

**VOICE CHARACTERISTICS IN MALE TO FEMALE
TRANSSEXUAL INDIVIDUALS**

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A Dissertation Submitted in Part Fulfilment for the Degree of
Master of Science (Speech-Language Pathology)
University of Mysore, Mysore

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JUNE 2011

CERTIFICATE

This is to certify that this dissertation entitled “*Voice Characteristics in Male to Female Transsexual Individuals*” is the bonafide work submitted in part fulfillment for the degree of Master of Science (Speech - Language Pathology) of the student with Register No. 09SLP002. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

I hereby declare that this dissertation entitled “*Voice Characteristics in Male to Female Transsexual Individuals*” is the result of my own study under the guidance of Ms. K. Yeshoda, Lecturer in Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of Diploma or Degree.

Mysore

June, 2011

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ACKNOWLEDGEMENT

"It is the Lord who goes before you. He will be with you; he will not fail you or forsake you. Do not fear or be dismayed"... (Deuteronomy 31:8)

Thank you Lord Jesus...

I take immense pleasure in thanking, Late. Dr. Vijayalakhmi Basavaraj and Dr. Savithri, for having permitted me to carry out my dissertation.

I wish to express my deep sense of gratitude to my Guide, Ms.K. Yeshoda Lecturer in Speech Sciences, for her valuable support and guidance.

My father gave me the greatest gift anyone could give another person - he believed in me. He believed that you can do this study.

*Acha , You've taught me so much,
I've watched how you live -
how you chase after life,
You inspire me to greater things
Dad you are my inspiration.*

A mother is a person who seeing there are only four pieces of pie for five people, promptly announces she never did care for pie.

Amma , Your arms were always open when I needed a hug. Your heart understood when I needed a friend. Your gentle eyes were stern when I needed a lesson. Your strength and love has guided me and gave me wings to fly.

*My brother, Deepuatten who always have a clear vision about his life.
Dee...you are the one who inspired me to stand out of the crowd and make
my own way in life.*

*My little sister Munni, you are the most adorable person in my life. Even
though you give strong and bold advices to me you will still remain a baby in
my eyes. Love you a lot.*

*My words won't be enough to thank Maamen, Babupappen, Athechy,
Ushaaunty and my lovely cousins...you guys rock!!!*

*My heartfelt gratitude to my church family. Special thanks to pastor Philip
and kerena, Charle's uncle and family for their prayers.*

*A true friend is someone who is willing to share his or her JMF with
you. Time shared together has always been important for me, as time is
something no one can ever buy nor take back. The moment a person shared
his or her time with you, he or she had already shared a part of his life with
you. I thank all my friends for spending their valuable time with me ...let
that be from 1 minute to 10 years...thank you Anj, Sarath, Maria, Merlin,
Anjali, Sandeep, Leeba, Jijo, Pinky,*

Joel, Brighty, Wishly,

*Gargi, Babi, Swapnaj, Sangu, Keerthi, Jeff, Kavi, AkashPriya, Mercy, Giten,
Riny, Kathi*

and many more...

Special thanks to Wishly. You are a wonderful friend. God bless you.

My sincere thanks to my auto uncle Vinod who was always available.

*A special note of thanks to all my subjects. Thank you for your support and
cooperation.*

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APPENDIX: 1. Questionnaire

**ALL INDIA INSTITUTE OF SPEECH AND HEARING
NAIMISHAM CAMPUS, MANASAGANGOTRI, MYSORE-570006**

The purpose of the study is explained to me and I _____ is willing to participate for the study entitled “voice characteristics in male to female transsexuals” as a subject.

Signature of the subject

QUESTIONNAIRE

Name

Age

Treatment: medical/non medical/others

Medical: Surgery/ Hormonal therapy (age/any complications, any medication after surgery/details on the counselling done by the surgeon).

Non medical: Psychological/Voice therapy/Counselling

Habits: Smoking:

Alcohol:

Education:

A) Occupation:

- How long do you use your voice?

- Do you have any ear infection and ear problem?
- Do you have any upper respiratory tract infection?
- Do you frequently clear your throat?

B) Life style:

- Do you indulge in lecturing, chanting, announcements, singing or cheering?
- Are you staying in dusty and noisy environment?
- Do you indulge in continuous long chat?
- Do you eat spicy and hot food frequently?

C) Vocal habits:

- Do you engage in loud speaking, screaming or shouting, practice any vocal activities/tasks or indulge in frequent throat clearing?

D) Symptoms exhibited:

- Does your voice tire very soon?
- Do you perceive roughness in voice?
- Pain, soreness/irritation or lump in throat?
- Do you use any solutions, salt water, mint etc to relieve your throat?
- Do you feel better voice in the morning or evening?
- Do you find difficulty in raising the voice?

- Do you experience any voice breaks/loss of voice during speaking?
- Did you undergo any operations like thyroidectomy, adenoidectomy, tonsillectomy and others?
- Any voice change after operation?
- Do you experience dryness in the throat?
- Are you allergic to AC, dust or medicines?
- Do you feel that your voice is influenced by any of the medical problems like diabetes, high blood pressure and others or subsequent medication?
- Do you suffer from anxiety, mental tension or stress?

E) Pre operative voice quality:

- Did you try to change your voice: self/ professional help?

F) Post operative voice quality:

- Have you ever felt that your voice is inappropriate for your gender?
- Did you consult any medical or non medical professional for the same?
- Did you undergo any treatment for voice change?
- Have you tried voluntarily changing your voice?
- Did you experience any voice change after transsexual surgery or hormonal therapy?
- Have you tried imitating any of your female friend's voice?

APPENDIX: 2. Perceptual rating scale

1-Very feminine,

2-feminine with slight low pitch,

3-unsure,

4-masculine with slight high pitch,

5- very masculine.

INTRODUCTION

Voice is a multidimensional series of measurable events. It is defined as a laryngeal modulation of the pulmonary air stream, which is then further modified by the configuration of the vocal tract (Brackett, 1971). It is our primary means of expression. Throughout life voice continues to change, reflecting our culture, personal habits, condition of health and age.

The sex of the speaker is often detected from his first “Good morning” on the telephone. Voice is a sign and secondary sexual “characteristic” and is influenced by sexual hormones. Sex hormones estrogens, progesterone and androgen are molecules, based on an 18 carbon atom, steroid framework. Sometimes it is hard to understand exactly what is meant by the term "sex", and how it differs from the closely related term "gender". "Sex" refers to the biological and physiological characteristics that define men and women. "Gender "refers to the socially constructed roles, behaviours, activities, and attributes that a given society considers appropriate for men and women.

To put it in another way, "male" and "female" are sex categories, while "masculine" and "feminine" are gender categories. Male and female are biologically assigned categories based on chromosomal patterns and genitalia at birth. Masculinity and femininity are gender terms that attempt to address prevalent behavioural expectations and conventions within a society (Andrews, 1999). Sexual preference or orientation is still another construct that is not necessarily aligned with an individual’s biological characteristics or gender expression (Money, 1988).

When one's psychological gender does not match one's anatomical gender or when there arises a conflict between the psychology and anatomy with respect to gender in the individual, this leads to gender dysphoria. Gender dysphoria is a term that connotes discomfort with one's socially and culturally assigned gender role. Dysphoria is derived from a Greek word meaning "hard to bear" (Brown & Rounsle, 1996).

Gender dysphoria or gender identity disorder is a broad term to include individuals who face conflicts with regard to their sexuality or gender. Some individuals believe there may be three different continua, and an individual may be at different points along each continuum. Either ends of the continuum are occupied by adult males and females or the gender dysphonic individuals fall in between. Gender dysphoria is sometimes used as a synonym for transsexualism because it refers to the discomfort and distress that transsexuals experience. Gender dysphonic individuals are commonly called as transsexual individuals. A "Transsexual" is a person whose external genital anatomy has been changed to resemble that of the opposite sex. There can be two types of transsexuals i.e. female to male transsexuals (FTM) and male to female transsexuals (MTF). Female to male transsexual (FTM) is a person seeking transition from their birth female gender to the male gender. Male to female (MTF) is a person seeking transition from their birth male gender to the female gender (King, Lindstedt, Jensen & Law, 1999). In some instances, a transsexual is referred to as transgender. This distinction is based on the method of treatment adopted for changing the biological sex. A gender dysphonic individual is considered transsexual (TS) if the treatment method for sex change is medical and transgender (TG) if it is non medical methods. However the use of these terms is not strictly followed and transsexual is more commonly used.

The diagnosis of Transsexualism was included in the DSM-III in 1980 for gender dysphonic individuals who demonstrated at least two years of continuous interest in transforming the sex of their bodies and their social gender status. Others with gender dysphoria could be diagnosed as Gender Identity Disorder of Adolescence or Adulthood, Non transsexual Type; or Gender Identity Disorder Not Otherwise Specified (GIDNOS). All these terms are used synonymously but still there exist differences between these varieties.

International Classification of Diseases 10 (ICD-10) by the World Health Organization defines transsexualism as, "the desire to live and be accepted as a member of the opposite sex, usually accompanied by the wish to make his or her body as congruent as possible with the preferred sex through surgery and hormonal treatment".

According to ICD 10, Transsexualism (F64.0) has three criteria for its diagnosis,

1). The desire to live and be accepted as a member of the opposite sex, usually accompanied by the wish to make his or her body as congruent as possible with the preferred sex through surgery and hormone treatment. 2).The transsexual identity has been present persistently for at least two years. 3).The disorder is not a symptom of another mental disorder or a chromosomal abnormality.

