how high the speaking fundamental frequency (SFF) should be for a transgender woman's voice to be perceived as female. It is generally accepted that the SFF must move out of cismale speaking range (roughly 100–140 Hz) into either a gender neutral range (145–175 Hz) or cisfemale range (roughly 180–220 Hz). After that, opinion varies widely, and has been summarized by Hancock & Garabedian (2013). Studies have suggested a minimum SFF of 155 Hz (Wolfe et al., 1990), 165 Hz (Oates & Dacakis, 1983), 172 Hz (Owen & Hancock, 2010), and 180 Hz (Gorham-Rowan & Morris, 2006). Dacakis, Oates, and Douglas (2012) say:

Despite the fact that an increase of F0 (fundamental frequency) into the female F0 range may not routinely result in perceptions of the speaker as female, the

evidence indicates that this is likely to increase listener perceptions of the voice as containing female attributes. (p. 167)

It is perhaps not surprising that something as complex and close to the human heart as voice cannot be modified by simply altering one parameter. We also recall that contributions from the larynx (F0 and harmonics) are inextricably linked to contributions from the vocal tract (vowel formants, resonance effects) (Baken & Daniloff, 1991). Perceptually they are difficult to separate and indications are that they both must rise for the voice to be perceived as female.

In any therapeutic work involving SFF it is important to use norms that are age appropriate and culturally appropriate for the individual. As an example, the mean SFF is different across biological age (Brown, Morris, Hollien, & Howell, 1991; Hollien & Paul, 1969; Linville & Fisher, 1985; Michel, Hollien, & Moore, 1966; Nishio & Niimi, 2008; Torre III & Barlow, 2009); across dialects of the same language (Awan & Mueller, 1996; Deutsch, Le, Shen, & Henthorn, 2009; Dolson, 1994); between monolingual and bilingual speakers of the same language (Abu-Al-Makarem & Petrosino, 2007; Altenberg & Ferrand, 2006; Ullakonoja, 2007); and naturally, between languages (Loveday, 1981; Mennen, Schaeffler, & Docherty, 2007; Muta, 1994; Natour & Wingate, 2009; Ohala, 1983; Ohara, 1992; van Bezooijen, 1995; Yuasa, 2008).

### **Resonance**

The word *resonance* has many meanings but in this context its meaning is highly specific. We refer to the filter function of the vocal tract on the sound wave produced by the larynx. Because of the interdependence of these organs, it is difficult to perceptually separate the contributions of source (larynx) and filter (vocal tract) in the gender perception of a voice (Carew et al., 2007). Research evidence shows that a voice may sound low even though the SFF is reasonably high and vice versa (Hillenbrand & Clark, 2009).

There is a 10% to 20% difference in length between the vocal tracts of cismen and

ciswomen (Titze, 2000) and this difference in length produces acoustic differences in the sound wave that disseminates from the lips. Typically vocal tract resonances are higher for ciswomen and children and lower for cismen. These resonance effects are found in unvoiced as well as voiced sounds, as can be demonstrated by saying the voiceless fricative /s/ and protruding and retracting the lips.

Vowel formants—the first, second, and often third resonances of the vocal tract (F1, F2, and F3, respectively)—are frequently calculated to measure the effect of the vocal tract filter on the voice. While the first and second formants determine the vowel identity and quality, all three formants reflect the overall length of the vocal tract (Carew et al., 2007). Carew et al. (2007) developed a protocol of oral resonance therapy for transsexual women that used a slight retraction of the lips to shorten the resonance tract during speech. They found that all three vowel formants were higher, with F3 being most significantly affected. Participants and listeners both perceived the voices as more feminine after treatment. Interestingly, there was a concurrent spontaneous increase in fundamental frequency although this was not targeted in therapy. In an early study, Mount and Salmon (1988) found that a transsexual woman was able to raise her SFF to 210 Hz but was not perceived as female until she raised her vowel formants. Gelfer and Mikos (2005) and Pasricha et al. (2008) found that both SFF and vowel formants were important for gender perception. Finally, a study of ciswomen and cismen by Hillenbrand and Clark (2009) looked at the role of SFF and formant frequencies in distinguishing the voices of men and women. They found that shifting either SFF or formants alone was usually ineffective in changing the perceived gender of the speaker but when the speaker changed both together, the person was perceived to be the opposite gender 82% of the time. Although the researchers found that shifting the SFF was somewhat more important than shifting the formants, they concluded that both speaking fundamental frequency and vowel formants are needed to specify the gender of a speaker. This finding is further corroborated by the formant- and SFF-scaling



research in Patterson, Smith, Dinther, and Walters (2007); Smith and Patterson (2005); and Smith, Patterson, Turner, Kawahara, and Irino (2005).

### ***Inflections***

The use of more upward gliding inflections and more frequent inflections (i.e., a more dynamic intonation contour) are generally considered to be feminine characteristics of voice production, while the use of a flatter speaking style has been considered to be more masculine (Pickering & Baker, 2012). Gelfer and Schofield (2000) found that using both a higher upper limit of SFF and a higher SFF facilitated the perception as female. However, two recent studies suggest that the use of a narrower inflectional range is perceived to be more feminine (Owen, 2009; Owen & Hancock, 2010). In 2014, Hancock, Colton and Douglas (2014) looked at intonation differences between transsexual women who passed as cisfemale and those who did not. The researchers found that the women who passed as cisfemale used more upward gliding intonations and a larger utterance semitone range than those who did not pass. The authors suggest that further, culture-specific study is needed of this important aspect of speech and voice production.

### ***Voice Quality***

In a study of ciswomen, van Borsel et al. (2009) found that breathiness was perceived to be a feminine characteristic of voice and suggested that this study needed to be replicated in transgender women. The adoption of a slightly breathy, or softer, quality is a frequent goal in many voice therapy protocols for transgender women (Davies & Goldberg, 2006a). The understanding is that this breathy quality may replicate the voice quality of ciswomen because of a small posterior gap between the vocal folds during vibration (Biever & Bless, 1989; Linville, 1992; Södersten & Lindestad, 1990). Palmer et al. (2012) undertook endoscopic and stroboscopic examination of nine transsexual women and noted that those who reported a “passing” female voice had a glottal closure

pattern with a posterior glottal gap. In another study the mean SFF and semitone range, but not perturbations (noise to harmonics ratio, vocal turbulence index, jitter percent, shimmer percent), were strongly related to the perception of femininity (Owen & Hancock, 2010). Yet other studies found further, conflicting results on the production and perception of breathiness and creakiness in speech (Henton & Bladon, 1985; Henton, Bladon, Hyman, & Li, 1988; Kreiman, Gerratt, & Antonanzas-Barroso, 2007). More work is needed to confirm the effect of voice quality on the perception of voice in transgender women.

### ***Articulation***

Female speakers may speak with more precision than male speakers (Oates & Dacakis, 1983) and modification of articulatory patterns is frequently included in speech/voice therapy protocols for transgender women. In their study with transsexual women, Free and Dacakis found that speech was perceived to be more feminine when the consonants were rated as “more precise” rather than “less precise” (Dacakis et al., 2012; Free & Dacakis, 2007).

### ***Speaking Intensity***

Women are generally considered to speak more quietly than men (Boonin, 2012). In one study of four transsexual women, the speaking loudness was the sole factor that accounted for gender perception (Holmberg et al., 2010). While this suggests that a moderate reduction in average speaking intensity, perhaps correlated with a slight increase in breathiness, may feminize the voice.

Some transgender individuals who are self-conscious about speech may use insufficient vocal intensity as a means of minimizing attention to their voice and some transwomen may speak quietly to try to “soften” the voice (Dacakis, 2002). To be functional in all situations, particularly with background noise, transwomen need to learn how to produce a strong voice that still maintains a feminine vocal quality.

### ***Speech Rate and Prosody***

Studies on speech rate in cis-men and cis-women have been inconclusive (Dacakis et al., 2012). Van Borsel and De Maesschalck (2008) looked at the speech rate of 28 transsexual women and found no significant differences when compared with the rates of nontranssexual men and women. On the basis of these results it appears that speech rate is not a useful parameter to target in speech/voice change.

Oates remarks: “Communication management for [transgender/transsexual] clients may [also] require a focus on . . . vocabulary, pragmatic behaviours, conversational topics and style, and nonverbal communication” (Oates, 2012, p. 50). Although there is some psycholinguistic literature on cisgender speakers that supports this statement, we were not able to uncover literature using transgender speakers.

### ***RESPONSIBILITIES OF THE VOICE-AND-COMMUNICATION PROFESSIONAL***

Throughout the world, feminization/masculinization services are delivered primarily by speech-language therapists (speech therapy) and laryngologists (vocal surgery). While speech-language therapists do not need to be experts in every realm of transgender care to work with transgender clients, it is expected that those providing speech feminization/masculinization services have a basic understanding of the processes involved in gender transition, the potential impact of testosterone on FtM speech, and trans-specific psychosocial issues that shape clients’ goals and treatment options. Understanding of basic sensitivity protocols such as use of preferred gender pronoun and name is essential but is outside the scope of this article.

To assist in greater understanding of transgender voice and communication issues, the client’s permission should be sought to share anonymous assessment data with other speech professionals and for research purposes. Over the past 10 years the literature on transgender voice and communication has substantially

increased but there is still a paucity of evidence in many areas, particularly in evidence-based clinical practice (Dacakis et al., 2012; Hancock & Helenius, 2012). As with all research, it is important that transgender clients’ involvement in research be fully voluntary—that is, it is not ethical to make service contingent on agreement to be studied.

As with other transgender care, we recommend that voice and communication services be offered in the context of a complete approach to transgender health that includes comprehensive primary care and a coordinated approach to psychological and social issues (Adler, Hirsch, & Mordaunt, 2012; Coleman et al., 2011; Söderpalm et al., 2004). Speech services must be individualized based on the individual’s goals and identity, the risks and benefits of treatment options, and consideration of social and economic issues.

In the following two sections we provide an overview of existing good practice in the assessment and treatment of the transgender voice. While the two sections are largely geared toward the needs of transwomen, many of the considerations and concerns also apply to the FtM voice.

### ***TRANS-SPECIFIC SPEECH/VOICE ASSESSMENT***

Change in a transgender person’s voice and communication starts with a thorough assessment. For a comprehensive discussion the reader is referred to Dacakis (2012a), “Assessment and Goal Setting Revisited” in Adler, Hirsch, and Mordaunt (2012).

Components of the initial assessment are

1. Establishing therapeutic rapport
2. Collecting the history
  - a. Psychosocial history
  - b. Voice use and vocal health
  - c. Medical history
3. Clinical assessment of speech and voice
  - a. Client’s subjective assessment
  - b. Acoustic/aerodynamic measurement
  - c. Speech-language therapist’s subjective analysis

- d. Developing goals and assessing potential for change
- e. Assisting the client in understanding therapeutic options

The following recommendations relate to the general initial assessment that should be conducted as part of a therapeutic evaluation and treatment plan. Clients who wish to pursue pitch-elevating surgery must undergo additional evaluation prior to surgery; this is discussed in the section “Surgical Feminization of the Larynx and Voice.”

### ***Establishing Therapeutic Rapport***

The relationship between client and clinician begins with the first interactions. In the initial session, the speech-language therapist is not only assessing the client, the client is also assessing the knowledge and supportiveness of the clinician. A relationship grounded in mutual respect, trust, and genuine care for the client’s well-being facilitates open communication and encourages active engagement in therapy; conversely, it can be difficult to build therapeutic rapport if conflicts arise in initial sessions. Many transgender people have had negative experiences with ill-informed or unempathetic health professionals, and there may be wariness about entering unreservedly into a relationship around communication, which is by its nature highly personal. Because the assessment process sets the stage for all future interaction, it is extremely important to make the client feel respected and safe, and to create a feeling of positive anticipation for the therapy process. One report identified storage of information, privacy issues in setting appointment times, client name preference, use of the client’s preferred pronouns, and therapist bias and judgments about gender transition issues that speech-language therapists need to consider in the intake process (King, Lindstedt, Jensen, & Law, 1999).

### ***Collecting the History***

Clients come to voice therapy with different backgrounds, goals and knowledge bases about

voice and communication change, so the speech-language therapist should match the input to the needs of the client. Client history should include information about both trans-specific concerns and general issues that may impact therapeutic options and potential outcomes. An initial open-ended question like, “What brings you to see me?” or “How can I help you?” may elicit a great deal of information. While some transgender individuals are very comfortable talking about their history, others are more private. In some cases it may be appropriate to revisit sensitive questions after therapeutic rapport has been well established.

### ***Psychosocial History: Voice, Speech and Sense of Self***

Our goal as speech-language therapists is to help the client develop voice and communication that is congruent with the person’s own sense of gender. While many may wish to pass as cismale or cisfemale, others may feel more comfortable with a presentation somewhere between these polarities of gender. A sensitive exploration of what best fits the client’s self-perception is necessary in determining goals in therapy. This question of “right fit” may be easy for the client to answer right away, or may be answered over time with experimentation, introspection, practice, and observation of role models. A self-evaluation questionnaire like the TVQ<sup>MIF</sup> (Dacakis et al., 2013: 21) can be useful in exploring and quantifying how well the voice fits the sense of self and how well it works in everyday life.

### ***Vocal Health, Voice Habilitation, and Voice Rehabilitation***

The process of voice feminization and masculinization is different from a rehabilitation process to treat a disordered voice, but there are three goals common to both:

1. training efficiency in voice production
2. helping clients achieve vocal ease endurance in all voice-use situations

3. supplying information clients need to maintain their vocal health (Adler & Antoni, 2012; Dacakis, 2000, 2002; Gold, 1999; Kaye, Bortz, & Tuomi, 1993; Mount & Salmon, 1988; Oates & Dacakis, 1997, 1983; Söderpalm et al., 2004; Titze & Verdolini Abbot, 2012).

If during the assessment, the speech-language therapist uncovers evidence of a voice disorder, such as roughness, limited range, difficulty projecting, rapid vocal fatigue, or effortful voice production, the usual protocols of investigation should be followed, beginning with referral to an otolaryngologist.

In their review of 25 cases of voice-and-communication change Hancock and Garabedian (2013) found that “28% presented with a voice disorder separate from gender presentation concerns.”

If a client has a voice disorder it is important to determine if it existed before any speech/voice change was undertaken or if it resulted from attempts to change the voice. Previous attempts to feminize/masculinize speech should be investigated, including techniques used, duration of self-directed or professionally directed therapy, and the client’s subjective feelings about the outcome (Adler & Antoni, 2012; Andrews, 1999; Dacakis, 2002; Gelfer, 1999; Perez, 2004). Modifying habitual pitch, adopting unfamiliar articulatory postures or producing the voice in nonhabitual ways can be fatiguing and potentially damaging for some people. Clients who developed dysphonia and vocal fatigue from previous attempts at voice feminization or masculinization may find this disappears when they adopt a more effective protocol. Others may require a traditional voice rehabilitation program before they undertake further voice change (Davies & Goldberg, 2006a).

### *Voice Use*

A full history of the client’s voice use should be collected, including professional and recreational use of the voice (e.g., involvement in singing/acting). This history is useful for exploring any areas of concern and

determining whether previous training could be tapped during therapy. Teachers, singers, and clients with heavy voice demands or difficult speaking situations will need maximally efficient voice-production habits to sustain their gender-modified voice and avoid phonotrauma. As in traditional voice therapy, creating a list of voice-use situations is useful in generalizing the new voice into everyday life and creating a hierarchy of practice (Dacakis, 2012a; Davies & Goldberg, 2006a).

### *Medical History*

In some clinics a laryngological examination is performed as a matter of course by an otolaryngologist. In others it is performed with a referral when there are symptoms of dysphonia or other signs of abnormal laryngeal function.

As in the assessment of any voice client, a full history of medical information relevant to the voice and speech should be recorded. This includes information about respiratory disease, upper respiratory tract infections, laryngopharyngeal reflux disease, thyroid function, head/neck surgeries or trauma, hearing loss, and other medical information relevant to speech and voice change. This includes problems stemming from self-directed attempts to modify voice, high vocal load, or any other conditions that could impact speech (de Bruin, Coerts, & Greven, 2000; Gelfer, 1999; Söderpalm et al., 2004). To assist in the coordination of care, other health professionals involved in the client’s general and trans-specific care should be noted (de Bruin et al., 2000; Söderpalm et al., 2004). All current medications (including feminizing or masculinizing hormones) should be recorded. As previously stated, clients who present with difficulty swallowing or symptoms that may suggest a voice disorder should be referred for laryngological examination (Dacakis, 2012a).

Lifestyle habits that may negatively impact speech and voice, such as smoking (tobacco, cocaine, marijuana) and more than moderate use of alcohol, should be explored. Because the stigma associated with substance abuse can make it difficult to get accurate

information, a gentler question could be, "Have you ever used . . . ?"

While female hormones have no effect on the voice of a transgender woman, some women report emotional changes that may affect the way they communicate so it can be useful to know if a transgender woman has been taking hormones and for how long. It is likely that androgens affect the voice of transgender men by thickening the vocal folds thus deepening the voice. Depending on the method of testosterone intake, this process can take up to 2 years to complete (cf. Papp, 2011a), so it is important to know the length of time a transgender man has been undergoing androgen therapy, the dose he is taking, and possibly also his recent serum testosterone levels.