A transsexual's conviction frequently establishes itself early in childhood and usually before puberty. The majority of transsexuals seeking medical help are males (Gelder, Gath & Mayou, 1983). The rehabilitation would be generally in the following lines:

- Psychotherapy: A gender dysphonic individual seeking sex change is usually referred to psychologist/psychiatric for detailed counselling.
- Information gathering: The clinician gathers information from a confirmed transsexual, who has completed at least three months of psychotherapy.

- Hormonal therapy: The administration of androgen hormones to female to male transsexuals and estrogen hormones to male to female transsexuals is succeeded by electrolysis of facial and body hair and is generally done by a hormonal therapist.
- Real life test: The transsexual has to undergo one or two year of cross dressing and partial hormonal therapy, where he/she has to live socially as the opposite sex.
- Surgery: There is a final psychological evaluation done before surgery. Orchidectomy for male to female and Mastectomy and Hysterectomy for female to male is performed. Post operative care or follow up are done every three months at least for a year.
- Post operative psychotherapy: A trained psychotherapist trained specifically in the area of gender dysphoria issues will treat transsexuals for personality issues. The process clearly involves coming to terms with how the client perceives herself/himself.
- Cross-dressing and cross-living: The client may be in the early stages of dressing in the world as the desired gender, perhaps on weekends, or may be presenting to the world as female or male full time. Sometimes, it is necessary in some personal roles (e.g., parent, work) to continue as male for a time, but the ultimate goal of most transsexuals is to be living as a woman or man all the time. This represents living in wholeness, integration, and honesty, because the person is no longer living a lie.
- Beginning electrolysis: The introduction of electrolysis is necessary because it is the only way to remove facial and body hair permanently, especially in male

to female transsexuals. It is a long, expensive, and uncomfortable process, depending on the amount of facial and body hair to be removed.

- Post surgery hormone therapy: Transsexual clients usually undergo hormonal treatment from an endocrinologist or other physician, who prescribes and monitors the dosages. The use of estrogen and progesterone with MTF transsexuals results in some development of breast and changes in the distribution of body fat. Sometimes, breast implants are obtained. Hormone therapy, however, does not change bone structure, so such features as large hands or shoulders may remain as a body image issue for some clients. Significant mood changes occur with the use of estrogen, not unlike the experiences and variations reported by biological females.
- Plastic surgery for cosmetic changes: Some clients undergo cosmetic surgery to reduce the masculine thyroid cartilage prominence. Others have facial reconstruction to change the contours of the forehead, cheekbones, and mandible in order to obtain more feminine facial structure.
- Phonosurgery: In some instances, the client may seek phonosurgery, to increase or decrease the mass, tension of the vocal folds to modify their voice.
- Voice therapy: Many clients seek the services of a speech-language pathologist because they dislike sounding masculine and they seek some direction in changing their voices to sound more feminine. Often, the client's expectations and assumption of stereotypical "feminine" characteristics of voice and speech must be carefully explored.

The rehabilitation of FTM is considerably less challenging when compared to the rehabilitation of MTF transsexual individuals, at least, from the voice and speech

aspects. Female to male transsexuals usually undergo androgen treatment which aids in physical changes similar to males i.e. appearance of beard, moustache, body hairs, changes in mucosa including vocal folds. With these changes considerable change in voice also take place. Males are not significantly affected by the estrogen which is administered. The obvious disorder of the voice that the speaker feels is the persisting male voice which does not fit the sound of the persona and image he or she is presenting to the world. But it is now well recognized by the medical team working with these clients that successful adjustment and transition into a new sex role needs a total approach, and that voice therapy is generally a very important element in successful rehabilitation. Therefore, speech and language therapists working in the area of adult issues work may very well find themselves being asked to help people in this client group. Consequently they should be aware of the medical process/procedures involved when sexual reassignment is considered, be conversant with the transsexual condition and the rehabilitation ramifications that this type entails.

Speech pathologists will be consulted primarily by male to female transsexual who wishes to learn feminine speech and voice patterns. It is widely acknowledged that female to male clients will have the advantage, compared to male to female, of the effects of hormone therapy to lower their vocal pitch which brings about considerable maleness to their voice. Damste (1967) reported that administration of androgen lowers the vocal pitch, hence the role of a speech and language pathologist is limited for female to male transsexual management but they play a significant role in rehabilitating male to female transsexuals by helping them alter their speech characteristics and pitch level to the desired gender. As the structures and conditions of the vocal tract for male to female transsexual matches only with biological males, even treatment with

feminizing hormones that bring about the development of other female characteristics would not help to develop feminine pitch level. Hence, the challenges for the speech language pathologist in treating the MTF could be multifold. First and foremost the vocal pitch, then voice quality and later prosodic features have to be modified to suit an adult female. This involves a carefully known voice management protocol to suit individual clients.

In 1983, Oates and Dacakis put forward the first general framework for voice therapy with transsexual individuals. This framework recommended that voice therapy should focus on changing fundamental frequency characteristics, in addition to speech features such as prosody, intensity, voice quality and resonance should also be considered to develop communication skills consistent with the client's desired gender.

Communication training for transsexuals focuses on articulation of speech sounds, vocabulary and conversational style as these aspects are different for males and females. Coerts, De Bruin and Greven (2000) suggested that the general goal of intervention would be to work on the adaptation of voice behaviour to the female gender role, taking into account, the build and character of the patient. The authors suggested certain aspects to be worked on like discriminating male and female voice, identifying the patient's own natural voice, minimizing chest resonance, stimulating a more lively intonation pattern, working on the use of gestures supporting speech which guides for lightness, delicacy and femininity, stimulation of light, delicate articulation which includes auditory discrimination, oral motor exercises, adapting intensity of speech to the female gender role, adapting speech rate and feminizing laughing and coughing so as to be recognised as a female gender. Hence speech and language

characteristics also need to be modified along with voice characteristics so that the individual will be better accepted as the opposite sex. Transsexual individuals face many psychological issues including social isolation, shame, fear, guilt, unemployment, non acceptance by family, depression etc. These issues may lead to use of inappropriate manners such as whispering, husky voice, throat clearing, soft voice, excessive crying or use of loud voice, excess use of voice leading to vocal misuse and abuse. If these habits are followed prior to the consult with speech language pathologist, then again management may be difficult. Presence of laryngeal lesions such as nodules, polyps, inflammation due to vocal misuse/abuse may confound the management further. It is important to ascertain the characteristics of voice in this group of clients prior to the initiation of management.

Most research focus on the rehabilitation of voice/speech characteristics of such clients with minimum information available on the actual characteristics of their voice. Hence it would be important to understand the differences in voice of male to female transsexual in comparison to adult female and male. The present study was planned to inquire in to the nature of voice in male to female transsexual individuals as compared to adult females and males.

NEED OF THE STUDY

Most studies focus on vocal tract and modifying the fundamental frequency and few other parameters of voice for bringing about change in the voice of male to female transsexual individuals. Very few studies are available wherein the characteristics of male to female transsexual individuals' voice have been studied. Hence the present study was planned to investigate into the nature of male to female (MTF) transsexuals'

voice, specifically to understand the acoustic characteristics of the voice of male to female (MTF) transsexuals.

Implications

The findings of the study would help in

- devising protocols for counselling, assessment and management of voice and speech problems in this group of clients.

REVIEW OF LITERATURE

“Males” and “Females” are biological categories with membership assigned on the basis of criteria such as chromosomal pattern and genitalia. Masculinity and Femininity are “gender forms”- descriptive of qualities and characteristics. The term ‘transsexual’ was coined by an American psychiatrist, Harry Benjamin in 1966. Charlotte Wolff (1977) defined transsexuals as” people who believe that their mind is trapped in the wrong-sex body”.

True transsexualism is distinct from homosexual, cross dressing, feministic or exhibitionistic nature of transsexual individual. It is a problem of gender identification, where the individual is firmly convinced that his or her psychological gender is opposite to the biological gender. As quoted by Benjamin in 1996, “transsexual has a strong desire to physically resemble the opposite sex and wishes to be accepted by the society as belonging to that sex. This condition is considerably overlapped with transvestite group who has only intermittent desire to see himself as a woman and wishes to preserve his male heterosexuality and vice versa.”

Transsexual individual are sometimes referred to as “assigned to target” gender terms such as “female to male “ for a transsexual man and “male to female “ for a transsexual woman. These terms are mainly used to prevent confusion. Transsexual people, like other people can be bisexual or homosexual.

Etiology

The etiology of transsexualism is unclear, abnormality in chromosomal or gonadal sex, hormonal function, internal and external genital morphology are reported as not being the evident causes. However, subtle organic dysfunction possibly related

to prenatal endocrine influences on the developing thalamus, is considered viable by some authors (Baker & Stoller 1968; Schapira, Davison & Brierley 1979). According to Brierley (1972), transsexualism is caused by faulty gender learning mechanism occurring in early childhood. These learning mechanism includes parental indifferences to or encouragement of cross dress behaviours, excessive attention to the opposite parent and absence of physical and emotional contact with the same sex parent. There is no distinct pattern of environment or psychological factors to explain the cause of gender problems in the transsexual individual (Brierley, 1979). The debate on etiology derives from confusion concerning the concept of gender, gender roles, relationship between gender identity, along with psychological and biological variables remaining ill defined (Friemuth & Hornstein, 1982).

Diagnosis

Transsexualism appears in the two major diagnostic manuals used by mental health professionals worldwide, the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM, 1994, currently in its fourth edition) and the International Statistical Classification of Diseases and Related Health Problems (ICD, 1996, Xth edition). The ICD-X includes transsexualism, dual role transvestism and gender identity disorder of childhood into its gender identity disorder category, and defines" transsexualism as desire to live and be accepted as a member of the opposite sex.

According to DSM (1994), diagnosis of transsexual individual requires four components:

- A desire or insistence that one is of the opposite biological sex (that is not due to a perceived advantage of being the other sex).

- Evidence of persistent discomfort with, and perceived inappropriateness of the individual's biological sex.
- The individual is not intersex (although a diagnosis of Gender identification disorder Not Otherwise Specified is available, which enables intersex people who reject their sex-assignment to access transsexual treatments).
- Evidence of clinically significant distress or impairment in work or social life.

Prevalence

The DSM-IV (1994) quotes a prevalence of roughly 1 in 30,000 assigned males and 1 in 100,000 assigned females seek sex reassignment surgery in the USA. The most reliable estimate of prevalence is from the Amsterdam Gender Dysphoria Clinic in the Netherland, the data spanning more than four decades in which the clinic has treated roughly 95% of Dutch transsexuals, which gives figures of 1:10,000 assigned males and 1:30,000 assigned females. Olyslager and Conway (2007) reported that the data from their own and other studies actually imply much higher prevalence, with minimum lower bounds of 1:4,500 male-to-female transsexuals and 1:8,000 female-to-male transsexuals for a number of countries worldwide. They suggest the prevalence might be as high as 1:500 births overall.

In India, though official reports on the prevalence of transsexual individual are lacking, there seems to be a higher incidence of such individuals in the recent past, owing to social tolerance.

Management

The rehabilitation of transsexual individuals is a team effort involving psychiatric /psychologist, endocrinologist, plastic surgeon, phonosurgeon, speech language pathologist and constitutes stages of rehabilitation involving each of these professionals. This will be followed by voice therapy and counselling.

Various authors have reported specific laryngeal procedure to increase pitch. Isshiki (1976) proposed cricothyroid approximation where the sutures for the cricothyroid approximation need to be tied very tightly to maintain high pitch. This helps in increased tension in the vocal folds which leads to the increase in vocal pitch. As reported the voice of the patient would be quite breathy or aphonic for one week to one month, and then gradually becomes near normal.

Saito and Kokawa (1977) introduced longitudinal incision of the vocal cords to reduce the activity of thyroarytenoid muscle by partial section which would then raise the pitch, since it works antagonistically against the cricothyroid muscle in terms of the pitch control.

Ishikki (1980) stated that it was not easy to achieve an elevated vocal pitch in transsexuals due to an increased mass of the vocal folds and it was difficult to reduce without touching them. Laryngeal framework surgery may alter the tension of the vocal fold but not the mass. If the low pitch was due to a lax vocal fold, due to paralysis of the cricothyroid muscle, it could be raised quite effectively by surgery that stretches the vocal fold, such as cricothyroid approximation, anterior shift of the anterior commissure or antero-posterior lengthening of thyroid ala. He suggested this as the treatment of choice for excessively low pitch, where in a combination of cricothyroid

approximation with the intrachordal injection of corticosteroid triamcinolone, would help in increasing the pitch of voice.

Gross (1999) conducted a study on pitch raising surgery in male to female transsexuals which revealed an increase in spontaneous fundamental frequency. Brown, Perry, Cheesman and Pring (2000), studied the voices of 14 male to female transsexuals who had undergone cricothyroid approximation to find whether surgery increased pitch, and whether the increased pitch made the voice to be perceived as female. All of his 14 subjects had undergone hormonal therapy. The surgical procedure used for the laryngeal framework operation was similar to Isshiki's type IV thyroplasty and all the surgeries were conducted by the same surgeon. The task given to the subjects were reading, counting and recitation (days of the week). Recording was done two weeks before and after surgery. Results revealed that the mean pitch was unchanged after surgery but the modal or most frequently used pitch increased significantly. This was seen in all subjects except two whose modal frequency varied considerably. There was a strong positive correlation between modal pitch and the number of listeners perceiving the voice as female. It was also found that the midpoint of judgement was at 173Hz, considered as dividing voices perceived as male and female.

Bralle, Bull, Gore and Edgerton (1978), conducted an experiment on a 49 year old male to female transsexual who had undergone hormonal treatment for 18 months and then underwent sex reassignment surgery. The primary goal of the experiment was to achieve an alteration of voice to a more feminine quality with regard to the increase in the habitual pitch and the secondary goal was to increase the client's effective pitch range. The subject was given seven hour long-therapy session. A perceptual study was also conducted with fifteen listeners who rated the masculinity or femininity of conversational speech samples from 3 male control subjects, 3 female controlled

subjects, and pre and post therapy samples from the transgendered subject. The post therapy results of perceptual study revealed that, on a 7 point masculinity-femininity rating scale, (with 1 representing a very masculine voice and 7 representing very feminine voice), the client improved from a rating of 3.7 pre therapy to 4.6 post therapy. The post therapy results of objective analysis indicated that the median fundamental frequency employed during conversational speech increased from 145Hz (pre treatment base line measure) to 165 Hz. The frequency range employed during the conversation speech also increased from 30 Hz during the initial evaluation session to 70 Hz during the last session. The objective analysis and the perceptual evaluation revealed that the client's voice had become more feminine after the treatment but still was clearly discriminable from the actual female voice. The result suggested that there was significant positive correlation between objective and perceptual evaluation.

Mount and Salmon (1988) conducted a study on a 63 year old transsexual who had undergone sex reassignment surgery to raise the speaking fundamental frequency. They aimed at increasing speaking fundamental frequency and formant frequency specifically at the level of F2 in vowels, by altering the tongue placement. The time period for therapy was 88 hours sessions over 11 month period. The progress seen in the subject was an increased speaking fundamental frequency from 110 Hz to 210 Hz in prolonged vowels and F2 values for |i|, |a| and |u| also increased. Though the subject achieved optimal speaking fundamental frequency as reported by the authors but according to the subject's report, she was still perceived as a male over the phone.

Spencer (1988) conducted a study on 8 transgendered speakers who were all receiving hormone treatment and were living either part or full time as females. Author reported that all the subjects were perceptually attempting to use female speech patterns and not all subjects had completed sex reassignment surgery. Perceptual evaluation

focussing on degree of masculinity and femininity and objective evaluation to obtain speaking fundamental frequency (SFF) were also done. The speech sample provided was the first 2 sentences of rainbow passage. Results indicated that 4 of the 8 transgendered subjects were perceived as female with 70% or better accuracy by the listeners. However, of those 4 subjects, 3 received low femininity ratings, lower than any of the female control subjects and the fourth received a rating only slightly above the lowest rated female control subjects. The range of SFFs in the female perceived group appeared to be 165-209Hz.

Coleman (1976) conducted a study on 40 male to female transsexuals to find their fundamental frequency and judgements of degree of maleness or femaleness. The results revealed that perception of the speaker's sex was primarily on the fundamental frequency and that vocal tract resonance has little or nothing to contribute for such perception. Again in 1983, Coleman studied the acoustic correlates of speaker's sex identification and its implication for transsexuals voice. He, in his study mentioned that fundamental frequency alone does not identify speaker's sex, but vocal tract resonance also. According to him, the perception of the vocal fundamental as the cue to the sex of the speaker was weakened by the presence of vocal tract resonance associated with the other sex. He indicated that the female vocal fundamental modulated by a male vocal tract could be expected to attain a degree of male quality since the dimensions of the vocal tract are fixed. He therefore, recommended that the persons contemplating a male to female sex change be informed that they may be unable to completely eliminate male quality from their voice.

Kalra (1991), in a study on a 32 year old male to female transsexual found that the fundamental frequency increased from 150 Hz to 200 Hz after four months of

weekly voice therapy. There were no reports as to whether the subject's voice was identified as female after voice therapy.

The success of voice therapy in instilling a new voice that suits the new sex and gender with pitch modification alone in male to female transsexuals is limited as they are still perceived as males. In this regard, a few authors have attempted to explain what other factors need to be considered for a successful change in voice quality.

Andrews and Schmidt (1997) examined conducted a study on 11 cross-dressers. which did not reveal marked differences between the speaking fundamental frequencies in two modes i.e. male mode and females' mode and study revealed SFF averaged as 119HZ and 135HZ respectively.

Gelfer and Schofield (2000) did a comparison of acoustic and perceptual measures of voice in male to female transsexuals perceived as female versus those perceived as male. The results indicated that subjects perceived as females had a higher mean speaking fundamental frequency (SFF) and a higher upper limit of speaking fundamental frequency than subjects perceived as male. A significant correlation between upper limit of SFF and ratings of femininity was achieved.