There is some discussion around whether a speech-language therapist should ask if the client has undergone genital reassignment/reconstruction surgery (GRS). While this procedure has no impact on speech/voice production it may affect a transperson's feelings about voice change, so it is important information for the speech-language therapist to have. Byrne (2007) notes that after gender reassignment surgery, some transwomen feel a comfort that their physical body is now congruent with their gender identity and developing a completely female voice is less important. However, some speech-language therapists may feel this is an intrusive, personal question and not necessary since it does not affect voice production. Further, not all transgender clients wish to undergo GRS, whether or not they live full time as women. Sensitivity and tact are important when approaching this question.

Trans-specific history should also include information about other feminization/masculinization treatments that relate directly to speech and voice (e.g., facial feminization surgery in MtFs, chest binding in FtMs) and any noted impact on speech following these treatments (Andrews, 1999; Gelfer, 1999; King et al., 1999; Söderpalm et al., 2004). It is not necessary to inquire specifically about trans-specific treatments that are unlikely to directly impact communication.

### *Clinical Assessment of Speech and Voice Parameters Associated With Gender*

A complete clinical analysis should include a variety of investigations with input from both the client and the clinician. The objective is to gain a thorough understanding of how well the speech and voice currently function in everyday life, how well they reflect the client's own sense of gender, and what potential there may be for speech and voice feminization (Andrews & Schmidt, 1997; Byrne, 2003; Coleman, 1983; Dacakis, 2002; Dacakis et al., 2013; de Bruin et al., 2000; Gelfer, 1999; Gelfer & Schofield, 2000; Gold, 1999; Oates & Dacakis, 1997; Wollitzer, 1994).

The following is a summary of a comprehensive trans-specific speech and voice assessment. For a full discussion the reader is referred to Dacakis (2012a).

#### *Client's Subjective Assessment*

Clients' feelings about their current voice and communication and their goals for change are related to self-perception, feelings about the perceptions of others, and function in day-to-day life. These can be assessed both formally and informally.

*Formal Evaluation.* The Transsexual Voice Questionnaire (TVQ<sup>MtF</sup>) has recently been developed by Dacakis et al. (2013). The FtM version is still under development. This questionnaire explores a transsexual woman's feelings about her voice and how well her voice functions in the real world. It can be used as an intake instrument and as an outcome measurement. The Transsexual Voice Questionnaire may be acquired free of charge at [www.shelaghdavies.com](http://www.shelaghdavies.com) and from Georgia Dacakis. For translation, authorization from the authors is required and WHO protocols for translation must be followed. Please contact Georgia Dacakis at La Trobe University, Melbourne, Australia, for further information ([g.dacakis@latrobe.edu.au](mailto:g.dacakis@latrobe.edu.au)).

*Informal Evaluation.* Asking clients for three things they would like to change about speech and voice or three situations in which they would like to sound more masculine or

feminine gives a brief insight into the clients' goals and can be reviewed at the end of voice therapy as a rough outcome measurement (Davies & Goldberg, 2006a). Dacakis (2012a) suggests other useful probes such as asking if the client wants to change communication in all speaking situations or if the client has a particular vocal image in mind. Questions about previous attempts to change speech and voice can yield information about the client's familiarity with the process and his or her stimulability for change. It may also alert the client to any potentially harmful vocal hyperfunction resulting from undirected voice change (Adler, Hirsch, & Mordaunt, 2012; Davies & Goldberg, 2006a).

### *Acoustic Analyses*

An assessment of the client's voice and speech gives a baseline against which to measure change and provides information about which changes would be most useful (Andrews & Schmidt, 1997; Kaye et al., 1993; King et al., 1999). The parameters of speech and voice relevant to gender perception of voice have been discussed earlier and will simply be mentioned here. They include the following:

- speaking fundamental frequency (SFF);
- speaking fundamental frequency range and variability;
- total physiological frequency range (or maximum phonation range, cf.);
- formants of vowels, in particular, the corner vowels /a/, /i/, and /u/; and
- average speaking intensity.

These may all be measured using a number of acoustics analysis software programs currently available. Some, such as Praat (<http://www.fon.hum.uva.nl/praat/>) or SFS/WASP (<http://www.speechandhearing.net/laboratory/wasp.htm>) may be downloaded free of charge. Some commercially available programs can be obtained through Kay-PENTAX, Tokyo, Japan, and LingWAVES, a program manufactured by WEVOSYS, Forchheim, Germany.

Speaking intensity may be measured using a sound level meter. Care should be taken to measure in dBC and to conform to the standard

distance from lip to sound level meter, as this varies throughout the world (Gramming & Sundberg, 1988). The total physiological and intensity ranges may also be measured and displayed in a vocal range profile, or phonetogram. This graph displays vocal intensity, usually on the vertical axis, against fundamental frequency on the horizontal axis, providing a clear picture of the maximal extent of these vocal parameters (Sulter, Wit, Schutte, & Miller, 1994).

It is useful to record the fundamental frequency in sustained vowels and the speaking fundamental frequency in various tasks such as sustained vowels, reading, picture description, and spontaneous speech. A variety of samples give a broader base and differences among them may reflect a voice in transition. There is generally less mental energy required to sustain a vowel, read, or describe a picture than to generate language in spontaneous conversation. If the SFF is higher in reading than in conversation this may suggest that the client needs high levels of concentration on voice production and cannot maintain this when required to think of the words as well (Dacakis, 2012a; Davies & Goldberg, 2006a). However, the difficulty among these tasks may also reflect other factors such as educational level or comfort with oral reading.

*Audio or Video Recordings.* Following standard practice in a speech/voice evaluation, audio or video recordings of the assessment should be made. These are useful for analyzing current communication patterns and setting goals for therapy. They also serve as a baseline against which to measure change and (with the consent of the client) as a resource to train student speech-language therapists. Some speech-language therapists videotape the assessment session and review the tape with the client, looking at speech/voice parameters and also nonverbal communication features such as gestures, movement, and facial expressions. Other speech-language therapists prefer not to use video footage as clients report finding it intrusive and intimidating (Davies & Goldberg, 2006a). Both audio and video recordings allow comparisons to be made during trial therapy, as is discussed later.

*Speech-Language Therapist's Perceptual Analysis.* As in a traditional speech and voice assessment, an experienced speech-language therapist can supplement the objective analysis by making perceptual assessments of voice quality, intonation patterns, speaking style (legato vs. staccato), and speech sound articulation.

### *Trial Therapy to Assess Potential for Change*

Once the assessment is complete the speech-language therapist can share the findings with the client, explain any technical details, and discuss possible parameters of change. This establishes a collaborative process, with client and clinician working together to establish goals.

At this point, trial therapy is useful to get a sense of how the voice and speech could change. For example, if the client wishes to feminize her voice, some words or short sentences can first be recorded at the habitual pitch. Then the speech-language therapist can assist the client to produce them efficiently at a higher pitch or at several higher pitches. The trials can be recorded and compared with the original one at the habitual pitch. This practice gives useful information about what feels comfortable and acceptable to the client and what may be possible. It also affords an opportunity to discuss the nature of the process of change. Change to any motor habit will feel unfamiliar and possibly uncomfortable simply because it is nonhabitual. However, this is a sign that things are moving and this movement is necessary to develop new habits. While the final decision about the nature of voice and communication change rests with the client, the clinician can assist this process by suggesting the client remain open to experimenting with what is unfamiliar (Adler, Hirsch, & Mordaunt, 2012; Davies & Goldberg, 2006a).

### *Assisting the Client in Understanding Therapeutic Options*

Two options open to the transgender client wishing voice feminization are voice therapy or phonosurgery. They may be available singly

or together and the availability of both varies widely throughout the world. The speech-language therapist should be familiar with options in his or her location, including the possibility of distance voice therapy through the Internet and be able to discuss the pros and cons with the client in a knowledgeable and unbiased way. Phonosurgery is discussed in more detail in the section "Surgical Feminization of the Larynx and Voice."

Should the client choose voice and communication therapy, the speech-language therapist should communicate clearly about what is involved in the therapy program, including length of practice time, the nature of the exercises, and frequency of practice sessions. This allows the client to make adjustments to daily routines to accommodate practice.

### *Timing of Therapy*

While there are no hard and fast rules about the timing of voice therapy, we should remember that a client's perception of voice may change as the person progresses through the transition process, so it is important to evaluate voice and communication near the beginning of any therapy program (Byrne, 2003, 2007; Dacakis, 2012a). The ability to progress in a speech/voice therapy program can be affected by a variety of factors and a frank discussion about choosing the optimal timing of a therapy program is useful. The impact of any planned surgeries on the timing of voice and communication therapy should also be considered.

Some psychosocial factors to investigate are the following:

1. Motivation for change: For a client beginning a new job in his or her desired gender, the stress and motivation can be very high. Others who talk only with supportive family and friends may not feel the same need to work hard on speech/voice change.
2. The amount of time spent in the desired gender role: Gelfer (1999) and Gold (1999) suggest that a transsexual woman living full time is likely to do better in

voice therapy. However, the transition process is a personal journey that varies widely among clients. Some clients may wish to feminize/masculinize the voice before they begin to present publicly at all. Others may feel more comfortable with a gender-neutral presentation while they work on their voice and communication. As with all aspects of the transgender process, the client's wishes should be respected.

3. Availability of practice opportunities: Does the client have sufficient time to devote to a structured exercise program? Is the client socially isolated or have a wide network of family, friends, and acquaintances with whom to practice?

### *Mental Health and Stability*

Transitioning is, by definition, a time of great upheaval and psychosocial stress. Before entering speech/voice therapy a client should reflect on whether they have the time and stability in life to undertake it. Issues of mental illness or substance abuse will obviously affect compliance with any therapy program. If psychosocial issues are significantly impacting treatment, referral to a trans-competent mental health professional may be useful.

### *Minimal Standards*

To date there are no minimal standards for the assessment of voice and communication in transgender clients. The field of practice is recent and the evidence base, still weak. It is recommended that once the evidence is sufficiently strong international minimal standards be developed. The establishment of minimal standards not only supports best practice among clinicians around the world but also, when standard assessment procedures are used, facilitates the collection of data. However it must be stressed that clients need to give their explicit permission for this data collection and distribution.

## **COMPONENTS OF A PROGRAM TO FEMINIZE VOICE AND COMMUNICATION**

In this section we will recount evidence- and practice-based approaches to feminizing voice and communication. For information on masculinization of voice and communication see the section "Masculinizing Speech: Physiology and Identity."

### ***Preparing for the Process of Voice-and-Communication Feminization***

Most expert speech-language therapists agree that feminizing voice and communication is a long process requiring considerable work on the client's part (Davies & Goldberg, 2006a). While therapy outcomes cannot be predetermined, the estimated amount of daily practice time and expected duration of the course of therapy should be discussed, as should the factors that can influence the course of therapy (Byrne, 2003). The process requires altering deeply ingrained communication habits and behaviors, which can be challenging to modify. It may be useful to use the Stages of Change model (Prochaska, DiClemente, & Norcross, 1992; Zimmerman, Olsen, & Bosworth, 2000) or other behavioral change tools to assist in anticipating and addressing barriers to implementing change. If pitch-changing surgery is sought, there should be discussion of the parameters of speech and voice that may still need work after surgery, as well as an estimation of the healing time involved and the time required to stabilize the new pitch (Dacakis, 2002; Neumann & Welzel, 2004; Wagner et al., 2003).

Some clients are interested primarily in an assessment of their speech and a professional opinion on what would be involved in changing it. Information about therapeutic options can help with decisions regarding the timing of gender transition. Specific objectives relating to voice modification depend on what is feasible to produce without strain, what fits with the client's self-image, and how important passing is to the client (some clients may be comfortable with



gender-neutral speech, while others will want to aim for a voice that is perceived by listeners as cismale or cisfemale).

### ***Education and Information***

Clients undergoing speech feminization need information in a number of areas, such as:

- how the voice is produced;
- physiological differences in biological male and female voice production systems;
- how these differences affect voice production and listener perception;
- gender-salient parameters of voice and communication specific to each client's (linguistic and cultural) community;
- treatment options, outcomes and risks; and
- strategies to prevent vocal fatigue or vocal injury.

While some transgender individuals are extremely well informed, others have no knowledge or have been exposed to inaccurate information via the Internet or peer groups.

### ***Pretherapy Voice Conditioning***

In a pilot project Dacakis (2012b) used Stemple's Vocal Function Exercises (Stemple, Lee, D'Amico, & Pickup, 1994) with a group of 19 participants recruited from a voice therapy waiting list. This voice exercise program included four sessions over a 7-week period. There were statistically significant improvements in a number of voice parameters and the clients perceived the therapy to be effective. Initial results suggest that this kind of pretherapy conditioning may be useful, particularly for distance therapy, as it is easy to monitor over online audio-video telecommunication software, such as Skype, for transwomen not yet presenting as female and for women on a voice therapy waiting list or without ready access to weekly therapy.

### ***Treatment Format: Individual and Group Sessions***

Traditionally voice and communication therapy has been delivered in a 1:1 setting to facilitate the personalized intervention necessary to modify and monitor change in target behaviors. Determining appropriate average speaking pitch, working with aspects the client finds especially challenging, and dealing with dysphonia are all best conducted in a 1:1 setting. However, there can be advantages to conducting therapy, at least partially, in a group setting. A group format is ideal for participants to share observations, insights, and practical advice. A group can facilitate peer support and reduce self-consciousness that a client may experience when working alone with a therapist (Davies & Goldberg, 2006a). Information about voice care and voice change can also be given efficiently in a group.

Some programs incorporate both group and individual formats. Examples are found in Davies and Goldberg (2006a) and in Mordaunt (2012). Group therapy may be used before 1:1 therapy for education purposes and to introduce participants to the process of change or after 1:1 therapy to offer support and further practice opportunities. In Davies and Goldberg (2006a), group therapy and 1:1 sessions are interspersed.

### ***Length of Treatment Time***

The length of treatment for transwomen generally ranges from a minimum of 15 hr to a maximum of 1 year of weekly sessions. Studies investigating optimal length of therapy time have shown mixed results. Some studies suggest that longer time in therapy correlates with higher SFF (Dacakis, 2000; Hancock & Garabedian, 2013). Two other studies demonstrated improvement after intervention of 5 weeks and 8 weeks, respectively (Carew et al., 2007; Gelfer & Tice, 2013). In the Gelfer study these changes lasted, at least in part, for up to 15 months after treatment.

Optimal treatment time for each individual will vary, depending on the degree of change sought, the client's natural abilities, the amount of time and energy the client devotes to

practice, and the presence of co-occurring psychosocial difficulties. A short program may promote increased focus and motivation while a longer course of treatment allows more time for habituation and generalization.

Psychosocial adjustment is an important part of changing speech and voice. Participants may require time to get in touch with what sort of voice best matches the person within. This is by necessity a process that takes time and professional input to assess what is desirable and possible. Many transgender individuals begin with the goal of having a pitch that is unrealistically high (MtF) or low (FtM); only with experimentation and practice will it become apparent that this is probably not achievable, necessary, or even desirable. Additionally, it can take time to feel that an altered voice is an authentic expression of self rather than an artificial “mask.”

### ***Speech and Voice Therapy Protocols***

Speech-language therapists are in the difficult situation of having to provide service in speech/voice feminization in the absence of evidence-based protocols. In this section we have chosen protocols that include standard outcome measures and those modeled on evidence-based protocols from the voice therapy literature with cisgender people.

Examples of two complete protocols for speech/voice feminization may be found in *Voice and Communication Therapy for the Transgender/Transsexual Client: A Comprehensive Clinical Guide* (Adler, Hirsch, & Mor-daunt, 2012) and in Davies and Goldberg (2006a). These protocols should be used advisedly as their efficacy and effectiveness have not been established in the literature.

### ***Perceptual-Motor Learning Principles***

In their recent book, *Vocology*, Titze and Verdolini Abbot (2012, pp. 217–238) discuss perceptual-motor learning principles and how they apply to the remediation of voice disorders (pp. 217–238). These apply equally well to voice and communication feminization and the reader is referred to this book for a comprehensive discussion of the principles underlying

speech and voice change. The principles include the following:

- using target sensations or images as input, rather than instructions;
- the need for attention and concentration on producing and reproducing the target sensation;
- progressing from simple tasks to more complex ones; and
- performing and learning behaviors together (such as breathing and voicing) if they should be performed together.

### ***Vocal Stretching, Vocal Conditioning***

Voice training protocols frequently begin with vocal flexibility exercises.

### ***Vocal Function Exercises***

Stemple’s *Vocal Function Exercises* (Stemple et al., 1994) have been used to facilitate a wider pitch range and train efficiency of voice production (Dacakis, 2012b; Gelfer & Van Dong, 2013). Dacakis used them for pretherapy voice conditioning and found they were beneficial. Gelfer and Van Dong used vocal function exercises along with their standard voice feminization program. They found that while listeners rated posttreatment voice recordings as more feminine, the addition of vocal function exercises did not improve outcomes, as compared with previous literature.

### ***Semi-Occluded Vocal Tract Techniques***

Semi-occluded vocal tract (SOVT) techniques may be used to facilitate voice production in the upper part of the pitch range; train a “head voice” or “mixed registration”; encourage efficient vocal fold vibration; and stimulate a forward sensation of the voice, or a high voice placement (Verdolini-Marston, Burke, Lessac, Glaze, & Caldwell, 1995). SOVT techniques include phonating into straws or tubes, lip or tongue trilling, the use of nasals /m/, /n/, voiced fricatives, e.g., /z/, /v/, and closed vowels, e.g., /u/, /i/. Two exercises are often used: a pitch glide throughout the middle and upper pitch

range and a messa di voce exercise, going from soft to loud and then soft again (Titze, 2000; Titze & Verdolini Abbot, 2012). Prolonging the voice at a higher pitch through a semi-occluded vocal tract may develop efficiency of voice production at a higher nonhabitual pitch (Davies, 2012; Davies & Goldberg, 2006a).

### *Raising the Speaking Fundamental Frequency*

These techniques have been used by experienced speech-language therapists to train an efficiently produced higher average speaking pitch.

1. Using trial therapy in the assessment session the clinician and client find a speaking pitch that is either in gender neutral or low cisfemale range and can be produced without strain. This is used as a training pitch and is prolonged using semi-occluded-vocal-tract techniques. Speech sounds, words then longer utterances are intoned then modulated in a natural way, always keeping the voice easily produced without the need for excessive vocal effort (Dacakis, 2012a; Davies & Goldberg, 2006a; Gelfer & Van Dong, 2013; Gelfer & Tice, 2013).
2. The client starts near the habitual speaking pitch and slowly raises the average speaking pitch throughout the therapy sessions. This continues until both the client and the clinician feel the pitch is appropriate and manageable (Mordaunt, 2012).
3. The speech-language therapist asks the client to sing “do re mi” then hold the pitch of “mi” and use that as a target for a higher, easier voice (Bennett, 2010).
4. The client uses a pitch well into cisfemale range, such as 220 Hz, as a target for pitch training (Perez, 2004).

### *Raising Vocal Tract Resonance Frequencies*

1. Instruct the client to use a forward tongue carriage and slightly spread lip posture

during speech. This technique was found to be effective in a clinical study of 10 transsexual women (Carew et al., 2007).

2. Use /i/ as a target mouth shape for high, forward tongue placement in other vowels (Mordaunt, 2012).
3. Use smaller jaw excursions during speech.

### *High Voice Placement*

1. Using /m/, /v/, and other semi-occluded–vocal tract sounds to cue a high, maximally forward voice placement (Davies & Goldberg, 2006a; Mordaunt, 2012; Titze & Verdolini Abbot, 2012).
2. Draw attention to sensations of vibration or resonance moving from the chest or throat into the mouth or front of face (Davies & Goldberg, 2006a; Mordaunt, 2012; Titze, 2001).

### *Language and Discourse Pragmatics*

While there are strong social stereotypes about gender norms and language (e.g., use of slang, intensifiers, and tag questions), gender-associated norms of language and discourse are so dependent on an ever-shifting social context that findings from studies conducted in past decades may not be reflective of current trends in the client’s speech community (Freidenberg, 2002; Oates & Dacakis, 1983). Additionally, there is strong interplay between gendered language norms and norms relating to culture, class, and age (Hasegawa & Hata, 1995; Linville, 1998; Moran, McCloskey, & Bady, 1995; Morris & Brown, 1994), so norms appropriate for one client would not be appropriate for another. If there are habits relating to vocabulary and syntactic choices, such as the use of modifiers, qualifiers, indirect versus direct speaking style, that the client finds discomforting or the clinician feels may contribute to perceptions that don’t fit the client’s self-image, we recommend that the speech-language therapist offer feedback in these areas, encouraging the client to weigh research findings or the clinician’s suggestions against personal experience.

We recommend that modification of language and discourse be based on the client's own observations of gender markers in the specific environmental context of concern to the client (e.g., work, home, cultural community, social setting). Clients with strong beliefs about "appropriate" language may benefit from the speech-language therapist's assistance to explore stereotype versus actual observed behavior of peers.

A discussion of gender-dependent communication variables in cisgender people, together with exercises, can be found in chapters 13 (Frazier & Hooper) and 14 (Crutchley, Hooper, & McCready) in Adler, Hirsch, and Mordaunt (2012).

### ***Nonverbal Communication: Facial Expressions, Posture, and Movement***

Norms relating to posture, gestures, and other nonverbal aspects of communication are strongly influenced by many things including cultural, class, and age norms. These behaviors also constantly change depending on many variables such as the speaker's mood and conversational partner or situation. It is not within the normal scope of practice of a typical speech-language therapist to provide a detailed assessment of nonverbal communication behaviors. If a client wishes input that the clinician feels unable to give, it may be possible to refer to a trans-competent speech-language therapist who has training in nonverbal communication. Other options include a discussion of the nonverbal parameters of communication, together with structured observations to be conducted within the client's community. This can help foster awareness and sensitivity to subtle changes in nonverbal communication, which could be more useful than learning and following rigid patterns of behavior.

A discussion of nonverbal communication and therapy protocols is found in Adler, Hirsch, and Mordaunt (2012): Hirsch and Van Borsel (chapter 15) and Boonin and Hirsch (chapter 16). These chapters are based on the authors' experience and observations and on literature of cisgender men and women.

### ***Habituation and Generalization***

The ability to use a feminine voice in everyday life is a significant achievement and also the goal of many transwomen who embark on speech/voice change. Some strategies can promote carryover into everyday life:

- practicing words that are typically part of daily conversation (e.g., hi, bye, yes, no);
- in clinical practice of conversational speech, focusing on situations/topics related to the client's life and engaging in role plays suggested by client to match real-life situations that pose the most difficulty (e.g., job interview, coffee shop interaction; e.g., Hooper, 1985);
- experimenting with emotional intensity by practicing sentences expressing feelings like joy, sorrow, irritation or anger; and
- mindful practice outside the clinic setting, in a wide variety of real-life settings, depending on comfort level

The process of habituation of any new motor act takes mindful practice over a period of time (Adams, 1971). Maintaining change outside the clinical setting is challenging and until recently has not been measured. In 2007, Ma et al. used Soundswell's computerized real-time phonetogram Phog 1.0 (Hitech Development AB, Täby, Sweden) to record voice in everyday situations among cisgender subjects with dysphonia (Ma et al., 2007). In 2009, Södersten, Hertegård, Larsson, and Holmberg (2009) researched the use of a portable dosimeter called the Ambulatory Phonation Monitor (APM) in one MtF client to monitor voice use outside the clinic. When her fundamental frequency decreased under a certain threshold level a tactile feedback signal was given to remind her about raising her fundamental frequency. Also the portable Voxlog system can provide tactile feedback when the speaker exceeds or goes below a certain fundamental frequency threshold level. This could be useful for transgender speakers. Dacakis et al. (2012) also suggest such a device may prove useful in a clinical context. In North America the dosimeter that is commercially available is the Ambulatory Phonation Monitor (APM),

developed collaboratively by Kay PENTAX and speech-language therapists from Massachusetts General Hospital.

### ***Follow-Up Sessions***

Follow-up sessions after the initial treatment has finished, or facilitated support groups for ongoing practice, may be useful in maintaining and entrenching changes made in therapy. Clinically supervised follow-up also provides an excellent opportunity to gather much-needed data about the effectiveness of a program over time.

#### ***Follow-Up Sessions (Group/Individual)***

There is as yet no empirical evidence regarding the optimum frequency for follow-up sessions, the optimum content, or the criteria for termination. In the absence of data, we suggest that refresher sessions could be initially offered 3 months after treatment and then at 4- to 6-month intervals or as the clinician and client deem appropriate.

Follow-up sessions can include a discussion of successes, problems, strategies, and difficulties the client has experienced since the end of therapy; a review of the core exercises of the program (to ensure the client is practicing correctly and to determine if the exercises are still appropriate); and time to address any concerns that have arisen since the end of treatment. Ideally, follow-up would include re-evaluation of the same parameters measured in the pretreatment assessment, both to assess the maintenance of the desired changes and also to evaluate the effectiveness of refresher sessions.

If the initial therapy was provided in a group setting, a group setting is a natural forum for refresher sessions. As with group format for initial therapy, group format for refresher work offers valuable opportunities for clients to compare experiences. In our experience this can be most useful and encouraging, especially for those in the early stages of their transition. Individualized follow-up may be more appropriate than the group format if the client has numerous concerns or unusual concerns that require individual attention or if the client feels uncomfortable in a group setting.

### ***Client-Run Voice and Communication Support Groups***

Self-help groups may be useful for transgender individuals who have completed clinical treatment and are seeking peer support to maintain or strengthen voice and communication changes. Client-run voice and communication groups can provide motivation to maintain practice, a forum to practice and to share ideas and concerns, and an opportunity to socialize and undertake specific role playing. Client-run groups can also foster the client's sense of ownership and control of speech and voice production so that he or she feels less dependent on the therapist.

In any self-help group there is a danger that an individual may inappropriately assume a professional clinical role. In a communication group, this could be circumvented by providing group facilitation training to members, by having the speech-language therapist as guest visitor from time to time, and by having self-help sessions along with therapist-run refresher sessions.

## ***IMPROVING ACCESS TO SERVICE***

### ***Distance Assessment and Therapy***

At the time of writing, online applications and forums such as the ones provided by Skype and Google Hangouts offer opportunities for interactive distance voice and communication therapy. These recent technological advances have the potential to greatly expand access to voice and communication services—one of the main difficulties experienced by many transgender people. However, speech-language therapists should be mindful of possible concerns with a lack of confidentiality inherent in Internet communication.

In her presentation at the WPATH 2011 symposium, Dacakis (2011) outlined a protocol for this kind of service delivery. Video conferencing is being used with increasing frequency in many health care settings. It has the potential to provide good visual and audio contact between speech-language therapists and geographically isolated clients and could also serve

as a training modality for speech-language therapists in the care of transclients.

### ***Improving Accessibility and Utility to Clients With Access Barriers***

The transgender community is tremendously diverse, and protocols must be flexible enough to address this diversity of service needs and issues relating to access. In the transgender voice and communication literature reviewed for this project, there was little discussion of modification to address the needs of clients who have difficulty accessing the typical setting or format of voice and communication services—including individuals who have speech, hearing, cognitive, or learning disabilities, are not highly fluent in the primary language spoken where they live, or are not literate or who are geographically isolated or cannot leave a residential facility, such as a prison or long-term care home. Without empirical evidence to guide practice, we offer the following suggestions based on our experience providing services to a diverse range of transgender clients.

For individuals who do not speak the speech-language therapist's language, an information package could be translated into a variety of languages. Providing voice and communication services in another language is not possible unless the speech-language therapist speaks the client's language well, as subtleties of inflections, inflectional range, word stress, and semantic and syntactic choices require a thorough knowledge of the language. The only direct therapeutic input that could perhaps be given would be in changing the speaking fundamental frequency and formant characteristics. Speech-language therapists who are multilingual could be supported to take trans-specific training, perhaps working in consultation with a more trans-experienced speech-language therapist to provide service in the client's primary language. If the client is partially fluent in the primary language of their community, wishes speech therapy in that language, and will be using it in everyday life, therapy delivered in that language can be beneficial as the client has the opportunity of

learning more-feminine/masculine patterns of speech as they acquire the language. For individuals who are only partially fluent in the language used in therapy, the therapeutic process will likely be longer and will require much more 1:1 input.

Transgender clients with speech or hearing disabilities who are able to attend voice and communication therapy sessions may find great benefit from using visual input during speech therapy. This has been used with good success with other populations (e.g., using palatography and ultrasound to work with phonological disorders in people with hearing impairments). For transgender clients, there are a number of software programs that record fundamental frequency and allow the creation of a "model voice wave." The speech-language therapist can record a desired average speaking pitch or an intonation pattern and the client could then use the visual input to copy it; alternatively, the speech-language therapist could record the lowest (MtF)/highest (FtM) desirable frequency and the client could use the visual input to keep the speaking pitch above (MtF) or below (FtM) this line.

Online and/or offline free pitch-measuring programs can be useful for clients' home practice. Speech-language therapists should be alert for other emerging applications for electronic communication devices. Some currently available programs include the following:

- Seventh String Tuner: <http://www.seventhstring.com/tuner/tuner.html>
- Praat: <http://www.praat.org>
- Mintleaf software: <http://mintleafsoftware.com/voice-monitor.html>
- Sonnetta Voice Monitor: <http://appstore.com/sonnetavoicemonitor>
- Voice Analyst: [https://play.google.com/store/apps/details?id = co.speechtools.voiceanalyst](https://play.google.com/store/apps/details?id=co.speechtools.voiceanalyst)

If a client has cognitive or learning disabilities, depending on the nature of the disability it may be useful to include a loved one or care aide in the therapeutic process. This person could help the client establish a regular practice

schedule and give input to the exercises, under the guidance of the speech-language therapist. A different format may be useful for the client who has difficulty processing the information necessary to change speech habits. Rather than using an approach that requires introspection (e.g., “How does that sound? Am I feeling my voice in my face?”), the speech-language therapist may be more directive in determining which exercises would most useful and could be performed appropriately by the client; the clinician and client together would draw up a practice schedule and the client would simply practice the motor movements outlined. Individualized attention is likely to be more effective than group work for providing the client with more intensive input. To be successful, this kind of format would require regular clinical intervention and support outside the therapy room.

### ***Self-Guided Speech Feminization***

There are many videos, websites, CDs, and other materials available for self-guided speech feminization. We cannot comment on the efficacy or safety of these materials, but we are concerned that (a) many are not produced by speech-language therapists and (b) there are risks associated with attempting to change the voice without professional assistance. Speech feminization/masculinization involves substantial changes in habitual production and so has the potential to cause a voice disorder or aggravate an existing one. It is strongly recommended that anyone seeking to feminize or masculinize speech first be assessed by a speech-language therapist, that a speech-language therapist be involved in monitoring progress, and that a speech-language therapist be consulted if there are any symptoms of vocal fatigue or negative changes to vocal quality. Additionally, we recommend that consumers be cautious of any materials promoting a rigid set of speech norms, as speech is highly individualized and culturally driven and cannot be guided solely by a set of generic rules.

Over the past 10 years, study and practice in the area of transgender voice and communication has expanded and deepened. We look

forward to greater understanding and better practice as this field continues to grow.

## ***SURGICAL FEMINIZATION OF THE LARYNX AND VOICE***

Transgender people wishing to feminize their voice or appearance through surgical means may choose to undergo two different kinds of surgical procedures:

1. A thyroid chondroplasty, which is a cosmetic procedure that reduces the size and angle of the thyroid cartilage to resemble the flatter, smaller cisfemale thyroid cartilage. It has no feminizing effect on the voice (Sandhu, 2007).
2. Phonosurgery, which can raise the speaking fundamental frequency and eliminate lower frequencies in the cisfemale speaking range (Spiegel, 2006).

### ***Thyroid Chondroplasty***

A thyroid chondroplasty, also called a tracheal shave, laryngeal shave or Adam’s apple reduction, may be performed alone or in addition to a phonosurgical procedure. This surgery may be performed by an otolaryngologist or plastic surgeon. The surgeon makes the incision in a crease at the front of the neck, directly over the larynx. In Sandhu’s opinion “Unless there is a history of keloid scar formation, the incision is not easily visible after a few weeks. The advantage of this technique is that it allows for the dimensions of the larynx to be measured accurately for maximal and safe removal of the laryngeal prominence” (Sandhu, 2007, p. 196). An alternative scar location is a small incision high on the midline of the neck. Although the advantage is that the scar is hidden under the chin, the scar cannot be placed in a natural crease and the patient is more likely to develop adhesions between the skin and the larynx so that there is “puckering” of the skin with swallowing. Sandhu (2007) notes there may be a small risk of detaching the vocal cords anteriorly, with an associated risk to the voice and airway. Spiegel (2006) notes that during this procedure it is important to preserve the

anterior attachment of the true vocal folds, otherwise an undesirable lowering of pitch can result. A summary of outcome data is found in Matai, Cheesman, and Clarke (2003).

### ***Voice Feminization Surgery***

As was discussed in the section “Average Speaking Fundamental Frequency,” a higher speaking fundamental frequency (SFF) is considered to be one of the most important components of a feminine voice and transwomen may undergo phonosurgery to raise both the SFF and frequency range, as well as to eliminate access to lower frequency ranges (Remacle et al., 2011; Spiegel, 2006; Wagner et al., 2003). Van Borsel found that the “perception of femaleness significantly correlated with the average fundamental frequency” (Adler & van Borsel, 2006). However, as was also discussed earlier, there are a number of voice characteristics that are believed to combine to produce a feminine voice. These include resonance characteristics, articulatory contacts, voice quality, and intonation contours. Adler and van Borsel (2006) noted that while a pitch-raising surgery may be a viable option to increase the speaking pitch in MtFs, this surgery alone may not be sufficient to produce a voice that is perceived as totally female.