Wolf, Ratusnik, Smith and Northrop (2000) conducted a study on twenty male to female transsexuals and recorded their responses based on the question asked on their home and work. The voice samples were randomized with ten biological males and ten biological females. Listeners were asked to judge the gender of the individual and also to rate the feminity of the voice based on seven point rating scale where 1 represents extremely feminine voice and 7 represents extremely masculine voice. The study revealed a mean speaking fundamental frequency of 172 Hz for the group of transgendered individuals perceived as female, with speaking fundamental frequency

ranging from 156 Hz to 195Hz. The authors also reported that the female perceived group had more vocal variability (in terms of upward and downward inflections).

Characteristics of the voice in transsexual

In general the research findings suggest that the speech language pathologist's clinical expertise with transsexuals are limited by three factors. Firstly, the clinician should be well aware of the differences between male and female speech which could be due to social division such as ethnic and occupation background (Smith, 1979). Secondly, a particular sex marker may be relevant only for a specific sub group of the population. Thirdly, the clinician should be cognisant of the data which demonstrates that the speech characteristics vary according to the external factors such as the sex of the listener (Aries, 1976). This potential confounding variable has not been considered in many investigations of sex markers in speech (Smith, 1979).

Many clients seek the services of a speech-language pathologist because they dislike sounding masculine and they seek some direction in changing their voices to sound more feminine. Often, the client's expectations and assumption of stereotypical "feminine" characteristics of voice and speech must be carefully explored and ascertained prior to the commencement of voice therapy.

Vanborsel (2001) explored the interaction between physical appearance and voice and they hypothesised that if the voice of the transsexual could betray biological gender, femininity would be judged higher in visual only presentation.

McNeill, Wilson, Clark and Deakin (2008) conducted a study on twelve male to female transsexuals who were asked to complete visual analogue scale, rating happiness with self perceived femininity of their voice. Fifteen speech language pathologist and

forty naive observers evaluated the anonymized recording, using the same rating system. The study demonstrates that happiness with the voice in male to female transgender client is not related to F0. Hence it is important to identify the other vocal parameters that contribute to the perception of the sex.

Wiltshire (1995) stated that the fundamental frequency is not the only vocal cue to sex identity. She mentioned that segmental features such as articulation, syntactic and lexical and the communicative skills also should be considered along with variables which include the vocal tract resonance, intonation and voice quality.

Colton and Casper (1996) reported that stress pattern timing, resonance, choice and use of lexical items and conversational styles also need to be changed along with fundamental frequency so as to be perceived as female. Hence therapy goals should focus on change in overall image rather than artificial changes, such as pitch changes which may cause laryngeal problems. They suggested strategies like slight increase in breathiness of voice, a production of lighter and softer voice which may be achieved by reducing vocal effort, increased use of pitch variability rather than loudness to mark inflection, stress and alter rhythm of speech, target non phonatory areas, such as conversational topics, conversational style and pragmatic aspects of communication.

Dacakis (1983) reported that the initial phase of management involves a comprehensive baseline assessment of the transsexual's vocal characteristics. Baseline voice data can be gathered from a variety of communicative tasks and ideally from a range of environments including naturalistic situations outside the clinic. Both instrumental and perceptual measures of pitch, loudness, voice quality, resonance and intonation parameters are required. The baseline data are then compared with research

data concerning gender differences in voice so that valid voice training targets can be selected for successful voice change.

Modification of voice of transsexuals typically progresses from production of isolated vowels and monosyllabic words, through phrases and sentences, reading passage, prose and poetry which encourage intonation variability to conversational speech. Once the transsexual has achieved new voice in conversational speech then generalisation needs to be focussed.

The success of voice therapy in case of male to female individual is limited. It has been reported in literature that the male to female transsexual individuals could not achieve a voice that was perceived as feminine, even after considerable surgical and therapeutic measures were taken for modifying the vocal pitch. This necessitates the need to understand, further the voice and speech characteristic of the transsexuals for providing a voice and speech that suits their new sex and gender.

The present study was planned in this regard, to understand the characteristics of the transsexual voice and also to find the extent of variation from adult females and males.

AIMS OF THE STUDY

- To investigate the voice characteristics of male to female transsexuals and compare the acoustic characteristics across the subgroups of transsexuals
- To compare the acoustic characteristics of MTF transsexuals with adult male and females
- To ascertain the degree of femininity in the voice of MTF transsexuals.

METHOD

SUBJECTS

The subjects comprised of two groups, speakers and the listeners.

Speakers

Control group: 20 normal individuals in the age range of 20-40 years mean age of 25 years (equal number of females and males) with no history of any health, speech, language and hearing problems will formed the control group.

Experimental group: 20 male to female transsexual individuals (MTF) in the age range of 20-40 years, with the mean of 26.35 years participated in the study. These subjects were contacted and recruited from a local transsexual support group. Ten of these subjects had completed their sex reassignment surgery and were living as women full time and they were termed as transsexual (TS). The remaining 10 had not yet undergone their surgeries but still living as women and were referred to as transgender (TG). Hence the experimental group had two sub groups-TS and TG. These subjects had undergone either surgical /non medical treatment for male to female (MTF) transition under professional supervision. The purpose of the study was explained to all subjects and written consent was taken from each subject before their inclusion in the study.

All the participants in this group filled the questionnaire (Appendix 1) devised for the purpose of the study. The questionnaire contained demographic details and questions addressed issues related to their lifestyle, social and family acceptance and medical and non-medical treatment for MTF transition.

Listeners

Five speech language pathologists in the age range of 35-55years with clinical experience of minimum of 5 years were chosen as participants for the perceptual experiments.

Procedure

Task

- 1.) Phonation: Sustained phonation of vowel /a/ at comfortable pitch and loudness for a duration of about 5 seconds.
- 2.) Spontaneous speech: On topic “self” for about 2 minutes.

Recording of speech sample

The subjects were seated comfortably and recording was carried out in a quiet environment individually. The phonation and the speech sample were recorded on to the Olympus digital recorder WS100. The microphone was positioned at a distance of about 5 inches from the speaker’s mouth during the recording.

Instructions: Each speaker subject was instructed to wear the Olympus digital recorder around the neck and was instructed to take a deep breath and phonate vowel /a/ at their comfortable pitch and loudness level in a single breath. Then they were instructed to speak continuously for about two minutes about self.

Perceptual experiment

Material: A 30 second sample was drawn from the spontaneous speech spoken by the experimental group sample was used as material for the perceptual experiment.

Instruction: Each listener was instructed to listen to the speech samples of the subjects in the experimental group and rate the speech for the degree of femininity perceived.

Analysis

The analysis was carried out in two phase's acoustical and perceptual analysis.

Acoustical analysis: phonation and spontaneous speech samples were converted into wave format (.wav) using Adobe Audition and then line fed into the external module of CSL 4500 using a sampling frequency of 4400Hz. Using Multidimensional Voice Profile (MDVP). 29 voice parameters grouped under the following eight major categories were extracted.

I. Fundamental frequency information measures:

- Fo (Average Fundamental Frequency /Hz/) - For all extracted momentum fundamental frequency values (reciprocal of momentum pitch periods)
- MFo (Mean Fundamental Frequency /Hz/)
- Fhi (Highest Fundamental Frequency /Hz/) - For all extracted pitch periods
- Flo (Lowest Fundamental Frequency /Hz/) - For all extracted pitch periods
- SDF0 (Standard Deviation of the Fundamental Frequency /Hz/) - Within the analyzed voice sample

II. Short and long term frequency perturbation measures

- Jita (Absolute Jitter /usec/) - An evaluation of the period-to-period variability of the pitch period within the analyzed voice sample. Voice break areas are excluded
- Jitt (Jitter Percent /%/) - Relative evaluation of the period-to-period (very short-term) variability of the pitch within the analyzed voice sample. Voice break areas are excluded. RAP,PPQ
- PPQ (Pitch Period Perturbation Quotient /%/) - Relative evaluation of the period-to-period variability of the pitch within the analyzed voice sample with a smoothing factor of 5 periods. Voice break areas are excluded
- SPPQ (Smoothed Pitch Period Perturbation Quotient /%/) - Relative evaluation of the short or long-term variability of the pitch period within the analyzed voice sample at smoothing factor defined by the user. The factory setup for the smoothing factor is 55 periods. Voice break areas are excluded
- RAP (Relative Average Perturbation /%/) - Relative evaluation of the period-to-period variability of the pitch within the analyzed voice sample with smoothing factor of 3 periods. Voice break areas are excluded
- vF0 (Fundamental Frequency Variation /%/) - Relative standard deviation of the period- to-period calculated fundamental frequency. It reflects the very long-term variations of Fo for all analyzed voice samples

III Short and long term amplitude perturbation measures:

- ShdB (Shimmer in dB /dB/) - Evaluation in dB of the period-to-period (very short-term) variability of the peak-to-peak amplitude within the analyzed voice sample. Voice break areas are excluded.
- Shim (Shimmer Percent /%/) - Relative evaluation of the period-to-period (very short-term) variability of the peak-to-peak amplitude within the analyzed voice sample. Voice break areas are excluded.
- sAPQ (Smoothed Amplitude Perturbation Quotient /%/) - Relative evaluation of the short- or long-term variability of the peak-to-peak amplitude within the analyzed voice sample at smoothing factor defined by the user. The factory setup for the smoothing factor is 55 periods (providing relatively long-term variability; the user can change this value as desired). Voice break areas are excluded.
- APQ (Amplitude Perturbation Quotient) /%/ - Relative evaluation of the period-to-period variability of the peak-to-peak amplitude within the analyzed voice sample at smoothing level of 11 periods. Voice break areas are excluded.
- vAm (Peak Amplitude Variation /%/) - Relative standard deviation of the period-to-period calculated peak-to-peak amplitude. It reflects the very long-term amplitude variations within the analyzed voice sample.