A number of reasons support the use of phonosurgery to feminize the voice in transgender women. The availability of speech-language therapists with this particular clinical competency may be limited in the area where the individual lives. Treatment outcomes may be influenced by the client’s commitment to therapy, level of practice outside of the therapy sessions, social confidence level, and emotional health. Whilst some clients show an aptitude for voice work and possess a “good ear,” which aids their skill acquisition, other clients find voice work challenging on a physical and/or emotional level. Some clients struggle with vocal fatigue, and to maintain a raised pitch, even with sustained voice therapy, progress may be limited (Adler, Constansis, & van Borsel, 2012).

Antoni (2007) notes, “Limited data exist regarding the formal outcomes of vocal surgery

with transsexuals” (p. 144). There is a paucity of outcome data for pitch-elevating surgery, particularly longitudinal data to monitor outcomes over time. In general, professional opinion is mixed about voice surgery, with some clinicians stating that it is not a viable treatment option (Andrews, 1999; Koufman, 2007), and others recommending and others recommending that voice surgery be considered a treatment of last resort for MtFs who have not experienced satisfactory increase in pitch following speech therapy (Lawrence, 2004; Oates & Dacakis, 1997; Wagner et al., 2003). Certainly the reported negative effects (compromised voice quality, diminished vocal loudness, adverse impact on swallowing or breathing, sore throat, wound infection, and scarring) and variable outcomes are a concern (Brown, Perry, Cheesman, & Pring, 2000; Dacakis, 2002; Koufman, 2007; Lawrence, 2004; Neumann & Welzel, 2004; Oates & Dacakis, 1997; Thomas, 2003; Wagner et al., 2003; Yang, Palmer, Murray, Meltzer, & Cohen, 2002).

However, some proponents of voice surgery suggest that surgery can protect the voice from damage caused by strain to elevate pitch through nonsurgical means (Brown et al., 2000; Neumann & Welzel, 2004; Yang et al., 2002). Given this, while there are clear risks of voice surgery and the decision to pursue it should be carefully considered, the decision about risk-benefit ratio and preferred technique is best left to the patient, with input from both a trans-experienced surgeon and a trans-experienced speech-language therapist.

### ***Presurgical Assessment***

In addition to the standard screening conducted prior to any surgery (assessing for risks relating to anesthesia, infection, etc.), assessment prior to pitch-elevating surgery should include an anatomical and functional assessment of the larynx, the client’s subjective assessment of the client’s voice, an acoustic analysis, audio or video recordings, and the clinician’s perceptual analysis.<sup>2</sup> Particular attention should be paid to the measurement of speaking fundamental frequency and frequency range and of voice quality (Neumann &



Welzel, 2004; Yang et al., 2002). Any dysphonia present before surgery should be addressed through standard voice therapy protocols prior to voice surgery. Care should be taken to ensure that the patient understands the risks and anticipated outcome of the technique that will be used.

After finding that some subjects have strained and unnaturally elevated voices following surgery, attributed to habitually speaking at an artificially elevated pitch for sustained periods of time prior to surgery, one surgical group reported testing for ability to phonate at a pitch within the masculine range as part of preoperative consultation. Clients who are unable to do this were felt to have the equivalent of a muscle tension dysphonia and were referred for preoperative voice therapy to recover the ability to produce relaxed phonation (Yang et al., 2002).

Estrogen is associated with risk for deep vein thrombosis and pulmonary embolism. If the patient will be immobilized for a prolonged period during or following surgery, consultation with the prescribing physician is necessary to discuss the advisability of tapering estrogen use before surgery.

Smoking increases the risk of complications from anesthetic and impairs healing, and there is evidence that smoking following voice surgery can negatively impact voice quality and pitch (Wagner et al., 2003). Patients should be made aware of the risks associated with smoking and of smoking cessation resources and should be strongly encouraged not to smoke prior to or immediately following surgery.

### ***Postsurgical Care***

Postsurgical care depends on the specific surgical technique employed. The surgeon should review aftercare instructions with the patient as part of informed consent prior to surgery, as well as provide written information to be consulted before and after surgery. The surgeon should also be easily accessible for questions relating to postoperative complications. If surgery is performed away from the patient's hometown, the patient's local primary care provider should consult

with the surgeon to determine appropriate follow-up.

Follow-up evaluation by the surgeon (or postoperative care coordinator if the surgeon is in a different location) is recommended at 1 week, 4 weeks, 12 weeks, and 6 months after surgery to monitor healing and recovery. Immediately following surgery, temporarily decreased pitch, diminished voice quality, and edema were commonly reported, with spontaneous recovery in most cases. Less-common complications that required medical intervention included mild emphysema, neck abscess, negative response to the sutures/plates used in cricothyroid approximation (requiring removal of the material), and loosening of the sutures used in cricothyroid approximation (requiring additional surgery) (Neumann & Welzel, 2004; Wagner et al., 2003).

For most techniques, it is recommended that patients not use their voice at all for 1 to 7 days after surgery and then to use the voice cautiously until any discomfort (e.g., due to postoperative edema) has passed (Brown et al., 2000; Neumann & Welzel, 2004). For the more invasive, combined thyroid cartilage and vocal fold reduction, 2 weeks vocal rest is suggested (Kunachak, Prakunhungsit, & Sujjalak, 2000). Following cricothyroid approximation, steam inhalation may be recommended to hydrate and lubricate the vocal cords to promote healing (Brown et al., 2000).

Speech therapy is recommended following surgery to help the patient adapt to and stabilize the new voice (Neumann & Welzel, 2004; Wagner et al., 2003). If pitch-elevating surgery was performed before other components of speech had been satisfactorily altered, other aspects of voice such as resonance, intonation, and articulation may also need to be addressed through speech and voice therapy (Dacakis, 2002; Neumann & Welzel, 2004).

### ***Voice Feminization Surgeries***

With one exception, the thyrohyoid approximation, the voice feminization surgery described in the literature addresses only pitch change.

Surgical techniques to elevate pitch are based on the physiological components of pitch (Kunachak et al., 2000):

$$F0 = \frac{1}{2} \times \sqrt{\frac{\text{mean vocal fold tension}}{\text{vocal fold density}}}$$

Fundamental frequency can thus be raised by shortening the folds, by decreasing the total mass of the folds, or by increasing the tension of the folds (Neumann, Welzel, & Berghaus, 2002; Pickuth et al., 2000; Yang et al., 2002). Surgical techniques to achieve this include anterior commissure advancement; creation of an anterior vocal web; cricothyroid approximation; induction of scarring along the vocal folds; and vocal-fold reduction by intracordal steroid injection, laser evaporation of the vocal fold, or composite reduction/reconstruction of the vocal fold (Brown et al., 2000; Kunachak et al., 2000; Neumann, Welzel, & Berghaus, 2002; Neumann, Welzel, Gonnermann, & Wolfradt, 2002; Neumann & Welzel, 2004; Oates & Dacakis, 1997; Pickuth et al., 2000; Wagner et al., 2003; Yang et al., 2002). To date, there has been very little literature discussing outcomes of any procedures other than the cricothyroid approximation. Based on the literature review, cricothyroid approximation is the only method that has been assessed with sufficient rigor to be considered a viable treatment option (Brown et al., 2000; Neumann, Welzel, & Berghaus, 2002; Neumann, Welzel, Gonnermann, & Wolfradt, 2002; Neumann & Welzel, 2004; Söderpalm et al., 2004; Yang et al., 2002; Wagner et al., 2003).

### ***Pitch-Elevating Surgical Procedures***

Cricothyroid approximation (CTA) is the most common voice feminization surgery and the only one that has a body of outcome data. It is also one of the few procedures that does not involve surgical alteration of the vocal folds themselves. In this procedure, “the cricoid cartilage is moved backward and upward and the thyroid cartilage is . . . moved forward and downward. Then the two cartilages are closer, and the vocal cord tension is increased.”

(Wagner et al., 2003, pp. 1158–1159). This mimics the contraction of the cricothyroid muscle that tenses and elongates the vocal folds, causing the pitch to increase. The cartilages are then secured in place by stitches and/or metal plates. This procedure, in effect, puts the vocal folds on permanent stretch. The surgery is carried out through a small skin excision over the larynx and may be performed at the same time as a thyroid chondroplasty.

In theory, CTA is reversible, but in some cases scar tissue has permanently fused the cartilages together. Where this fusion has not happened, the stitches/plates can loosen over time, causing the cartilage to move back to its original position and the pitch to drop. Because the vocal folds aren’t directly surgically changed by this technique, it may be possible to perform additional surgery if the CTA is not sufficient.

While several studies have described an increase in SFF after CTA (Brown et al., 2000; Kanagalingam et al., 2005; Neumann, Welzel, & Berghaus, 2002; Neumann & Welzel, 2004; Yang et al., 2002), the amount of the pitch increase was variable and the subjective outcomes to the surgery were mixed. Yang et al. reviewed 20 patients and found a mean change in SFF of 57 Hz (from a mean of 145 Hz preoperatively to 202 Hz postoperatively). In 2004, Neumann & Welzel (2004) looked at 67 patients and found that a year post-CTA, 30% of the voices were within cisfemale pitch range and 32% were in a gender neutral range.

Patient satisfaction with post-CTA voice was also mixed. In Yang et al. (2002), 58% of the patients expressed satisfaction and 33% expressed dissatisfaction; 42% described their postoperative voice as “rough or hoarse.” When describing how well their voice worked on the phone, 31% said they were never perceived as male, 47% reported being occasionally taken as male, and 22% said they were frequently considered to have a masculine voice. At a follow-up a year or more after surgery, 29% of the subjects reported dysphagia with liquids. A review of CTA surgery by Kanagalingam et al. (2005) found that 79% of patients were satisfied with the results and 71% had increased fundamental frequency both in reading and speaking.

The variability of outcomes after a CTA may result from anatomical differences in the cricothyroid joint itself (Storck et al., 2011; Windisch, Hammer, Proding, Friedrich, & Anderhuber, 2010). In 2011, Storck and colleagues sought to determine why a CTA worked well in some patients and not others and to see if there was a way of predicting how successful a CTA would be. Using high-resolution computerized tomography and three-dimensional imaging software, they examined 24 cadaver larynges of transsexual women who had undergone CTA. They found that the anatomical structure of the CTJ [cricothyroid joint] influences directly (1) the position of the effective rotation axis and (2) the elongation of the vocal folds. "Based on the location of this effective rotation axis, we could distinguish three groups. In group I (N = 13), the rotation axis was located in the lower third; in group II (N = 5), it was located in the middle third; and in group III (N = 6), it was located in the upper third of the cricoid. The elongations of the vocal fold were 12%, 8%, and 3%, in groups I, II, and III, respectively" (Storck et al., 2011, p. 632).

### *Shortening the Vocal Folds*

Other phonosurgeries are available to transgender women; however, these are more invasive than the cricothyroid approximation and there is sparse literature on both the surgical procedures and the outcomes.

There are a number of reported surgical techniques used to shorten the vocal folds, allowing them to vibrate at a higher frequency (e.g., Gross, 1999). One such procedure is called the anterior commissure advancement. The epithelial tissue of the anterior third of the true vocal folds is ablated, then this tissue is sutured together to form a nonvibrating anterior web (Remacle et al., 2011). An example of a variation of this procedure, in which no sutures are used, is described on the Yeson Voice Center website ([http://www.yesonvc.net/disease/feminization\\_surgery.asp](http://www.yesonvc.net/disease/feminization_surgery.asp)).

Another example of a voice feminization laryngoplasty technique is described by Thomas and Macmillan (2013). In this procedure, a 10- to

14-mm wide segment of the anterior thyroid cartilage is removed. The true and false vocal folds are split in the anterior midline and the anterior portions of both are excised. The true vocal folds are then sutured together to create a new anterior commissure and the thyroid alae are brought back together to create a smaller larynx.

### *Other Procedures*

In some more recent patients of Dr. Thomas, an additional surgery, a thyrohyoid approximation, was performed. The thyroid cartilage was raised and sutured to the hyoid bone to diminish, as much as possible, the thyrohyoid space. The goal in this procedure is to create more feminine resonance characteristics by shortening the vocal tract.

In discussing outcomes Thomas and Macmillan (2013) note that the feminization laryngoplasty elevated SFF into cisfemale range and resulted in a permanent loss of bass notes. They also provide references for online voice recordings of patients who had undergone both of these surgeries. However, we could uncover no further literature discussing these surgical procedures and would advise caution in undertaking a highly invasive surgery for which there is, as yet, little outcome data.

Another phonosurgery available to transgender women is Laser-Assisted Voice Adjustment or LAVA. In this procedure a CO<sub>2</sub> laser is used to vaporize portions of the vocal folds, resulting in a decrease in mass and increase in stiffness. The scarring resulting from this procedure produces a significant rise in pitch (Orloff et al., 2006). Orloff et al. conducted a retrospective review of 31 patients, with a mean follow-up time of 23 weeks. While pitch increases averaging 26 Hz were reported, the evaluation also showed decreased vocal quality, loudness, and vocal range. In 2010, Kocak et al. described the use of a modified LAVA procedure in a small study of 3 patients whose voices were not improved by cricothyroid approximation. After the vocal folds had been vaporized with a CO<sub>2</sub> laser they were tensed medially and stabilized with sutures. The authors reported higher SFF and improved patient satisfaction after surgery (Kocak et al., 2010).

In summary, there is a variety of phonosurgical procedures available to transgender women wishing to increase the pitch of the voice. However, variable outcomes and paucity of outcome data suggest that these procedures be approached with caution and that they should be coupled with voice therapy to address other gendered aspects of speech and voice production (Dacakis, 2002, 2012b; Orloff et al., 2006; Spiegel, 2006).

### **MASCULINIZING SPEECH: PHYSIOLOGY AND IDENTITY**

#### ***Introduction***

The lacuna in both the global research efforts on and therapeutic treatment of the FtM vocal changes does not make it possible to provide a summary of current good practice. Instead, this section of the companion document attempts to summarize and interpret the results of the existing evidence-based research and give an overview of gendered voice and speech issues that a speech practitioner working with FtM people needs to be aware of.

Although the effects of sex hormones on the human voice have been widely documented, up until recently very few studies addressed transgender individuals directly. Instead, practitioners had to rely on studies that explored the vocal maturation of biological males (e.g., Titze, 1994), women's voices changing due to endocrine problems or the treatment of their symptoms (e.g., Pattie, Murdoch, Theodoros, & Forbes, 1998), and the ageing voice (e.g., Titze, 1994).

A small number of recent studies have begun to document the effects of exogenous androgen hormones in transgender men, or FtM transsexuals (Adler & van Borsel, 2006; Constansis, 2008; Damrose, 2009; Papp, 2011a; van Borsel et al., 2000; van Borsel, Cuypere, & van den Bergh, 2001). Although other researchers have presented pitch change data for transitioning transgender men, longitudinal studies are still scarce, especially ones that interpret the changes using a psycho-acoustic pitch-scale for accurate within- and between-subject comparisons. As it will be shown below, besides the changes in the speaking fundamental frequency

(SFF), it is important to also monitor the changes in the available maximum phonational range (MPR)—that is, the distance between the lowest and highest phonational frequencies (cf. p. 49). In addition to documenting the amount of change during the first year on testosterone, it is important to characterize the timing of the changes and following the changes for possibly multiple years. The motivation behind this is that some of the most frequent questions from FtMs commencing testosterone therapy address (a) how soon the changes are noticeable, (b) how low their SFF may reach, (c) how long it takes for the mean fundamental frequency to reach its lowest and settle, and (d) how their singing voice might be impacted by the changes.

Several newer studies on the FtM voice challenge existing assumptions about the FtM vocal transitioning process. Specifically, results in Papp (2011a) and Zimman (2012) do not support some theories of transitioning (e.g., Heath, 2006) that view the FtM transitioning process as striving for an unambiguously masculine end result. Similarly, Papp's and Zimman's results are not consistent with theories of gender that define gender in terms of a binary opposition of male and female categories and of transgenderism as the "switching" from one feature set to another. Instead, their data suggest that many transgender men view gender as a continuum and they are often comfortable with (a) moving in general toward a more masculine, as opposed to unambiguously masculine, self-representation and (b) keeping their vocal gender fluid and adjusting features of it to circumstances, which may even call for demasculinizing vocal descriptors.

The difference between habitual and "passing" pitch is of special interest in transsexual and transgender populations. In the case of MtF transsexuals who went through puberty as males, the question is how speech-language therapists can safely retrain speakers to use a potentially very different range in their repertoire for everyday communication without voice quality deteriorating or becoming aphonic, without losing intonational variety and projecting power, and without developing vocal

pathologies. The little documentation available on the hormonal transitioning of FtMs usually shows substantial lowering of the fundamental frequency (Adler, Constansis, & van Borsel, 2012; Papp, 2011a; Zimman, 2010). There is little information, however, on whether speakers' actual habitual pitch lowers in tandem with the predicted habitual or optimal speaking pitch (usually calculated with reference to the pitch floor or the Maximum Phonation Range). Negotiating the distance between a "passing" pitch versus the actual speaking fundamental frequency is very likely a task for the speech-language therapist. As there is evidence that listeners are able to locate a speaker's SFF within their phonational range without having been exposed to the speaker's entire range (Bishop & Keating, 2012; Honorof & Whalen, 2005), speech practitioners need to be aware that the gendered perception of speech is not a trivial matter that purely depends on the SFF and speaking range of the SFF but depends on a host of other acoustic descriptors that we still know fairly little about.

Related to the accurate measurement of the acoustic correlate of the speaking pitch, the fundamental frequency, is the issue of the psychoacoustic representation—that is, the comparability of the values, both within and between clients. It is often convenient to measure absolute frequencies in Hz when pitch or change in pitch is studied. But while the production of frequency is linear by nature, the perception of frequency is largely logarithmic. As a result, logarithmic or other nonlinear auditory scales of frequency representation are required to accurately characterize perceptual changes in the speaking fundamental frequency. One such recommended scale is the semitone (ST) scale. On one hand, being one of the few commonly used scales both in clinical practice and musicology, the results are easily interpretable for the widest possible audience. Additionally, the ST scale is the only scale with only one agreed-upon formula that has remained virtually unchanged in the past many centuries, unlike the Bark, Mel, and Equivalent Rectangular Bandwidth (ERB) scales (Miller, 2002).

### *Speaking Fundamental Frequency*

There is substantial evidence that androgens in adolescent cis-men, ciswomen with hyperandrogenism (excessive production and/or secretion of androgens in women), and MtF clients who went through adolescence as males not only lower the SFF, but they do so permanently. The change in SFF is interpreted to be caused by the increase of vocal fold mass with possible contribution from vocal fold stiffness as well. The irreversibility of this change has been amply documented in the literature on cis-men, ciswomen with hyperandrogenism, and MtF transsexuals. As an example, case studies of females in androgen therapies establish that this noticeable deepening of the habitual pitch happens in the first 3 months of the therapy, and is permanent and irreversible even on cessation of the androgens (Baker, 1999; Barbieri, Evans, & Kistner, 1982; Boothroyd & Lepre, 1990; Mercatis, Peaper, & Schwartz, 1985; Newman & Forbes, 1993; Pattie et al., 1998; Wardle, Whitehead, & Mills, 1983).

Evidence on SFF changes in FtM individuals is more scarce though. Van Borsel et al. (2000) and Adler, Constansis, and van Borsel (2012) present longitudinal data of two FtMs, with data points collected about every 2 months. Damrose's (2009) subject was a 33-year-old semi-professional jazz singer, recorded monthly for 20 months. Papp (2011a) recorded seven subjects fortnightly during the first year of testosterone therapy and measured SFF and formant changes. Zimman (2012) recorded 10 transgender men eight times during a window of about 40 to 60 weeks, most of them in the first or second year of transitioning. The changes in SFF in the above studies seem to be following an S-curve: after the initiation of the androgen therapy there is a marked drop in SFF that plateaus out after a number months. The majority of the changes are completed within a year, but Papp (2011a) observed further lowering during the second year on testosterone, and also as a result of oophorectomy (the removal of the ovaries) and the onset of menopause. Papp also found previously

undocumented patterns in which some transgender men show a reverse J-pattern in pitch changes: after the initial drop and plateau, the habitual pitch slightly rises. As an upward shift is deemed impossible on purely physiological bases, Papp hypothesizes that this is due to transgender men fine-tuning their habitual SFF to match their gender identity and express nuances (gender expression and sexual orientation) within their gender.

In Papp's experience some transgender men have actively or passively resisted speaking in a lower (chest) voice. In LW's account, when he felt a strange "rumbling" in his chest he usually recalibrated himself to a higher pitch, unless it was a formal situation demanding authoritative behavior, in which he maintained the low pitch. As another example, TJ would often ask whether his voice had changed during the course of the androgen therapy—by that he meant an observable change in the mean fundamental frequency, which he himself did not perceive as changing. He was indeed correct: over 1 year on testosterone his mean habitual pitch changed from 200 to 170 Hz, which is a change of 3 ST. At the same time, however, his pitch floor lowered from 130 to 80 Hz, or more than 8 ST. If his habitual pitch had recalibrated to a predicted 4 ST over his pitch floor he would have been speaking at around 100 Hz, which is an unambiguously masculine pitch. When asked if he tried to play with his voice and speak lower, TJ's answer was that he had tried and since "it sounded weird" he reverted (close) to his pretestosterone habitual pitch.

It has been observed that some transgender men have problems "passing" as males well into their time on testosterone when their predicted optimal pitch based on their available pitch floor (cf. Awan, 1993; Britto & Doyle, 1990; Cooksey, 2000; Boone, McFarlane, Berg, & Zraick, 2009) and/or their habitual pitch was unambiguously masculine (Nygren, 2014; Papp, 2011a; Söderpalm et al., 2004; van Borsel et al., 2000). These findings make a strong case for including a speech-language therapist in the routine medical care of transgender men. The role of a speech-language therapist could include both mapping the habitual speaking fundamental frequency and

intensity within the available pitch range of transgender men and facilitating behavioral changes or making referrals to other professionals, such as endocrinologists and ear-nose-throat specialists (ENTs), as a trained specialist is able to make distinctions between transgender men reporting temporary, developmental phenomena versus potentially acute problems relating to the habitual speaking fundamental frequency.

One type of problem encountered in practice is when transgender men exhibit little or no lowering of the habitual fundamental frequency and the pitch maxima, even though they have been on testosterone for over a year. This is likely a physiological-hormonal problem, which needs to be investigated with the help of a speech-language therapist, an ear-nose-throat specialist, and/or an endocrinologist. Another kind of problem is reported by individuals who demonstrably have access to cismale-normative fundamental frequencies (which they may or may not know about) but do not seem to be able to speak at those frequencies habitually. These transgender men would then need to be retrained to realize the existence of and then adjust to frequency ranges that are conducive to presenting as the desired gender. Naturally, a speech-language therapist would not need to work with the third group of individuals who, while having access to a cismale SFF, exhibit higher-than-cismale habitual frequency values and are happy with the way they are read (be it gay, queer, androgynous, effeminate, or on occasion, female).

### *Maximum Phonation Range*

Maximum phonation range is the physical range where an individual is able to phonate audibly (cf. Hallin, Fröst, Holmberg, & Södersten, 2012; Holmberg et al., 2010; Sanchez, Oates, Dacakis, & Holmberg, 2014; Sulter et al., 1994). At its simplest it is used as a diagnostic tool to document changes in the voicing source, but given the importance of the speaking fundamental frequency in trans populations, it is very useful to monitor the voice changing as a result of testosterone therapy. The lowest available frequency (also known as

the Minimum F0) is elicited by asking the client to glide or scale down as low as they can and sustain the lowest note. The highest available frequency is usually elicited by asking the client to glide or scale up as high as they can, with no regard to voice quality. Musically untrained clients usually find it easiest if they imagine they are on a roller coaster ride and they imitate the sharp rises and deep falls of the roller coaster with their voice. It is up to the speech-language therapist to record and auditorily evaluate the client's production during the assessment/elicitation session in order to get the true extremes of the phonatory range. Then the results of the acoustic measurement should be expressed in a psychoacoustic scale (e.g., semitones, ERB) and it could be recorded as one of the indicators of vocal change.

The correct interpretation of the MPR results is crucial in giving good feedback to transgender men. Results in Damrose (2009) and Adler, Constansis, and van Borsel (2012) seem to document a marked change in the maximum phonation range (MPR) of transgender men transitioning on testosterone. They conclude that as a result of testosterone therapy the three transgender men's MPR has decreased when expressed in Hz. Building on their work, Papp (2011a) converted their original results into semitones and found that, by the end of the documented vocal transitioning, the MPR of Damrose's subject shrank by 1.3 ST, but the MPR of the two subjects in Adler et al.'s study not only did not shrink but in fact expanded by a trivial 0.3 ST. A net change in the range of 1 ST over 12 months is a perceptually insignificant change that is well within the ranges of documented time-of-day fluctuations (Lehto, Laaksonen, Vilkmán, & Alku, 2008; van Mersbergen, Verdolini, & Titze, 1999), longitudinal fluctuations over a month (Gelfer, 1989), and on par with within-day versus across-day differences (Murry, Brown, & Morris, 1995). As such, it indicates no perceptual narrowing of the available pitch range. On the contrary, the consistency of the size of the ranges is quite remarkable considering the time span of over one year between the first and last measurements. This reanalysis of the findings of previous studies indicates only a relocation of the

entire pitch range to a lower fundamental frequency interval.

The results in Papp (2011a) also lend further support to the temporariness of the range reduction: transitioning did indeed lead to loss of range (as measured in semitones) around 150 to 200 days into the testosterone therapy, but by the end of the first year on testosterone most subjects not only regained but actually largely surpassed their original range. As pointed out in Adler, Constansis, and van Borsel (2012), this "bottleneck" is due to the steadily lowering pitch floor, which is concurrent with a temporary lack of access to the upper range.

Papp's overview of the changes of the pitch descriptors during the first year of testosterone therapy shows that the sentential mean fundamental frequency decreased substantially in some subjects. On average the 1-year SFF means are about 3 to 11 ST lower and the SFF minima about 6 to 12 ST lower than the pretestosterone values. SFF maxima changed differently among subjects. Some speakers lost about 8 to 9 ST from their upper range, while others gained 4 to 10 ST in the upper range by the end of their first year on testosterone. In Papp's study, two speakers experienced a slight decline in pitch range (3–4 ST), while the others experienced that their pitch range widened over the first year on testosterone by more than an octave (12+ ST). A hitherto unexamined finding in Papp (2011a) is that the location of the mean SFF value within the MPR also changed. Speakers' mean SFF before transitioning was higher than the predictable 3 to 4 ST above the pitch floor. This distance grew in the case of every transgender man in this study. In the case of two speakers, this means that they spoke a full octave (12 ST) above their pitch floor. This "buoyancy" of the mean pitch over the pitch floor is observable in the subjects in the study by Adler, Constansis, and van Borsel (2012) as well, whose mean SFF was about 7 to 8 ST over their pitch floor.

Introspection from Papp's study participants seems to raise the point that the speed, but not necessarily the magnitude, of the mean SFF decrease might correlate with the amount or ratio of hormones in the body. Subjects who took larger amounts of testosterone, or whose

estrogen production was (virtually) nonexistent (cf. postmenopausal and postorchiectomy transgender men) felt they demonstrated a faster, more hyperbolic change. This, however is not borne out (yet) by empirical evidence: Nygren (2014) found no or only weak correlations between hormone levels and fundamental frequency values over the first 18 months of the testosterone therapy.

### ***Surgical Lowering of the Fundamental Frequency***

While it is not common, surgical intervention is available to lower the speaking fundamental frequency using techniques developed by Isshiki, Taira, and Tanabe (1983). The vocal fold relaxation technique has been used in cases of mutational falsetto and hypogonadic males as well as transgender men (Hoffman et al., 2014; Kocak et al., 2008; Remacle, Matar, Verduyck, & Lawson, 2010).

### ***Vocal Tract Resonances***

The growth of the vocal tract length in biological males is usually accounted for by the growth spurt during adolescence and the descent of the larynx. However, a change in transgender men's height or laryngeal descent is not reported in the studies so far. This suggests that no physiological (as opposed to behaviorally conditioned) changes are to be expected as a result of the androgen therapy. However, the results of Papp's longitudinal study (2011) reveal previously undocumented lowering in the vowel formant values over the first year of testosterone therapy. The first three formant values, which had been previously not considered a factor during the vocal transitioning, were significantly lower during the first year of hormone therapy. This trend was lent further support by Zimman (2012).

There are a few physiological changes in the bony or cartilaginous structures around the vocal tract in transgender men. Antoszewski, Zadzińska, and Foczpanski (2009) found that the size of FtM transsexuals' maxillary and mandibular canines and the first molars is between those of cismales and cisfemales.

Informal introspection by transgender men in Papp (2011a) indicates that the angle between the posterior part of the mandible and the lower border of the ramus changes noticeably during transitioning, creating a more masculine jawline. Some transgender men experience the growth of the bony protrusion of an Adam's apple, which may be accompanied with other laryngeal cartilage shifts and growths. All these phenomena indicate that these structures in and around the vocal tract may remain sensitive to androgens comparatively late in life.

Papp's findings based on two subjects followed for multiple years strongly suggest that besides physiological forces, behavioral modifications may also lie behind the observed formant changes. This is evidenced by steady progress toward more-masculine formant values, followed by the reversal of the values a number of years into the androgen therapy, much like the inverse J-curve observed in the SFF of these men. This increased ability to make behavioral choices, which is facilitated by the physiologically altered structures, provides further evidence of the relative flexibility of speech features that were previously thought of as largely fixed. The slow fluctuation and sometimes reversal of the values further support the idea that speakers continually fine-tune features as they repeatedly relocate themselves along the gender continuum.

### ***Breathing***

#### ***Binders***

Transgender men who have gone through hormonal adolescence as females often wear a compressing layer of clothing in order to create a more masculine looking chest. The binders may range from ACE bandage and (multiple, layered) sports bras to tight tops and specially-made binders covering the whole torso. Introspection among transgender men holds that the strong chest compression that especially larger-chested transgender men need to employ often leads to shortness of breath, inadequate breath support for voicing and physical exercise, and, in especially severe cases, fainting and cracked ribs.



While wearing binders is a non-negotiable part of many no-surgery or pre-surgery transgender men, it might be useful to help clients monitor their pulmonary/spirometric values (such as descriptors of the (forced) inspiratory and expiratory vital capacity maneuvers, and total lung capacity) by comparing in-binder and no-binder tidal breathing, especially at the beginning of the social transitioning, which often coincides with the onset of habitually wearing a binder. As proper pulmonary support is necessary for good laryngeal valving efficiency; also phonation intensity should be checked in transgender men—that is, whether they can project in a sustained manner.

### *Hormones*

Hormone therapy might affect ventilatory responses to obstructive lung problems (such as asthma, chronic obstructive pulmonary disease (COPD), bronchitis), as testosterone, progesterone and estrogen are known to alter ventilatory control. Moreover, gender differences exist in lung function and metabolic demand, both of which may affect the ventilatory compensatory responses to airway obstruction. We recommend surveying and monitoring a history of pulmonary or ventilatory problems in clients on hormones.

### *Sleep-Disordered Breathing*

A lack of consistent results is found in studies of ventilatory responses in men and women. However, there are a number of observed risk factors that were not well understood prior to the publication of population-based studies that included both genders. Although the gender differences are less striking than once thought, there still appears to be a higher prevalence of both sleep-disordered breathing (SDB) and obstructive sleep apnea (OSA) in men than in (premenopausal) women. OSA is a relatively common condition often characterized by snoring, recurrent episodes of cessation of breathing, disrupted sleep, and daytime somnolence. Associated serious complications are hypertension, increased risk of heart disease, stroke, and increased susceptibility to industrial and motor

vehicle accidents (Park, Ramar, & Olson, 2011; Ramar & Guilleminault, 2007).

The reason for the male predominance remains uncertain. Because testosterone contributes to fat deposition in the neck and upper body and reshapes the mandible and possibly the pharyngeal cavity, it may contribute to the development of OSA through reduced or altered upper airway size. In support of the hypothesis connecting testosterone with OSA is the increased prevalence, induction, or worsening of OSA in these groups:

- postmenopausal women (Bixler et al., 2001; Shahar et al., 2003; Young, Finn, Austin, & Peterson, 2003);
- women with high endogenous levels of testosterone and/or polycystic ovarian syndrome (PCOS) (Dexter & Dovre, 1998; Fogel et al., 2001; Vgontzas et al., 2001);
- women with exogenous testosterone administered (Johnson, Anch, & Remmers, 1984); and
- hypogonadal, elderly, or obese men through administration of testosterone (Hoyos, Killick, Yee, Grunstein, & Liu, 2012; Killick et al., 2013; Liu et al., 2003; Matsumoto et al., 1985; Sandblom et al., 1983; Schneider et al., 1985).

Most of these studies controlled for the effects of age and weight/BMI, as both have been found to show positive correlation with the prevalence of OSA. For documented and possible risk factors of OSA see Ramar and Guilleminault (2007); for further testosterone-induced risk factors consult the WPATH Standards of Care E. Coleman et al. (2011).

Because OSA may be worsened or unmasked by androgen therapy in FtM individuals, and since it may be a risk factor for a number of further health problems, we recommend that the speech-language therapist should regularly ask the clients about changes in quality of sleep and snoring.

### **SUMMARY AND OUTLOOK**

As shown above, during the process of vocal masculinization, hormonal and psychosocial

forces often work in tandem in order to create a voice that represents not only the true gender but the true complete identity of transgender men, which includes expressions of age, ethnicity, sexual orientation, and fluidity in and around gender. As such, voice and speech goals may change during transitioning, whether the transgender man is taking testosterone or not. In order to gauge the goals and the vocal satisfaction, it is recommended to survey the clients before, during, and after the therapy provided by the speech and language therapist. The survey should preferably include (among other information) client expectations, vocational demands on voice, current satisfaction with voice and communication, age, menopause/oophorectomy status, amount of testosterone taken and method of administration, current SFF descriptors, use of chest binders, snoring and sleep-disordered breathing, and if the client is comfortable with sharing such information, the current gender identity and/or sexual orientation. This information, taken together with culturally appropriate sociolinguistic usage will help the speech-language therapist recommend pitch, formant, breathiness, and creakiness goals that give a voice to the person within.