IV. Voice breaks related measures

- DVB (Degree of Voice Breaks (%)) - Ratio of the total length of areas representing voice breaks to the time of the complete voice sample.
- NVB (Number of Voice Breaks) - Shows how many times the generated Fo was interrupted from the beginning of the first until the end of the last voiced area.

V. Sub harmonic related measures

- DSH (Degree of Sub-Harmonics (%)) - Estimated relative evaluation of sub-harmonic to F_0 components in the voice sample.
- NSH (Number of Sub-Harmonic Segments) - Found during analysis.

VI. Voice irregularity measures

- DUV (Degree of Voiceless (%)) - Estimated relative evaluation of non harmonic areas (where F_0 cannot be detected) in the voice sample. In case of non sustained phonation from the beginning to the end of the data acquisition, DUV will evaluate also the pauses before, after and/or between the voice sample(s).
- NUV (Number of Unvoiced Segments) - Detected during the autocorrelation analysis
- PER (Pitch Periods) - Detected during the period-to-period pitch extraction.
- PFR (Phonatory Fundamental Frequency Range) - Range between F_{hi} and F_{lo} expressed in number of semi-tones.
- SEG (Total Number of Segments) - Computed during the autocorrelation analysis.
- T_0 (Average Pitch Period /ms/) - For all extracted pitch periods.
- T_{sam} /sec/ - Length of Analyzed Data Sample.

VII. Noise related measures: NHR, VTI and SPI

VIII. Tremor related parameters

- ATRI (Amplitude Tremor Intensity Index (%)) - Average ratio of the amplitude of the most intense low-frequency amplitude modulating component (amplitude tremor) to the total amplitude of the analyzed voice signal.
- Fatr (Amplitude-Tremor Frequency /Hz/) - The frequency of the most intensive low-frequency amplitude-modulating component in the specified amplitude-tremor analysis range. If the corresponding ATRI value is below the specified threshold, the Fatr value is zero.
- Fftr (Fo-Tremor Frequency /Hz/) - The frequency of the most intensive low-frequency Fo-modulating component in the specified Fo-tremor analysis range. If the corresponding FTRI value is below the specified threshold, the Fftr value is zero.
- FTRI (Frequency Tremor Intensity Index (%/)) - Average ratio of the frequency magnitude of the most intensive low-frequency modulating component (Fo-tremor) to the total frequency magnitude of the analyzed voice signal.

The spontaneous speech sample was subjected to Real time pitch (RTP) CSL 4500 analysis and following acoustic parameters were extracted:

- Mean F0(SMF0)
- Minimum F0(SMinF0)
- Maximum F0(SMaxF0)
- Standard deviation F0(SDF0)
- Fundamental frequency variation (vF0) and
- Relative Average Perturbation (SRAP %)

Perceptual Analysis:

Each listener was given a response sheet and was asked to listen to the samples and judge individually. The listeners were asked to rate the degree of femininity on a 5 point rating scale ranging from 1 to 5 where 1 indicated very feminine and 5 indicated very masculine(Appendix.2).

Statistical analysis

The extracted acoustic parameters were analysed using SPSS version 17 for further comparisons.

RESULTS

A total of 40 subjects were divided into control and experimental groups. Each group consisted of 20 subjects. In the control group there were 10 adult male and 10 adult female and in the experimental group there were 10 transgender and 10 transsexual subjects. The present study aimed to,

- Investigate the voice characteristics of male to female transsexuals (MTF) and compare the acoustic characteristics across the subgroups with the experimental group
- To compare the acoustic characteristics of MTF transsexuals with adult male and females
- To ascertain the degree of femininity in the voice of MTF.

SPSS version 17 was used for statistical analysis. Mean and standard deviation was extracted. The raw data was subjected to Paired t-test and one way ANOVA were done.

The results will be discussed under the following headings

- I. Acoustic analysis
- II. Perceptual analysis

Acoustic analysis

The 29 acoustic parameters of voice under eight major categories of MDVP for phonation for the experimental group are tabulated in table 1.

From table 1, it can be seen that the mean values for frequency related parameters were lesser in the transgender (TG) group when compared to the transsexual (TS) group. The mean values for most of the short and long-term perturbation measures were lower for TG group compared to the TS group.

Table 1: Mean, standard deviation and ‘t’ values of acoustic parameters in phonation for the 2 sub-groups in experimental group.

Parameters	TG-Mean	SD	TS-Mean	SD	t- value
Mean F0	128.00	26.16	138.92	37.22	-.75
APP(T0)	8.04	1.40	7.50	1.54	.82
Fhi	154.54	42.05	166.52	35.70	-.68
Flo	107.90	20.15	121.43	43.62	-.89
SDF0	5.65	7.03	6.05	4.18	-.15
Fftr	4.76	1.74	5.37	2.32	-.66
Fatr	3.35	1.70	5.04	2.61	-1.75
Jita	198.60	115.11	199.46	155.36	-.01
Jitt(%)	2.20	1.59	2.94	2.25	-.84
RAP	1.26	.89	1.75	1.36	-.95
PPQ	1.37	1.02	1.85	1.46	-.86
Sppq	2.42	2.23	2.29	1.64	.15
vF0	5.01	4.35	4.78	3.69	.12
ShdB	.85	.53	.91	.73	-.20
Shim	7.72	4.25	9.81	6.67	-.83
APQ	9.13	5.29	7.52	4.86	.70
sAPQ	11.25	6.32	10.25	6.28	.35
vAm	18.65	13.54	19.88	11.24	-.22
NHR	3.01	8.7492	0.19	.07	1.02
VTI	0.08	0.1	.03	.01	1.54
SPI	18.12	11.93	27.52	18.7	-1.34
FTRI	2.13	3.18	1.10	1.16	0.96
ATRI	4.72	2.12	4.38	3.49	0.26
DVB	3.03	6.99	7.44	13.4	-.92
DSH	1.11	3.51	.00	.00	1.00
DUV	19.35	29.51	16.61	28.63	0.21
NVB	0.5	0.84	.8	1.13	-.66
NSH	0.9	2.84	.00	.00	1.00
NUV	7.7	8.09	19.1	31.26	-1.11

But the mean values for the short and long-term amplitude perturbation measures were higher in the TG group compared to the TS group. But the mean values for the remaining parameters varied in both groups. These differences were not statistically significant.

Table 2 depicts the acoustic parameters of speech for the experimental group. Here, it can be noticed that the mean values for the acoustic parameters of speech varied between the two subgroups. The mean SF0, SMinF0 and SRAP were lower in TG when compared to the TS group. Mean SmaxF0, SSDF0 and SvF0 were lower in TS group. However, these differences were not significant.

Table 2: Mean, standard deviation and ‘t’ values of acoustic parameters in speech for the 2 sub-groups in experimental group.

Parameters	TG-Mean	SD	TS-Mean	SD	t-value
SMF0	134.25	18.88	140.11	30.73	-.51
SMinF0	96.21	11.14	110.76	26.16	-1.61
SMaxF0	220.87	67.46	191.7	74.52	.91
SSDF0	33.34	31.09	15.62	8.71	1.73
SvF0	0.16	0.07	0.10	0.04	2.09
SRAP	1.62	0.75	1.9	1.12	-.64

As there were the acoustic parameters in voice and speech were not statistically significant across the two subgroups of the experimental group, the two subgroups were combined and then compared for similarities or differences and the significance of such variations with the control group subjects.

The results are discussed as acoustic parameters of voice (based on the eight major categories of MDVP) and acoustic parameters of speech in the subsequent paragraphs.

I. Acoustic parameters extracted by MDVP CSL 4500 are the shown in the following tables.

Table 3 depicts the fundamental frequency related parameters of phonation for the experimental group and control group. Here it can be noticed that the Mean F0 (Mean=133.4Hz, SD=31.8), high F0 (Mean=160.5Hz, SD=38.4) values were higher for MTF than adult males and when MTF were compared with adult female it was found that mean F0(Mean=225.1Hz, SD=15.7), highF0(Mean=230.9Hz, SD=16.7) and low F0(Mean=216.2,SD=16.3) values were higher for females compared to MTF. SDF0 (Mean=5.8Hz, SD=5.6) value was higher for MTF than adult male and adult female.

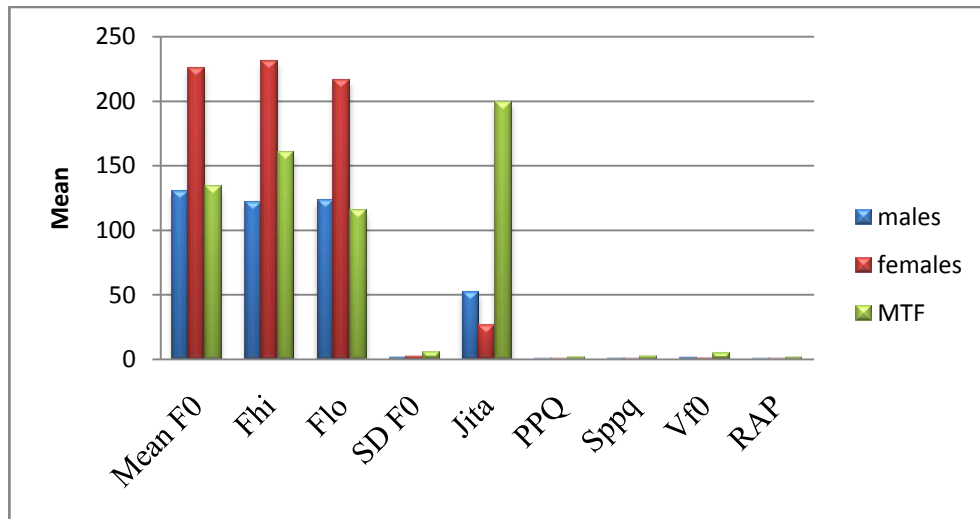
Table 3: Mean, standard deviation and 't' values for the fundamental frequency information measures for experimental and control groups.