While transitioning on androgens is very frequent among FtMs, it is not the only way to reshape the voice and speech by any means. Many no-hormone or pre-hormone transgender men may seek out a speech-language therapist's help in order to reshape their voice and speech. According to Papp's large-scale survey (Papp, 2011b), a large proportion of transgender men have started smoking or have considered starting smoking in order to lower their SFF. While evidence suggests (e.g., Gilbert & Weismer, 1974) that smoking might indeed lower the SFF, speech-language therapist should promote alternative, sustainable, nondamaging ways to reshape a transgender man's voice.

Finally, as suggested above, there is much to learn about the perception of the trans-male voice, both accompanied by or in absence of visual clues. Observations by transgender men, such as "I sound weirdly nasal," "People keep asking if I have a cold," "People say I sound like a young gay

man, but I'm straight and in my 40s," indicate outstanding issues. These issues were quantifiable in Nygren's (2014) dissertation: She found that in her pool of 50, for nearly a quarter of transgender men, voice and communication therapy was needed due to problems with vocal fatigue and instability, insufficient lowering of pitch and projecting power, and problems with the voice sounding too young.

These issues might include the source-filter mismatch in some transgender men possibly caused by the combination of cismale-like SFF and cisfemale-like resonances; altered resonances possibly due to changing bone and cartilage structures; or temporary dysphonia during the first year on testosterone while the SFF, much like in cismale adolescence, is still in flux.

All these further emphasize the importance of (gender(ed)) sensitivity, good training in speech-language therapists, and continued focused research in order to better serve this invisible, but sizeable, population.

## **SUMMARY OF RECOMMENDATIONS**

### ***Voice and Communication Intervention for Gender Nonconforming Individuals***

1. Transgender voice and communication services should be offered in the context of a complete approach to transgender health that includes comprehensive primary care and a coordinated approach to psychological and social issues.
2. In working with gender nonconforming clients, the speech-language therapist's primary goal is to help the client develop voice and communication that more closely approximates the client's sense of self.
3. Feminizing/masculinizing voice involves nonhabitual use of the voice-producing mechanism. To prevent the possibility of vocal damage, professional evaluation and assistance are essential.
4. Self-guided voice and communication change without professional supervision

is not recommended. Clients intending to pursue self-guided voice change should be encouraged to, at a minimum, have an initial professional assessment and then to consult with their primary care provider if they develop symptoms of vocal fatigue or negative changes to vocal quality. Self-help voice and communication groups should have appropriate clinical support.

### ***Clinical Competence***

1. Voice and communication professionals working with transgender individuals must have a basic understanding of transgender health (including hormonal and surgical feminization/masculinization) and trans-specific psychosocial issues; they must be familiar with basic sensitivity protocols such as use of preferred gender pronoun and name.
2. Gender nonconforming individuals who are seeking voice and communication services for reasons other than speech feminization/masculinization can be treated by trans-sensitive speech-language therapists using standard voice and communication protocols. voice and communication feminization/masculinization requires additional clinical expertise and special clinical protocols.

### ***Client Inclusion and Exclusion***

1. Voice and communication services should be available to the full spectrum of the transgender community, including MtF and MtF transsexuals and others who are gender nonconforming.
2. The need for voice and communication services should not be evaluated based on hormonal use, pursuit of sex reassignment surgery, or length or percentage of time living in the desired gender role.
3. Services should be adapted as needed to fit a client's individual needs, including accommodation relating to speech or

hearing disability, mental illness, cognitive disability, learning disability, physical disability, geographic isolation, or incarceration.

### ***Treatment Decisions***

1. The client is responsible for treatment decisions, supported by the clinician's informed professional opinion, assessment data, and any allies the client wishes to be involved.
2. To support fully informed treatment decisions, clients should be informed of the following:
  - a. potential risks and benefits associated with treatment options
  - b. estimated duration of treatment;
    - factors that can influence the outcome or duration of treatment
3. Existing protocols for voice and communication feminization should be reviewed and considered when developing individualized treatment plans. As there are no established protocols for speech masculinization, FtMs seeking this service should be informed that the protocol is a trial.
4. While modification of existing protocols is encouraged, all treatment plans (including those using new or experimental techniques) are expected to be based on a clearly articulated, logical, and valid clinical rationale. Departure from existing protocols should be explained as such to the client as part of fully informed consent and should be documented in detail to facilitate evaluation.

### ***Assessment***

1. Assessment prior to voice and communication feminization/masculinization should include the following:
  - a. psychosocial, voice use, voice health, and medical history
  - b. clinical assessment of speech and voice including:
    1. the client's subjective assessment

2. instrumental measurement
  3. the clinician's subjective analysis
  4. an assessment of potential for change
  5. assistance with understanding therapeutic options
2. As there is evidence that behavioral changes (of pitch, inflection, resonance, etc.) may degrade over time, periodic re-evaluation is recommended following treatment with further clinical assistance as needed.

### *Voice and Communication Therapy*

1. Voice and communication therapy should be individualized based on each person's goals and identity, the risks and benefits of treatment options, and consideration of social and economic issues.
2. Rather than adopting a rigid and artificial set of voice and communication norms, it is recommended that clients be assisted to develop an individualized and context-specific set of norms based on communication patterns in their own social, cultural, work, and home environments.
3. It is clinically optimal to be able to offer both individual sessions and group treatment, with the proportion of time in each format depending on the client's therapeutic needs and goals.

### *Pitch-Elevating Surgery*

1. As there is no professional consensus regarding the effectiveness and risk-benefit ratio of pitch-elevating surgery, care should be taken to ensure that clients are fully informed of potential risks, postoperative care requirements, and possible outcomes (including decreased pitch).
2. Assessment by both a laryngologist and speech-language therapist is recommended prior to surgery.
3. Prior to surgery, the laryngologist should discuss after-care instructions with the

patient and provide written after-care instructions.

4. Voice therapy should be offered following phonosurgery to help the patient adapt to and stabilize the new voice.

### *Outcome Evaluation*

1. Outcomes should be rigorously evaluated and documented.
2. At minimum, the baseline assessment should be repeated immediately following the end of therapy. Ideally, re-evaluation would take place at 6 months, 1 year, 5 years, and 10 years after treatment.
3. Evaluation should include client satisfaction with the treatment outcome and with the quality of care provided, as well as perceptual and objective measures of voice and communication change.
4. Informal or formal sharing of outcome data (with colleagues, at conferences, in publications, etc.) must occur only if the client has provided fully informed and voluntary written consent.

### *Research*

1. There is a paucity of data relating to speech feminization/masculinization. Further research in this area is eagerly anticipated.
2. To ensure that participation in research is voluntary, services should not be offered solely as part of a research protocol.

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### NOTES

1. For the rest of the document we will use *speech-language therapist* (SLT) and *clinician* as umbrella terms for speech-language therapists and pathologists. Other speech and voice specialists, such as singing teachers and speaking voice trainers may also be involved in discrete areas of the voice and communication needs of the transgender population.

2. The sections “Presurgical Assessment,” “Postsurgical Care” to “Voice Feminization Surgeries” were reproduced from Davies and Goldberg (2006b).

### References

- Abu-Al-Makarem, A., & Petrosino, L. (2007). Reading and spontaneous speaking fundamental frequency of young Arabic men for Arabic and English languages: A comparative study. *Perceptual and Motor Skills, 105*(2), 572–580.
- Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behaviour, 3*(2), 111–149.
- Adler, R. K., & Antoni, C. (2012). Vocal health and phonotrauma. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed., pp. 139–152). San Diego, CA: Plural.
- Adler, R. K., Constansis, A. N., & van Borsel, J. (2012). Female-to-male considerations. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed., pp. 153–187). San Diego, CA: Plural.
- Adler, R. K., Hirsch, S., & Mordaunt, M. (Eds.). (2012). *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed.). San Diego, CA: Plural.
- Adler, R. K., & van Borsel, J. (2006). Female-to-male considerations. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (pp. 139–168). San Diego, CA: Plural.
- Altenberg, E. P., & Ferrand, C. T. (2006). Fundamental frequency in monolingual English, bilingual English/Russian, and bilingual English/Cantonese young adult women. *Journal of Voice, 20*(1), 89–96.
- American Speech-Language-Hearing Association. (2005). *Evidence-based practice in communication disorders* (Position statement). Retrieved from <http://www.asha.org/policy/>
- Andrews, M. L. (1999). *Manual of voice treatment: Pediatrics through geriatrics* (2nd ed.). San Diego, CA: Singular.
- Andrews, M. L., & Schmidt, C. P. (1997). Gender presentation: Perceptual and acoustical analyses of voice. *Journal of Voice, 11*(3), 307–313.
- Antoni, C. (2007). The role of the speech and language therapist. In J. Barrett (Ed.), *Transsexual and other disorders of gender identity: A practical guide to management* (pp. 139–156). Oxfordshire, UK: Radcliffe Publishing Ltd.
- Antoszewski, B., Zadzinska, E., & Foczpanski, J. (2009). The metric features of teeth in female-to-male transsexuals. *Archives of Sexual Behavior, 38* (3), 351–358.
- Awan, S. N. (1993). Superimposition of speaking voice characteristics and phonetograms in untrained and trained vocal groups. *Journal of Voice, 7*(1), 30–37.
- Awan, S. N., & Mueller, P. B. (1996). Speaking fundamental frequency characteristics of white, African American, and Hispanic kindergartners. *Journal of Speech and Hearing Research, 39*(3), 573–577.
- Baken, J., & Daniloff, R. G. (1991). *Readings in clinical spectography of speech*. San Diego, CA: Singular.
- Baker, J. (1999). A report on alterations to the speaking and singing voices of four women following hormonal therapy with virilizing agents. *Journal of Voice, 13*(4), 496–507.
- Barbieri, R. L., Evans, S., & Kistner, R. W. (1982). Danazol in the treatment of endometriosis: Analysis of 100 cases with a 4-year follow-up. *Fertility and Sterility, 37*(6), 737–746.
- Bennett, J. W. (2010). Exploring behavioural voice change methods in the transgendered population. *Canadian Journal of Speech-Language Pathology and Audiology, 34*(1), 63.
- Biemans, M. A. J. (2000). *Gender variation in voice quality* (Unpublished doctoral dissertation). Katholieke Universiteit Nijmegen, Nijmegen, The Netherlands.
- Biever, D. M., & Bless, D. M. (1989). Vibratory characteristics of the vocal folds in young adult and geriatric women. *Journal of Voice, 3*, 120–131.
- Bishop, J., & Keating, P. (2012). Perception of pitch location within a speaker’s range: Fundamental frequency, voice quality and speaker sex. *Journal of the Acoustical Society of America, 132*(2), 1100–1112.
- Bixler, E., Vgontzas, A., Lin, H., Ten Have, T., Rein, J., Vela-Bueno, A., & Kales, A. (2001). Prevalence of

- sleep-disordered breathing in women: Effects of gender. *American Journal of Respiratory and Critical Care Medicine*, 163, 608–613.
- Boone, D. R., McFarlane, S. C., Berg, S. L. V., & Zraick, R. I. (2009). *The voice and voice therapy* (8th ed.). New York, NY: Pearson.
- Boonin, J. (2012). Articulation. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed., pp. 249–262). San Diego, CA: Plural.
- Boothroyd, C. V., & Lepre, F. (1990). Permanent voice change resulting from Danazol therapy. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, 30(3), 275–276.
- Bralley, L. A., Bull, G. L., Gore, C. H., & Edgerton, M. T. (1978). Evaluation of vocal pitch in male transsexuals. *Journal of Communication Disorders*, 11(5), 443–449.
- Britton, N. J., & Hall, J. A. (1995). Gender-based expectancies and observer judgments of smiling. *Journal of Nonverbal Behavior*, 19(1), 49–65.
- Britto, A. I., & Doyle, P. C. (1990). A comparison of habitual and derived optimal voice fundamental frequency values in normal young adult speakers. *Journal of Speech and Hearing Disorders*, 55(3), 476–484.
- Brown, M., Perry, A., Cheesman, A. D., & Pring, T. (2000). Pitch change in male-to-female transsexuals: Has phonosurgery a role to play? *International Journal of Language & Communication Disorders*, 35(1), 129–136.
- Brown, W. R., Morris, R. J., Hollien, H., & Howell, E. (1991). Speaking fundamental frequency characteristics as a function of age and professional singing. *Journal of Voice*, 5, 310–315.
- Byrne, L. A. (2003). Self-perceptions of pragmatic communication abilities in male-to-female transsexuals. *Advances in Speech Language Therapy*, 5(1), 15–25.
- Byrne, L. A. (2007). *My life as a woman: Placing communication within the social context of life for the transsexual woman* (Unpublished doctoral dissertation). La Trobe University, Melbourne, Australia.
- Carew, L., Dacakis, G., & Oates, J. (2007). The effectiveness of oral resonance therapy on the perception of femininity of voice in male-to-female transsexuals. *Journal of Voice*, 21(5), 591–603.
- Chung, D., Tsuji, D. H., Sennes, L. U., & Imamura, R. (2007). Upper displacement of the anterior commissure: Experimental study of a new phonosurgical approach to raising vocal pitch. *Annals of Otolaryngology, Rhinology, and Laryngology*, 116, 462–470.
- Coleman, E., Bocking, W., Botzer, M., Cohen-Kettenis, P., DeCuypere, G., Feldman, J., . . . Zucker, K. (2011). Standards of care for the health of transsexual, transgender, and gender-nonconforming people, version 7. *International Journal of Transgenderism*, 13, 165–232.
- Coleman, R. O. (1983). Acoustic correlates of speaker sex identification: Implications for the transsexual voice. *Journal of Sex Research*, 19, 293–295.
- Constansis, A. N. (2008). The changing female-to-male (FTM) voice. *Radical Musicology*, 3. Retrieved from <http://www.radical-musicology.org.uk/2008/Constansis.htm>
- Cooksey, J. M. (2000). Male adolescent transforming voices: Voice classification, vocal skill development and music literature selection. In L. Thurman & G. Welch (Eds.), *Bodymind and voice: Foundations of voice education* (pp. 811–841). Colleagueville, MN: Voice-Care Network.
- Dacakis, G. (2000). Long-term maintenance of fundamental frequency increases in male-to-female transsexuals. *Journal of Voice*, 14(4), 549–556.
- Dacakis, G. (2002). The role of voice therapy in male-to-female transsexuals. *Current Opinion in Otolaryngology and Head and Neck Surgery*, 10(3), 173–177.
- Dacakis, G. (2011, September). *Skype-delivered therapy for voice feminization*. Paper presented at the World Professional Association for Transgender Health Biennial International Symposium (WPATH 2011), Atlanta, GA.
- Dacakis, G. (2012a). Assessment and goal setting: Revisited. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed., pp. 111–138). San Diego, CA: Plural.
- Dacakis, G. (2012b, September). *Stemple's vocal function exercise for voice feminization*. Paper presented at the Canadian Professional Association for Transgender Health Third Biennial Conference (CPATH 2012), Winnipeg, Canada.
- Dacakis, G., Davies, S., Oates, J. M., Douglas, J. M., & Johnston, J. R. (2013). Development and preliminary evaluation of the Transsexual Voice Questionnaire for Male-to-Female Transsexuals. *Journal of Voice*, 27(3), 312–321.
- Dacakis, G., Oates, J., & Douglas, J. M. (2012). Beyond voice: Perceptions of gender in male-to-female transsexuals. *Current Opinion in Otolaryngology and Head and Neck Surgery*, 20(3), 165–170.
- Damrose, E. J. (2009). Quantifying the impact of androgen therapy on the female larynx. *Auris, Nasus, Larynx*, 36(1), 110–112.
- Davies, S. (2012, September). *Finding the voice within: Evidence-based practice in transgender voice training*. Paper presented at the Canadian Professional Association for Transgender Health Third Biennial Conference (CPATH 2012), Winnipeg, Canada.
- Davies, S., & Goldberg, J. M. (2006a). Clinical aspects of transgender speech feminization and masculinization. *International Journal of Transgenderism*, 9(3–4), 167–196.

- Davies, S., & Goldberg, J. M. (2006b). *Transgender speech feminization/masculinization: Suggested guidelines for BC clinicians*. Vancouver, Canada: Vancouver Coastal Health, Transcend Transgender Support & Education Society, and the Canadian Rainbow Health Coalition.
- de Bruin, M. D., Coerts, M. J., & Greven, A. J. (2000). Speech therapy in the management of male-to-female transsexuals. *Folia Phoniatrica et Logopaedica*, *52*, 220–227.
- Descloux, P., Isoard-Nectoux, S., Matoso, B., Matthieu-Bourdeau, L., Schneider, F., & Schweizer, V. (2012). Transsexuality: Speech therapy supporting the “voice” of transformation. *Revue De Laryngologie Otologie Rhinologie*, *133*(1), 41–44.
- Deutsch, D., Le, J., Shen, J., & Henthorn, T. (2009). The pitch levels of female speech in two Chinese villages. *Journal of the Acoustical Society of America*, *125*(5), EL208–213.
- Dexter, D. D., & Dovre, E. J. (1998). Obstructive sleep apnea due to endogenous testosterone production in a woman. *Mayo Clinic Proceedings*, *73*(3), 246–248.
- Diehl, R. L., Lindblom, B., Hoemeke, K. A., & Fahey, R. P. (1996). On explaining certain male-female differences in the phonetic realization of vowel categories. *Journal of Phonetics*, *24*(2), 187–208.
- Dolson, M. (1994). The pitch of speech as a function of linguistic community. *Music Perception*, *11*(3), 321–331.
- Eckert, P., & McGonnell-Ginet, S. (1999). New generalizations and explanations in language and gender research. *Language in Society*, *28*(2), 185–201.
- Eckert, P., & McGonnell-Ginet, S. (2003). *Language and gender*. Cambridge, UK: Cambridge University Press.
- Fogel, R. B., Malhotra, A., Pillar, G., Pittman, S. D., Dunaif, A., & White, D. P. (2001). Increased prevalence of obstructive sleep apnea syndrome in obese women with polycystic ovary syndrome. *Journal of Clinical Endocrinology and Metabolism*, *86*, 1175–1180.
- Free, N., & Dacakis, G. (2007, September). *Articulation and the perception of gender in male-to-female transsexuals*. Paper presented at the World Professional Association for Transgender Health Biennial International Symposium (WPATH 2007), Chicago, IL.
- Freidenberg, C. B. (2002). Working with male-to-female transgendered clients: Clinical considerations. *Contemporary Issues in Communication Science and Disorders*, *29*, 43–58.
- Gelfer, M. P. (1989). Stability in phonational frequency range. *Journal of Communication Disorders*, *22*(3), 181–192.
- Gelfer, M. P. (1999). Voice treatment for the male-to-female transgendered client. *American Journal of Speech Language Pathology*, *8*, 201–208.
- Gelfer, M. P., & Mikos, V. A. (2005). The relative contributions of speaking fundamental frequency and formant frequencies to gender identification based on isolated vowels. *Journal of Voice*, *19*(4), 544–554.
- Gelfer, M. P., & Schofield, K. J. (2000). Comparison of acoustic and perceptual measures of voice in male-to-female transsexuals perceived as female versus those perceived as male. *Journal of Voice*, *14*(1), 22–33.
- Gelfer, M. P., & Tice, R. M. (2013). Perceptual and acoustic outcomes of voice therapy for male-to-female transgender individuals immediately after therapy and 15 months later. *Journal of Voice*, *27*(3), 335–347.
- Gelfer, M. P., & Van Dong, B. R. (2013). A preliminary study on the use of vocal function exercises to improve voice in male-to-female transgender clients. *Journal of Voice*, *27*(3), 321–334.
- Gilbert, H. R., & Weismer, G. (1974). The effects of smoking on the speaking fundamental frequency of adult women. *Journal of Psycholinguistic Research*, *3*(3), 225–231.
- Gold, L. (1999). *Voice training for the transsexual*. Unpublished manuscript. Retrieved from <http://www.vasta.org/newsletter-past/99/summer03.html>
- Gorham-Rowan, M., & Morris, R. (2006). Aerodynamic analysis of male-to-female transgender voice. *Journal of Voice*, *20*(2), 251–262.
- Grainger, A. S., & Dunbar, R. I. M. (2009). The structure of dyadic conversations and sex differences in social style. *Journal of Evolutionary Psychology*, *7*(1), 83–93.
- Gramming, P., & Sundberg, J. (1988). Spectrum factors relevant to phonetogram measurements. *Journal of the Acoustical Society of America*, *83*, 2352–2360.
- Gross, M. (1999). Pitch-raising surgery in male-to-female transsexuals. *Journal of Voice*, *13*(2), 246–250.
- Günzburger, D. (1989). Voice adaptation by transsexuals. *Clinical Linguistics and Phonetics*, *3*(2), 163–172.
- Günzburger, D. (1993). An acoustic analysis and some perceptual data concerning voice change in male-female transsexuals. *European Journal of Disorders of Communication*, *28*(1), 13–21.
- Hall, J. A., Coats, E. J., & Smith, L. (2005). Nonverbal behavior and the vertical dimension of social relations: A meta-analysis. *Psychological Bulletin*, *131*, 898–924.
- Hallin, A. E., Fröst, K., Holmberg, E. B., & Södersten, M. (2012). Voice and speech range profiles and Voice Handicap Index for males—methodological issues and data. *Logopedics, Phoniatrics, Vocology*, *37*(2), 47–61.
- Hancock, A. B., Colton, L., & Douglas, F. (2014, March). Intonation and gender perception: Applications for transgender speakers. *Journal of Voice: Official Journal of the Voice Foundation*, *28*(2), 203–209.
- Hancock, A. B., & Garabedian, L. M. (2013). Transgender voice and communication treatment: A retrospective chart review of 25 cases. *International Journal of Language and Communication Disorders*, *48*(1), 54–65.

- Hancock, A. B., & Helenius, L. (2012). Adolescent male-to-female transgender voice and communication therapy. *Journal of Communication Disorders, 45*(5), 313–324.
- Hancock, A. B., Krissinger, J., & Owen, K. (2011). Voice perceptions and quality of life of transgender people. *Journal of Voice, 25*(5), 553–558.
- Hasegawa, Y., & Hata, K. (1995). The function of F0-peak delay in Japanese. In J. Ahlers, L. Bilmes, J. S. Guenter, B. A. Kaiser, & J. Namkung (Eds.), *Proceedings of the 21st annual meeting of the Berkeley Linguistics Society* (pp. 141–151). Berkeley, CA: Berkeley Linguistics Society.
- Heath, R. A. (2006). *The Praeger Handbook of Transsexuality: Changing gender to match mindset*. Santa Barbara, CA: Praeger.
- Henton, C. G., & Bladon, R. (1985). Breathiness in normal female speech: Inefficiency versus desirability. *Language and Communication, 5*(3), 221–227.
- Henton, C. G., Bladon, R., Hyman, L., & Li, C. (1988). Creak as a sociophonetic marker. In L. M. Hyman & C. N. Li (Eds.), *Language, speech and mind: Studies in Honour of Victoria A. Fromkin* (pp. 3–29). London, UK: Routledge.
- Hess, U., Adams, J. R. B., & Kleck, R. E. (2004). Dominance, gender and emotion expression. *Emotion, 4*, 378–388.
- Hillenbrand, J., & Clark, M. (2009). The role of F0 and formant frequencies in distinguishing the voices of men and women. *Attention, Perception and Psychophysics, 71*(5), 1150–1166.
- Hofman, M. R., Devine, E. E., Remacle, M., Ford, C. N., Wadium, E., & Jiang, J. J. (2014). Combined type IIIB with bilateral type I thyroplasty for pitch lowering with maintenance of vocal fold tension. *European Archives of Otorhinolaryngology, 271*(6), 1621–1629.
- Hogg, M. A. (1985). Masculine and feminine speech in dyads and groups: A study of speech style and gender salience. *Journal of Language and Social Psychology, 4*(2), 99–112.
- Hollien, H., & Paul, P. A. (1969). A second evaluation of the speaking fundamental frequency characteristics of post-adolescent girls. *Language and Speech, 12*, 119–124.
- Holmberg, E. B., Oates, J. M., Dacakis, G., & Grant, C. (2010). Phonetograms, aerodynamic measurements, self-evaluations, and auditory perceptual ratings of male-to-female transsexual voice. *Journal of Voice, 24*(5), 511–522.
- Honorof, D. N., & Whalen, D. H. (2005). Perception of pitch location within a speaker's F0 range. *Journal of the Acoustical Society of America, 117*(4/1), 2193–2200.
- Hooper, C. R. (1985). Changing the speech and language of the male to female transsexual client: A case study. *Journal of the Kansas Speech-Language-Hearing Association, 25*, 1–6.
- Hoyos, C. M., Killick, R., Yee, B. J., Grunstein, R. R., & Liu, P. Y. (2012). Effects of testosterone therapy on sleep and breathing in obese men with severe obstructive sleep apnoea: A randomized placebo-controlled trial. *Clinical Endocrinology, 77*(4), 599–607.
- Hudson, T., de Jong, G., McDougall, K., Harrison, P., & Nolan, F. (2007). F0 statistics for 100 young male speakers of Standard Southern British English. In *Proceedings of ICPHS XVI Saarbrücken* (pp. 1809–1812). Saarbrücken, Germany: Universität des Saarlandes.
- Iseli, M., Shue, Y.-L., & Alwan, A. (2007). Age, sex, and vowel dependencies of acoustic measures related to the voice source. *Journal of the Acoustical Society of America, 121*(4), 2283–2295.
- Isshiki, N., Taira, T., & Tanabe, M. (1983). Surgical alteration of the vocal pitch. *Journal of Otolaryngology, 12*(5), 335–340.
- Jacobson, B. H., Johnson, A., Grywalski, C., Silbergleit, A., Jacobson, G., Benninger, M. S., & Newman, C. W. (1997). The voice handicap index (VHI): Development and validation. *American Journal of Speech Language Pathology, 6*(3), 66–70.
- Johnson, M. W., Anch, A. M., & Remmers, J. E. (1984). Induction of the obstructive sleep apnea syndrome in a woman by exogenous androgen administration. *American Review of Respiratory Disease, 129*(6), 1023–1025.
- Johnston, J. R. (2007). *Thinking about child language: Research to practice*. Greenville, SC: Thinking Publications University.
- Kalra, M. A. (1977). Voice therapy with a transsexual. In R. Gemme & C. Wheeler (Eds.), *International congress on sexology* (pp. 77–84). New York, NY: Plenum Press.
- Kanagalingam, J., Georgalas, C., Wood, G. R., Ahluwalia, S., Sandhu, G., & Cheesman, A. D. (2005). Cricothyroid approximation and subluxation in 21 male-to-female transsexuals. *Laryngoscope, 115*(4), 611–618.
- Kaye, J., Bortz, M. A., & Tuomi, S. K. (1993). Evaluation of the effectiveness of voice therapy with a male-to-female transsexual subject. *Logopedics, Phoniatrics, Vocology, 18*(2–3), 105–109.
- Killick, R., Wang, D., Hoyos, C. M., Yee, B. J., Grunstein, R. R., & Liu, P. Y. (2013). The effects of testosterone on ventilatory responses in men with obstructive sleep apnea: A randomised, placebo-controlled trial. *Journal of Sleep Research, 22*, 331–336.
- King, J. B., Lindstedt, D. E., Jensen, M., & Law, M. (1999). Transgendered voice: Considerations in case history management. *Logopedics, Phoniatrics, Vocology, 24*(1), 14–18.
- King, R. S., Brown, G. R., & McCrea, C. R. (2011). Voice parameters that result in identification or misidentification of biological gender in male-to-female



- transgender veterans. *International Journal of Transgenderism*, 13, 117–130.
- Kocak, I., Akpınar, M. E., Cakir, Z. A., Dogan, M., Bengisu, S., & Celikoyar, M. M. (2010). Laser reduction glottoplasty for managing androphonia after failed cricothyroid approximation surgery. *Journal of Voice*, 24, 758–764.
- Kocak, I., Dogan, M., Tadihan, E., Cakir, Z. A., Bengisu, S., & Akpınar, M. E. (2008). Window anterior commissure relaxation laryngoplasty in the management of high-pitched voice disorders. *Archives of Otolaryngology*, 134(12), 1263–1269.
- Koufman, J. A. (2007). *Call for a moratorium on voice feminization surgery for the m-to-f transsexual in the United States*. Retrieved from <http://www.inbroaddaylight.net/moratorium.htm>
- Kreiman, J., Gerratt, B. R., & Antonanzas-Barroso, N. (2007). Measures of the glottal source spectrum. *Journal of Speech, Language, and Hearing Research*, 50, 595–610.
- Kunachak, S., Prakunhungsit, S., & Sujjalak, K. (2000). Thyroid cartilage and vocal fold reduction: A new phonosurgical method for male-to-female transsexuals. *Annals of Otolaryngology, Rhinology, and Laryngology*, 109(11), 1082–1086.
- LaFrance, M., Hecht, M. A., & Paluck, E. L. (2003). The contingent smile: A meta-analysis of sex differences in smiling. *Psychological Bulletin*, 129, 303–334.
- Lawrence, A. (2004). *Voice feminization surgery: A critical overview*. Retrieved from <http://www.annalawrence.com/voicesurgery.html>
- Lehto, L., Laaksonen, L., Vilkmann, E., & Alku, P. (2008). Changes in objective acoustic measurements and subjective voice complaints in call center customer-service advisors during one working day. *Journal of Voice*, 22(2), 164–177.
- Linville, S. E. (1992, December). Glottal gap configurations in two age groups of women. *Journal of Speech and Hearing Research*, 35, 1209–1215.
- Linville, S. E. (1998). Acoustic correlates of perceived versus actual sexual orientation in men's speech. *Folia Phoniatrica et Logopaedica*, 50(1), 35–48.
- Linville, S. E., & Fisher, H. B. (1985). Acoustic characteristics of women's voices with advancing age. *Journal of Gerontology*, 40(3), 324–330.
- Liu, P. Y., Yee, B., Wishart, S. M., Jimenez, M., Jung, D. G., Grunstein, R. R., & Handelsman, D. J. (2003). The short-term effects of high-dose testosterone on sleep, breathing, and function in older men. *Journal of Clinical Endocrinology and Metabolism*, 88, 3605–3613.
- Loveday, L. (1981). Pitch, politeness and sexual role: An exploratory investigation into the pitch correlates of English and Japanese politeness formulae. *Language and Speech*, 24(1), 71–89.
- Ma, E., Robertson, J., Radford, C., Vagne, S., El-Halabi, R., & Yiu, E. (2007). Reliability of speaking and maximum voice range measures in screening for dysphonia. *Journal of Voice*, 21(4), 397–406.
- MacAulay, M. (2001). Tough talk: Indirectness and gender in requests for information. *Journal of Pragmatics*, 33(2), 293–316.
- Matai, V., Cheesman, A. D., & Clarke, P. M. (2003). Cricothyroid approximation and thyroid chondroplasty: A patient survey. *Otolaryngology: Head and Neck Surgery*, 128(6), 841–847.
- Matsumoto, A. M., Sandblom, R. E., Schoene, R. B., Lee, K. A., Giblin, E. C., Pierson, D. J., & Bremner, W. J. (1985). Testosterone replacement in hypogonadal men: Effects on obstructive sleep apnoea, respiratory drives, and sleep. *Clinical Endocrinology*, 22, 713–721.
- McNamara, C. (2007). Re-inhabiting an uninhabitable body: Interventions in voice production with transsexual men. *Research in Drama Education*, 12, 195–206.
- McNeill, E. J., Wilson, J. A., Clark, S., & Deakin, J. (2008). Perception of voice in the transgender client. *Journal of Voice*, 22(6), 727–733.
- Mendoza, E., Valencia, N., Munoz, J., & Trujillo, H. (1996). Differences in voice quality between men and women: Use of the long-term average spectrum (LTAS). *Journal of Voice*, 10(1), 59–66.
- Mennen, I., Schaeffler, F., & Docherty, G. (2007). Pitching it differently: A comparison of the pitch ranges of German and English speakers. In *Proceedings of the XVI ICPhS* (pp. 1769–1772). Saarbrücken, Germany: Universität des Saarlandes.
- Mercaitis, P. A., Peaper, R. E., & Schwartz, P. A. (1985). Effect of danazol on vocal pitch: A case study. *Obstetrics and Gynecology*, 65(1), 131–135.
- Mészáros, K., Vitéz L. C., Szabolcs, I., Goth, M., Kovács, L., Görömbei, Z., & Hacki, T. (2005). Efficacy of conservative voice treatment in male-to-female transsexuals. *Folia Phoniatrica et Logopaedica*, 57(2), 111–118.
- Michel, J. F., Hollien, H., & Moore, P. (1966). Speaking fundamental frequency characteristics of 15, 16 and 17 year-old girls. *Language and Speech*, 9, 46–51.
- Miller, M. (2002). *The complete idiot's guide to music theory*. New York, NY: Alpha Books.
- Mondorf, B. (2002). Gender differences in English syntax. *Journal of English Linguistics*, 30, 158–180.
- Moran, M. J., McCloskey, L., & Bady, L. (1995). Listener age estimates of elderly African American and Caucasian male speakers. *Journal of Cross-Cultural Psychology*, 26, 751–758.
- Mordaunt, M. (2012). Group therapy for transgender/transsexual clients. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed., pp. 393–412). San Diego, CA: Plural.
- Morris, R. J., & Brown, W. S. (1994). Age-related differences in speech variability among women. *Journal of Communication Disorders*, 27(1), 49–64.