	Male		MTF		Female	
	Mean	SD	Mean	SD	Mean	SD
Mean F0	129.7	13.6	133.4	31.8	225.1	15.7
Fhi	122.0	40.2	160.5	38.4	230.9	16.7
Flo	122.9	10.9	114.6	33.8	216.2	16.3
SD F0	1.2	0.3	5.8	5.6	1.8	0.5

Table 4 depicts the frequency perturbation related parameters of phonation for the experimental group and control group. Here it can be noticed that mean and standard deviation values for frequency perturbation parameters i.e. Jita(Mean=199.0msec,SD= 33.0),Jitt%(Mean=2.5,SD=1.9), PPQ%(Mean=1.6,SD=1.2), RAP%(Mean=1.5,SD=1.1), sPPQ%(Mean=2.3,SD=1.9) and vF0%(Mean=4.9,SD=3.9) were higher for MTF than adult males and females.

Table 4. Mean, SD values for frequency perturbation parameters for males, females and transsexual subjects for phonation task.

	Male		MTF		Female	
	Mean	SD	Mean	SD	Mean	SD
Jita	51.9	19.6	199.0	133.0	26.4	8.6
Jitt(%)	0.6	0.2	2.5	1.9	0.6	0.2
PPQ	0.3	0.12	1.6	1.2	0.4	0.2
RAP	0.3	0.16	1.5	1.1	0.3	0.14
sPPQ	0.6	0.12	2.3	1.9	0.3	0.12
vF0	0.9	0.16	4.9	3.9	0.8	0.3

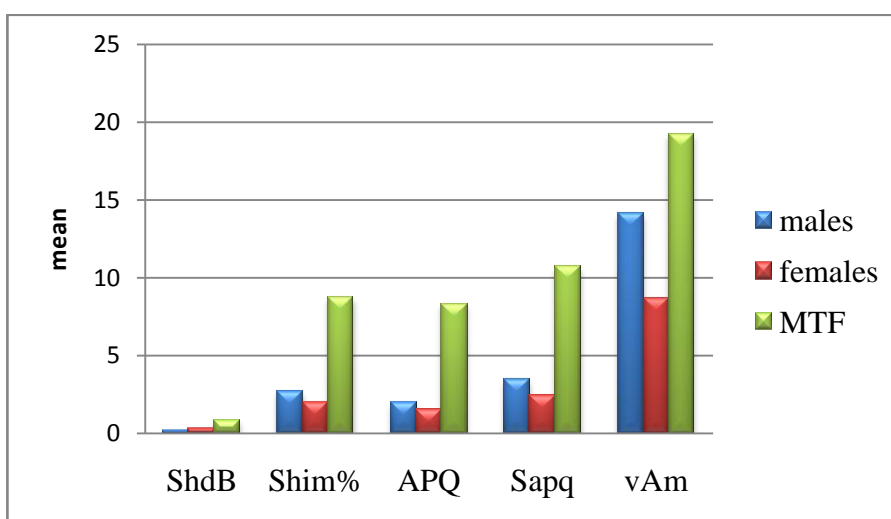


Graph 1. Reveals that mean, high and low F0 is higher for females compared to male and transsexuals. Absolute jitter is significantly higher than for MTF and high F0 value is greater in MTF than males.

Table 5 depicts the short and long term amplitude related perturbation parameters of phonation for the experimental group and control group. Here it can be noticed that MTF had higher score in APQ%(Mean=8.3,SD=5.0), ShdB(Mean=0.6dB,SD=0.5),Shim(Mean=8.7dB,SD=5.5),SAPQ%(Mean=10.7,SD=6.) and vAm%(Mean=19.2,SD=12.1) than adult males and adult female.

Table 5. Mean, SD values for short and long term amplitude related perturbation parameters for males, females and transsexual subjects for phonation task

	Male		MTF		Female	
	Mean	SD	Mean	SD	Mean	SD
APQ	2.0	0.6	8.3	5.0	1.5	0.4
ShdB	0.2	0.07	0.6	0.5	0.3	0.3
Shim	2.7	0.8	8.7	5.5	2.0	0.9
SAPQ	3.4	0.9	10.7	6.1	2.4	0.6
vAm	14.1	7.5	19.2	12.1	8.7	3.7



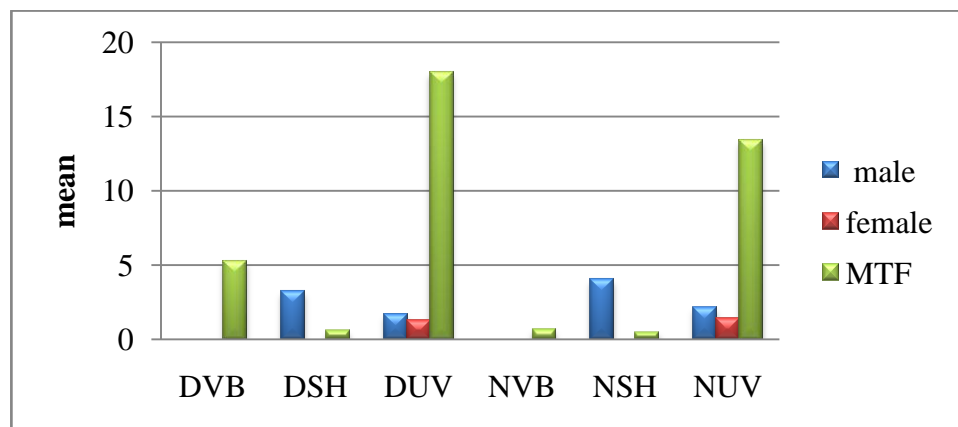
Graph.2 shows that all the short term and long term amplitude perturbation parameters i.e. shimmer, shimmer%, amplitude perturbation quotient and smooth amplitude perturbation quotient are higher in MTF than adult males and adult females.

Table 6 depicts the fundamental frequency related parameters of phonation for the experimental group and control group. Here it can be noticed that the sub harmonic parameters i.e. DSH% (Mean=3.2, SD=10.2) and NSH% (Mean=4, SD=12.6) scores were higher for males than MTF. When MTF were compared with adult females it was found that sub harmonic parameters i.e. DSH% (Mean=0.5, SD=2.4) and NSH% (Mean=0.4, SD=2.0) scores were higher for MTF than adult females. Mean and

standard deviation scores for the parameters under voice breaks i.e. NVB% (Mean=0.6, SD=0.9) and DVB% (Mean=5.2, SD=10.6) and parameters under voice irregularity i.e. NUV and DUV were higher for MTF compared to adult males and adult females.

Table 6. Mean and SD values for males, females and male to female transsexuals for voice irregularity, voice breaks and sub harmonic components for phonation task.

	Male		MTF		Female	
	Mean	SD	Mean	SD	Mean	SD
NUV	2.1	6.6	13.4	22.9	1.4	2.9
DUV	1.6	5.3	17.9	28.3	1.2	2.7
DVB	0	0	5.2	10.6	0	0
NVB	0	0	0.6	0.9	0	0
DSH	3.2	10.2	0.5	2.4	0	0
NSH	4	12.6	0.4	2.0	0	0

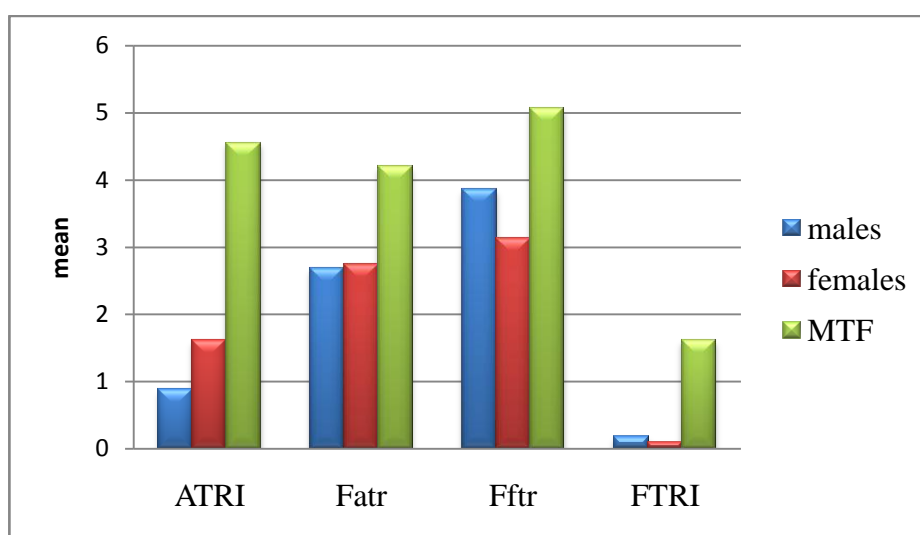


Graph. 3 shows that degree of unvoiced and number of voice breaks are higher in MTF than males and females.