- Mount, K. H., & Salmon, S. J. (1988). Changing the vocal characteristics of a postoperative transsexual patient: A longitudinal study. *Journal of Communication Disorders, 21*(3), 229–238.
- Murry, T., Brown, W. S., & Morris, R. J. (1995). Patterns of fundamental frequency for three types of voice samples. *Journal of Voice, 9*(3), 282–289.
- Muta, Y. (1994). Cross-cultural and cross-gender speaking fundamental frequency study: Japanese and English. In P. Agbedor, D. Black, P. Hopkins, & M. Warbey (Eds.), *Working papers of the linguistics circle of the University of Victoria* (Vol. 12, pp. 39–47). Victoria, Canada: University of Victoria.
- Natour, Y. S., & Wingate, J. M. (2009). Fundamental frequency characteristics of Jordanian Arabic speakers. *Journal of Voice, 23*, 560–566.
- Neumann, K., & Welzel, C. (2004). The importance of the voice in male-to-female transsexualism. *Journal of Voice, 18*, 153–167.
- Neumann, K., Welzel, C., & Berghaus, A. (2002). Cricothyroidopexy in male-to-female transsexuals—modification of Thyroplasty Type IV. *International Journal of Transgenderism, 6*(3). Retrieved from [http://web.archive.org/web/20070720020846/http://www.symposium.com/ijt/ijtvo06no03\\_03.htm](http://web.archive.org/web/20070720020846/http://www.symposium.com/ijt/ijtvo06no03_03.htm)
- Neumann, K., Welzel, C., Gonnermann, U., & Wolfardt, U. (2002). Satisfaction of MtF transsexuals with operative voice therapy—a questionnaire-based preliminary study. *International Journal of Transgenderism, 6*(4). Retrieved from [http://web.archive.org/web/20070708150509/http://www.symposium.com/ijt/ijtvo06no04\\_02.htm](http://web.archive.org/web/20070708150509/http://www.symposium.com/ijt/ijtvo06no04_02.htm)
- Newman, D., & Forbes, K. (1993). The effects of danazol on vocal parameters—Is an objective prospective study needed?. *Medical Journal of Australia, 19*(8), 575.
- Nishio, M., & Niimi, S. (2008). Changes in speaking fundamental frequency characteristics with aging. *Folia Phoniatrica et Logopaedica, 60*, 120–127.
- Nygren, U. (2014). *Effects of increased levels of androgens on voice and vocal folds in women with congenital adrenal hyperplasia and female-to-male transsexual persons* (Unpublished doctoral dissertation). Karolinska Institutet, Stockholm, Sweden.
- Oates, J. M. (2012). Evidence-based practice in voice therapy for transgender/transsexual clients. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed., pp. 45–68). San Diego, CA: Plural.
- Oates, J. M., & Dacakis, G. (1983). Speech pathology considerations in the management of transsexualism—a review. *British Journal of Disorders of Communication, 18*(3), 139–151.
- Oates, J. M., & Dacakis, G. (1997). Voice change in transsexuals. *Venereology, 10*(3), 178–87.
- Ohala, J. J. (1983). Cross-language use of pitch: An ethological view. *Phonetica, 40*, 1–18.
- Ohara, Y. (1992). Gender-dependent pitch levels: A comparative study in Japanese and English. In K. Hall, M. Bucholtz, & B. Moonwomon (Eds.), *Locating power: Proceedings of the Second Berkeley Women and Language Conference* (pp. 469–477). Berkeley, CA: Berkeley Women and Language Group.
- Orloff, L. A., Mann, A. P., Damrose, J. F., & Goldman, S. N. (2006). Laser-assisted voice adjustment (LAVA) in transsexuals. *Laryngoscope, 116*(4), 655–660.
- Owen, K. (2009). *Comparing self-perceptions to subjective and objective measures of femininity in transgender speakers* (Unpublished master's thesis). George Washington University, Washington, DC.
- Owen, K., & Hancock, A. B. (2010). The role of self- and listener perceptions of femininity in voice therapy. *International Journal of Transgenderism, 12*, 272–284.
- Palmer, D., Dietsch, A., & Searl, J. (2012). Endoscopic and stroboscopic presentation of the larynx in male-to-female transsexual persons. *Journal of Voice, 26*(1), 117–126.
- Papp, V. G. (2011a). *The female-to-male transsexual voice: Physiology vs. performance in production* (Unpublished doctoral dissertation). Rice University, Houston, TX.
- Papp, V. G. (2011b, September). *A large-scale online survey on the vocal satisfaction of FtMs*. Paper presented at the Biennial Conference of the World Professional Association for Transgender Health Symposium (WPATH 2011), Atlanta, GA.
- Papp, V. G., & Townsend, B. (2012, October). *Inhabiting acoustic spaces: The interaction of fundamental frequency and the gender/sexuality divide in female-to-male transsexuals*. Paper presented at the conference New Ways of Analyzing Variation (NWAV 41), Bloomington, IN.
- Park, J. G., Ramar, K., & Olson, E. J. (2011). Updates on definition, consequences, and management of obstructive sleep apnea. *Mayo Clinic Proceedings, 86*, 549–555.
- Pasricha, N., Dacakis, G., & Oates, J. M. (2008). Communicative satisfaction of male-to-female transsexuals. *Logopedics, Phoniatrics, Vocology, 33*(1), 25–34.
- Patterson, R., Smith, D. R. R., Dinther, R., & Walters, T. (2007). Size information in the production and perception of communication sounds. In W. A. Yost, A. N. Popper, & R. R. Fay (Eds.), *Auditory perception of sound sources* (pp. 43–75). New York, NY: Springer.
- Pattie, M. A., Murdoch, B. E., Theodoros, D., & Forbes, K. (1998). Voice changes in women treated for endometriosis and related conditions: The need for comprehensive vocal assessment. *Journal of Voice, 12*, 366–371.
- Perez, K. (2004). *Voice feminization for transgender women*. Retrieved from <http://www.exceptionalvoice.com/home/voice-feminization>

- Pickering, J., & Baker, L. (2012). A historical perspective and review of the literature. In R. K. Adler, S. Hirsch, & M. Mordaunt (Eds.), *Voice and communication therapy for the transgender/transsexual client: A comprehensive clinical guide* (2nd ed., pp. 1–34). San Diego, CA: Plural.
- Pickuth, D., Brandt, S., Neumann, K., Berghaus, A., Spielmann, R. P., & Heywang-Köbrunner, S. H. (2000). Spiral computed tomography before and after cricothyroid approximation. *Clinical Otolaryngology and Allied Sciences*, 25(4), 311–314.
- Podesva, R. J. (2007). Phonation type as a stylistic variable: The use of falsetto in constructing a persona. *Journal of Sociolinguistics*, 11(4), 478–504.
- Podesva, R. J. (2011). Saliency and the social meaning of declarative contours: Three case studies of gay professionals. *Journal of English Linguistics*, 39(3), 233–264.
- Prochaska, J. O., DiClemente, C. C., & Norcross, J. C. (1992). In search of how people change: Applications to addictive behaviors. *American Psychological Association*, 47(9), 1102–1114.
- Ramar, K., & Guilleminault, C. (2007). Risk factors. In C. A. Kushida (Ed.), *Obstructive sleep apnea: Pathophysiology, comorbidities, and consequences* (pp. 197–223). New York, NY: Informa Healthcare.
- Remacle, M., Matar, N., Morsomme, D., Verduyck, I., & Lawson, G. (2011). Glottoplasty for male-to-female transsexualism: Voice results. *Journal of Voice*, 25(1), 120–123.
- Remacle, M., Matar, N., Verduyck, I., & Lawson, G. (2010). Relaxation thyroplasty for mutational falsetto treatment. *Annals of Otolaryngology, Rhinology, and Laryngology*, 119(2), 105–109.
- Robb, M., Gilbert, H., & Lerman, J. (2005). Influence of gender and environmental setting on voice onset time. *Folia Phoniatica et Logopaedica*, 57(3), 125–133.
- Sanchez, K., Oates, J. M., Dacakis, G., & Holmberg, E. B. (2014). Speech and voice range profiles of adults with untrained normal voices: Methodological implications. *Logopedics, Phoniatrics, Vocology*, 39(2), 62–71.
- Sandblom, R. E., Matsumoto, A. M., Schoene, R. B., Lee, K. A., Giblin, E. C., Bremner, W. J., & Pierson, D. J. (1983). Obstructive sleep apnea syndrome induced by testosterone administration. *New England Journal of Medicine*, 308, 508–510.
- Sandhu, G. (2007). Feminisation of the larynx and voice. In J. Barrett (Ed.), *Transsexual and other disorders of gender identity* (pp. 191–197). London, UK: Radcliffe.
- Schneider, B. K., Pickett, C. K., Zwillich, C. W., Weil, J. V., McDermott, M. T., Santen, R. J., . . . White, D. P. (1985). Influence of testosterone on breathing during sleep. *Journal of Applied Physiology*, 61, 618–623.
- Schumann, K., & Ross, M. (2010). Why women apologize more than men: Gender differences in thresholds for perceiving offensive behavior. *Psychological Science*, 21, 1649–1655.
- Shahar, E., Redline, S., Young, T., Boland, L. L., Baldwin, C. M., Nieto, F. J., . . . Robbins, J. A. (2003). Hormone replacement therapy and sleep-disordered breathing. *American Journal of Respiratory and Critical Care Medicine*, 167, 1186–1192.
- Simpson, A. P. (2009). Breathiness differences in male and female speech: Is H1-H2 an appropriate measure? In P. Branderud & H. Traunmüller (Eds.), *Proceedings of FONETIK 2009* (pp. 172–176). Stockholm, Sweden: Department of Linguistics, Stockholm University.
- Smith, D. R. R., & Patterson, R. D. (2005). The interaction of glottal-pulse rate and vocal tract length in judgements of speaker size, sex, and age. *Journal of the Acoustical Society of America*, 118(5), 3177–3186.
- Smith, D. R. R., Patterson, R. D., Turner, R., Kawahara, H., & Irino, T. (2005). The processing and perception of size information in speech sounds. *Journal of the Acoustical Society of America*, 117(1), 305–318.
- Söderpalm, E., Larsson, A., & Almqvist, S.-A. (2004). Evaluation of a consecutive group of transsexual individuals referred for vocal intervention in the west of Sweden. *Logopedics, Phoniatrics, Vocology*, 29(1), 18–30.
- Södersten, M., Hertegard, S., Larsson, H., & Holmberg, E. (2009). Use of ambulatory biofeedback for transsexual male-to-female clients. *Clinical application note: Applications for speech and voice* [Computer software manual]. Montvale, NJ: KayPentax.
- Södersten, M., & Lindestad, P.-A. (1990). Glottal closure and perceived breathiness during phonation in normally speaking subjects. *Journal of Speech and Hearing Research*, 33, 601–611.
- Spencer, L. E. (1988). Speech characteristics of male-to-female transsexuals: A perceptual and acoustic study. *Folia Phoniatica et Logopaedica*, 40(1), 31–42.
- Spiegel, J. H. (2006). Phonosurgery for pitch alteration: Feminization and masculinization of the voice. *Otolaryngologic Clinics of North America*, 39(1), 77–86.
- Stemple, J. C., Lee, L., D'Amico, B., & Pickup, B. (1994). Efficacy of vocal function exercises as a method of improving voice production. *Journal of Voice*, 8(3), 271–278.
- Storck, C., Gehrler, R., Fischer, C., Wolfensberger, M., Honegger, F., Friedrich, G., & Gugatschka, M. (2011). The role of the cricothyroid joint anatomy in cricothyroid approximation surgery. *Journal of Voice*, 25(5), 632–637.
- Sulter, A. M., Wit, H. P., Schutte, H. K., & Miller, D. G. (1994). A structured approach to vocal range profile (phonetogram) analysis. *Journal of Speech and Hearing Research*, 37(5), 1076–1085.
- Thomas, J. P. (2003). *Cricothyroid approximation and laryngeal reduction: Information on risks specific to this pitch altering surgery and reduction of the external appearance of the voice box*. Retrieved from <http://www.voicedoctor.net/surgery/consentform/pitchconsent.html>

- Thomas, J. P., & Macmillan, C. (2013). Feminization laryngoplasty: Assessment of surgical pitch elevation. *European Archives of Otorhinolaryngology*, 270(10), 2695–2700.
- Titze, I. R. (1994). *Principles of voice production*. Englewood Cliffs, NJ: Prentice-Hall.
- Titze, I. R. (2000). *Principles of voice production* (2nd ed.). Iowa City, IA: National Center for Voice and Speech.
- Titze, I. R. (2001). Acoustic interpretation of resonant voice. *Journal of Voice*, 15(4), 519–528.
- Titze, I. R., & Verdolini Abbot, K. (2012). *Vocology: The science and practice of voice habilitation*. Salt Lake City, UT: National Center for Voice and Speech.
- Torre, P., III, & Barlow, J. A. (2009). Age-related changes in acoustic characteristics of adult speech. *Journal of Communication Disorders*, 42, 324–333.
- Townsend, B., & Papp, V. G. (2012, November). *Disclosure and (in)visibility: Acoustic navigation of the gender-sexuality border in Houston trans men*. Paper presented at the Annual Conference of the Anthropological Association of America (AAA), San Francisco, CA.
- Traunmüller, H., & Eriksson, A. (1995). *The frequency range of the voice fundamental in the speech of male and female adults*. Retrieved from <http://www2.ling.su.se/staff/hartmut/>
- Turner, R., & Patterson, R. D. (2003). An analysis of the size information in classical formant data: Peterson and Barney (1952) revisited. *Acoustical Society of Japan*, 33(9), 585–589.
- Ullakonoja, R. (2007). Comparison of pitch range in Finnish (L1) fluency and Russian (L2). In J. Trouvain & W. J. Barry (Eds.), *Proceedings of the 17th International Congress of Phonetic Sciences* (pp. 1701–1704). Saarbrücken, Germany: Universität des Saarlandes.
- Van Bezooijen, R. (1995). Sociocultural aspects of pitch differences between Japanese and Dutch women. *Language and Speech*, 38, 253–265.
- Van Borsel, J., Cuyper, G., de Rubens, R., & Destaeke, B. (2000). Voice problems in female-to-male transsexuals. *International Journal of Language and Communication Disorders*, 35, 427–442.
- Van Borsel, J., Cuyper, G., de, & van den Berghe, H. (2001). Physical appearance and voice in male-to-female transsexuals. *Journal of Voice*, 15, 570–575.
- Van Borsel, J., & De Maesschalck, D. (2008). Speech rate in males, females, and male-to-female transsexuals. *Clinical Linguistics and Phonetics*, 22, 679–685.
- Van Borsel, J., Janssens, J., & de Bodt, M. (2009). Breathiness as a feminine voice characteristic: A perceptual approach. *Journal of Voice*, 23, 291–294.
- Van Borsel, J., Van Eynde, E., Cuyper, G., de, & Bonte, K. (2008). Feminine after cricothyroid approximation? *Journal of Voice*, 22, 379–384.
- Van Mersbergen, M. R., Verdolini, K., & Titze, I. R. (1999). Time-of-day effects on voice range profile performance in young, vocally untrained adult females. *Journal of Voice*, 13(4), 518–528.
- Verdolini-Marston, K., Burke, M. K., Lessac, A., Glaze, L., & Caldwell, E. (1995). Preliminary study of two methods of treatment for laryngeal nodules. *Journal of Voice*, 9(1), 74–85.
- Vgontzas, A., Legro, R. S., Bixler, E., Grayev, A., Chrousos, G. P., & Chrousos, G. P. (2001). Polycystic ovary syndrome is associated with obstructive sleep apnea and daytime sleepiness: Role of insulin resistance. *Journal of Clinical Endocrinology and Metabolism*, 86(2), 517–520.
- Wagner, I., Fugain, C., Monneron-Girard, L., Cordier, B., & Chabolle, F. (2003). Pitch-raising surgery in fourteen male-to-female transsexuals. *Laryngoscope*, 113(7), 1157–1165.
- Wardle, P. G., Whitehead, M. I., & Mills, R. P. (1983). Non-reversible and wide ranging voice changes after treatment with danazol. *British Medical Journal*, 287(1), 946–946.
- Windisch, G., Hammer, G. P., Proding, P. M., Friedrich, G., & Anderhuber, F. (2010). The functional anatomy of the cricothyroid joint. *Surgical and Radiologic Anatomy*, 32(2), 135–139.
- Wolfe, V. I., Ratusnik, D. L., Smith, F. H., & Northrop, G. (1990). Intonation and fundamental frequency in male-to-female transsexuals. *Journal of Speech and Hearing Disorders*, 55(1), 43–50.
- Wollitzer, L. C. (1994). *Acoustic and perceptual cues to gender identification: A study of transsexual voice and speech characteristics* (Unpublished master's thesis). University of British Columbia, Vancouver, BC.
- Yang, C. Y., Palmer, A. D., Murray, K. D., Meltzer, T. R., & Cohen, J. I. (2002). Cricothyroid approximation to elevate vocal pitch in male-to-female transsexuals: Results of surgery. *Annals of Otolaryngology, Rhinology, and Laryngology*, 111, 477–485.
- Young, T., Finn, L., Austin, D., & Peterson, A. (2003). Menopausal status and sleep-disordered breathing in the Wisconsin Sleep Cohort Study. *American Journal of Respiratory and Critical Care Medicine*, 167, 1181–1185.
- Yuasa, I. P. (2008). *Culture and gender of voice pitch: A sociophonetic comparison of the Japanese and Americans*. Sheffield, UK: Equinox.
- Zimman, L. (2010). Female-to-male transsexuals and gaying voices: A pilot study. *Colorado Research in Linguistics*, 22, 1–21.
- Zimman, L. (2012). *Voices in transition: Testosterone, transmasculinity, and the gendered voice among female-to-male transgender people*. (Unpublished doctoral dissertation). University of Colorado, Boulder, CO.
- Zimmerman, G. L., Olsen, C. G., & Bosworth, M. F. (2000). A “stages of change” approach to helping patients change behavior. *American Family Physician*, 61, 1409–1416.