Table 7 depicts the tremor related parameters of phonation for the experimental group and control group. Here it can be noticed that the ATRI (Mean=4.5, SD=2.8), Fatr (Mean=4.2, SD=2.3), Fftr (Mean=5.0, SD=2.0) and FTRI (Mean=2.3, SD=0.1) were higher for MTF than adult males and females.

Table7. Mean and SD values for males, females and male to female transsexuals for tremor related parameters for phonation task.

	Male		MTF		Female	
	Mean	SD	Mean	SD	Mean	SD
ATRI	0.8	1.6	4.5	2.8	1.6	1.5
Fatr	2.6	0.7	4.2	2.3	2.7	0.4
Fftr	3.8	1.4	5.0	2.0	3.1	0.2
FTRI	0.2	0.14	1.6	2.3	0.1	0.06



Graph. 4 shows that all the tremor related parameters i.e amplitude tremor intensity index, frequency tremor intensity index, frequency and amplitude frequency are higher in MTF than males and females.

Table 8 depicts the noise related parameters of phonation for the experimental group and control group. Here it can be noticed SPI (Mean=22.8, SD=16.0) and NHR (Mean=1.6, SD=6.2) value was higher for MTF than adult males and females. VTI (Mean=0.06, SD=0.1) value was higher for adult males when compared with MTF but VTI (Mean=0.05) value was higher for MTF than adult females.

Table 8. Mean and SD values for males, females and male to female transsexuals for noise related parameters for phonation task.

	Male		MTF		Female	
	Mean	SD	Mean	SD	Mean	SD
VTI	0.06	0.1	0.05	0.07	0.03	0.14
SPI	16.0	7.2	22.8	16.0	13.3	5.3
NHR	0.12	0.01	1.6	6.2	0.1	0.01

From table 9, it can be seen that there is significant difference for all frequency related parameters was seen across the 3 groups.

Table 9. shows the degree of freedom, F value and Significant difference values of the frequency related parameters for phonation task across all the 3 groups.

	df	F	Sig.
Mean F0	2	51.797	.000
APP(T0)	2	32.728	.000
Fhi	2	25.330	.000
Flo	2	54.085	.000
SDF0	2	5.682	.007

From table 10, it can be seen that there is significant difference for all frequency perturbation related parameters was seen across the 3 groups.

Table 10. shows the degree of freedom, F value and degree of significant difference values for frequency perturbation related parameters for phonation task across all the 3 groups.

	df	F	Sig.
Jita	2	14.052	.000
Jitt%	2	9.735	.000
RAP	2	9.280	.001
PPQ	2	8.874	.001
sPPQ	2	9.478	.000
vF0	2	9.992	.000

From table 11, it can be seen that there is significant difference for all the short and long term amplitude perturbation related parameters was seen across the 3 groups ($p < 0.05$).

Table 11 depicts the degree of freedom, F value and degree of significant difference values for short and long term amplitude related parameters for phonation task across all the 3 groups.

	df	F	Sig.
ShdB	2	7.557	.002
Shim	2	12.731	.000
APQ	2	16.428	.000
sAPQ	2	15.440	.000
vAm	2	4.139	.024

From table 12, it can be seen that there is significant difference seen across the 3 groups only in number of voice breaks ($p < 0.05$).

Table 12. shows the degree of freedom, F value and degree of significant difference values for voice breaks, sub harmonic component and voice irregularity for phonation task across all the 3 groups.

	df	F	Sig.
DVB	2	2.353	.109
DSH	2	1.110	.340
DUV	2	3.231	.051
NVB	2	4.214	.022
NSH	2	1.269	.293
NUV	2	2.254	.120

From table 13, it can be noticed that there is significant difference seen in amplitude tremor intensity index across all the 3 groups ($p < 0.05$).

Table 13. Shows the degree of freedom, F value and degree of significant difference values for tremor related parameters for phonation task across all the 3 groups.

	df	F	Sig.
ATRI	2	9.345	.001
Fftr	2	1.778	.189
Fatr	2	1.890	.170
FTRI	2	3.097	0.058

From table 14, it can be seen that there is no significant difference seen in the noise parameters across the 3 groups ($p < 0.05$).

Table 14. Shows the degree of freedom, F value and degree of significant difference values for noise related parameters for phonation task across 3 groups.

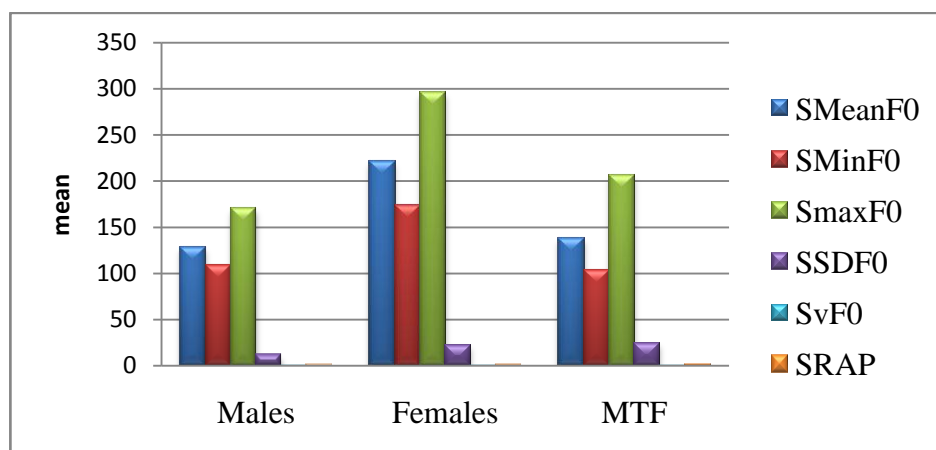
	df	F	Sig.
NHR	2	.560	.576
VTI	2	.495	.613
SPI	2	2.292	.115

II. Speech analysis using Real Time Pitch of CSL 4500

From table 15, it can be noticed that SMeanF0 (Mean=137.1, SD=25.0), SMaxF0 (Mean=206.3, SD=70.7) values were higher for MTF than adult male. But when adult females and MTF were compared it was found that SMeanF0 (Mean=220.5Hz, SD=18.1), SMinF0 (Mean=174.1Hz, SD=28.0), SMaxF0 (Mean=295.9Hz, SD=51.6) values were higher for adult females than MTF. SSDF0 (Mean=24.4Hz, SD=24.0) value was higher for MTF than adult males and females.

Table 15. Mean and standard deviation values of speech parameters for spontaneous speech task for experimental and control group.

	Male		MTF		Female	
	Mean	SD	Mean	SD	Mean	SD
SMF0	127.9	15.0	137.1	25.0	220.5	18.1
SMinF0	108.4	13.2	103.4	20.9	174.1	28.0
SMaxF0	170.6	27.6	206.3	70.7	295.9	51.6
SSDF0	11.3	3.0	24.4	24.0	22.4	7.4
SvF0	0.1	0.07	0.1	0.06	0.1	0.02
SRAP	0.8	0.2	1.7	0.9	1.0	0.2



Graph. 5 reveals that maximum fundamental frequency in speech in females is greater followed by MTF and males.

From table 16, it can be seen that there is significant difference seen in SMeanF0, SMinF0, SMaxF0, SRAP across the 3 groups ($p < 0.05$).

Table 16. Shows the degree of freedom, F value and degree of significant difference values of speech related parameters for phonation task across the 3 groups.

Parameters	Df	F	Sig
SMF0	2	61.9	.00
SMinF0	2	39.0	.00
SMaxF0	2	12.6	.00
SSDF0	2	1.9	.162
SvF0	2	1.2	.287
SRAP	2	7.3	.002

III. Perceptual assessment:

Table 17. Total% response for the perception of femininity by the Judges.

	1	2	3	4	5
J1	0%	5%	0%	30%	65%
J2	0%	5%	5%	35%	55%
J3	5%	15%	10%	25%	45%
J4	5%	10%	10%	10%	65%
J5	5%	30%	0%	5%	15%

Judge 1 rated the voice of 65% of the subjects to be very masculine and 30% of the subjects in the experimental group was perceived as masculine with slight high pitch and only 5% of the subjects were perceived as feminine with slight low pitch.

Judge 2 rated the voice of 55% of the subjects to be very masculine and 35% of the subjects in the experimental group was perceived as masculine with slight high pitch and only 5% of the subjects were perceived as feminine with slight low pitch. 5% of the subjects were also rated as unsure.

Judge 3 rated the voice of 45% of the subjects to be very masculine and 25% of the subjects in the experimental group was perceived as masculine with slight high pitch. 15% and 10% of the subjects were perceived as feminine with slight low pitch and unsure respectively. The rest 5% of the subjects was rated as very feminine.

Judge 4 rated the voice of 65% of the subjects to be very masculine and 10% of the subjects in the experimental group was perceived as masculine with slight high pitch. 10% of the subjects were perceived as both feminine with slight low pitch and unsure. The rest 5% of the subjects was rated as very feminine.

Judge 5 rated the voice of 15% of the subjects to be very masculine and 5% of the subjects in the experimental group was perceived as masculine with slight high pitch. 30% and 5% of the subjects were perceived as feminine with slight low pitch and very feminine respectively.

DISCUSSION

The present study aimed to understand the voice characteristics in the transsexuals and also to compare them across a subgroup of transsexuals, adult females and adult males.

I. Acoustic analysis

The results were first discussed for TG and TS subgroups within the experimental group. It was found that the fundamental frequency information measures, mean F0, Fhi, Flo, SDF0 were lower in the TG group. But the perturbation measures were higher in this group, that is, the TG group had lower mean F0 values and increased frequency and amplitude perturbations when compared to the TS group, even though these differences were not significant. This indicates that the TG group had a mean F0 value closer to adult males even after some form of treatment for MTF transition. Similar trends were noticed for speech also. Lowered mean F0 and increased perturbations may be attributed to any form of vocal misuse and abuse used to achieve adult female voice characteristics.

The variations noticed across the subgroups of MTF transsexuals in the experimental group were statistically insignificant. Hence, the subgroups were combined and then compared for similarities and differences across females and males in the control group.

Comparison of acoustic parameters of voice

The acoustic parameters of voice of the experimental group extracted from the phonation samples using MDVP were compared with the males and females in the control group based on the eight major categories.

Fundamental frequency information and amplitude parameters: The present study shows that Mean F0 and high F0 values were higher for MTF than adult males but the same parameters were lower than adult females. SDF0 value was higher for MTF than adult males and adult females. A significant difference for all frequency related parameters was seen across the 3 groups ($p < 0.05$).

Short and long-term frequency perturbation parameters: The present study found that mean and standard deviation values for frequency perturbation parameters i.e. Jita, Jitt%, PPQ, RAP, sPPQ and vF0 were higher for MTF than adult males and females. A significant difference for frequency perturbation related parameters was seen across the 3 groups except for FTRI ($p < 0.05$).

Short and long-term amplitude perturbation parameters: Results of the study shows that MTF had higher score in APQ, ShdB, Shim%, SAPQ and vAm than adult males and adult females. A significant difference for all the short and long term amplitude perturbation related parameters was seen across the 3 groups ($p < 0.05$).

The increased score for frequency and amplitude perturbation parameters can be due to their inappropriate vocal habits like loud speaking, screaming and shouting to the public, imitating the pitch of the desired gender, talking in falsetto and whispering. Life style including habit of alcohol intake and inappropriate vocal hygiene also contributes to the voice change.

Voice irregularity, Voice breaks and Sub Harmonic parameters: The present study shows that sub harmonic parameters i.e. DSH and NSH scores were higher for MTF than adult females. Mean scores for the parameters under voice breaks i.e. NVB and DVB and parameters under voice irregularity i.e. NUV and DUV were also found to be higher for MTF than adult males and adult females. There is significant difference seen across the 3 groups only in number of voice breaks ($p < 0.05$).

Tremor related parameters: Tremor parameters ATRI, Fatr, Fftr and FTRI were higher for MTF than adult males and females. Result suggests that there is significant difference seen in amplitude tremor intensity index across the 3 groups ($p < 0.05$).

Noise related parameters: When MTF were compared with adult males and adult females it was found that SPI and NHR value was higher for MTF than adult males and females. VTI value was higher for adult males when compared with MTF but VTI value was higher for MTF than adult females. Result suggests that there is no significant difference seen in the noise parameters across 3 groups ($p < 0.05$).

Comparison of the acoustic parameters of speech

The acoustic parameters of speech were extracted from the spontaneous speech samples using RTP were compared with the males and females in the control group.

When MTF and adult males were compared it was found that SMeanF0, SMaxF0 values were higher for MTF than adult male. But when adult females and MTF were compared it was found that SMeanF0, SMinF0, SMaxF0 values were higher

for adult females than MTF. SSDF0 value was higher for MTF than adult males and females. Result suggests that there is significant difference seen in SMeanF0, SMinF0, SMaxF0, SRAP across the 3 groups ($p < 0.05$).

II. Perceptual analysis:

The results reveal that the 5 judges perceived above 50% of the subjects as very masculine and below 20% of the subjects were perceived as feminine with slight low pitch and only 5% of the subjects as very feminine.

The subjects who had higher fundamental frequency, mean speaking fundamental frequency and higher upper limit of speaking fundamental frequency were perceived as female than subjects perceived as very masculine. A significant perceptual correlation was present between above acoustic parameters and ratings of femininity.

The present study revealed a mean speaking fundamental frequency ranging from 109 Hz to 220 Hz for the group of transsexuals were perceived as feminine with slight low pitch. The study by Wolf, Ratusnik, Smith and Northrop (2000) revealed a mean speaking fundamental frequency from 156 Hz to 195 Hz for the group of transsexual individuals perceived as female.

The present study is in consonance with the study by Gelfer, Schofield (2000) where the authors did a comparison of acoustic and perceptual measures of voice in MTF and the results indicated that subjects perceived as females had higher mean speaking fundamental frequency and a higher upper limit of speaking fundamental frequency than subjects perceived as males. A significant correlation between upper limit of SFF and ratings of femininity was achieved.

The study by Coleman (1976) on 40 male to female transsexual individual on their fundamental frequency, frequency averages and judgements of degree of maleness or femaleness also reveals that the perception of the speaker's sex was primarily on the fundamental frequency and is in agreement with the present study.

SUMMARY AND CONCLUSION

The present study aimed to investigate the voice characteristics of male to female transsexuals and compare the acoustic characteristics across the subgroups of transsexuals, to compare the acoustic characteristics of MTF transsexuals with adult male and females and to ascertain the degree of femininity in the voice of MTF transsexuals.

The present study included 3 groups of 20 transsexuals and 10 males and females respectively. Voice samples both phonation and spontaneous collected were subjected to acoustic analysis in MDVP and Real Time Pitch respectively. Perceptual assessment of spontaneous speech sample by 5 qualified speech language pathologists was done.

The objective results revealed that there is significant difference in frequency and amplitude related parameters. There was significant positive correlation between perceptual judgement on the femininity of voice and fundamental frequency, speaking fundamental frequency and upper limits of speaking fundamental frequency.

The study is limited in terms of the sample size, limited instrumentation, exclusion of segmental and supra segmental factors in spontaneous speech, not considering the vocal abusive and misuse behaviours and the effects of drugs and hormonal treatment on the subjects.

Future research

Which vocal characteristics are most important in gender identification? This was the chief question addressed in this study. The present study and past research results reveals that SFF, upper limits of SFF and fundamental frequency play have a

dominating role to play. Supra segmental features like stress, intonation and rhythm are to be explored in this population. Research on efficacy of different therapy techniques are in the infancy stage. Finally, further research is needed to determine how gender is identified when additional or semantic cues are available and how greater success in altering gender perception for the male to female transsexual population may be attained.

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APPENDIX

APPENDIX: 1. Questionnaire

**ALL INDIA INSTITUTE OF SPEECH AND HEARING
NAIMISHAM CAMPUS, MANASAGANGOTHRI, MYSORE-570006**

The purpose of the study is explained to me and I _____ is willing to participate for the study entitled “voice characteristics in male to female transsexuals” as a subject.

Signature of the subject

QUESTIONNAIRE

Name

Age

Treatment: medical/non medical/others

Medical: Surgery/ Hormonal therapy (age/any complications, any medication after surgery/details on the counselling done by the surgeon).

Non medical: Psychological/Voice therapy/Counselling

Habits: Smoking:

Alcohol:

Education:

A) Occupation:

- How long do you use your voice?
- Do you have any ear infection and ear problem?
- Do you have any upper respiratory tract infection?

- Do you frequently clear your throat?

B) Life style:

- Do you indulge in lecturing, chanting, announcements, singing or cheering?
- Are you staying in dusty and noisy environment?
- Do you indulge in continuous long chat?
- Do you eat spicy and hot food frequently?

C) Vocal habits:

- Do you engage in loud speaking, screaming or shouting, practice any vocal activities/tasks or indulge in frequent throat clearing?

D) Symptoms exhibited:

- Does your voice tire very soon?
- Do you perceive roughness in voice?
- Pain, soreness/irritation or lump in throat?
- Do you use any solutions, salt water, mint etc to relieve your throat?
- Do you feel better voice in the morning or evening?
- Do you find difficulty in raising the voice?
- Do you experience any voice breaks/loss of voice during speaking?
- Did you undergo any operations like thyroidectomy, adenoidectomy, tonsillectomy and others?
- Any voice change after operation?

- Do you experience dryness in the throat?
- Are you allergic to AC, dust or medicines?
- Do you feel that your voice is influenced by any of the medical problems like diabetes, high blood pressure and others or subsequent medication?
- Do you suffer from anxiety, mental tension or stress?

E) Pre operative voice quality:

- Did you try to change your voice: self/ professional help?

F) Post operative voice quality:

- Have you ever felt that your voice is inappropriate for your gender?
 - Did you consult any medical or non medical professional for the same?
 - Did you undergo any treatment for voice change?
 - Have you tried voluntarily changing your voice?
 - Did you experience any voice change after transsexual surgery or hormonal therapy?
 - Have you tried imitating any of your female friend's voice?
-

APPENDIX: 2.

Perceptual rating scale

1-Very feminine,

2-Feminine with slight low pitch,

3-Unsure,

4-Masculine with slight high pitch,

5-Very masculine.