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A STUDY OF VOICE CHARACTERISTICS IN WOMEN WHO HAVE UNDERGONE TOTAL ABDOMINAL HYSTERECTOMY WITH BILATERAL SALPINGO-OOPHORECTOMY (TAH+BSO)

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INTRODUCTION:

Voice is the sound made by vibration of the vocal folds caused by air passing out through the larynx and upper respiratory tract, the vocal folds being approximated. Expired air provides the energy required to activate the laryngeal vibrator and produce sound waves which pass through the vocal tract (the resonator) (Greene & Mathieson 1995).

Changes in hormones in the body have an effect on the voice. The quality of voice output can be affected by a variety of variables, including changes in sex hormone levels. The two main female sex hormones are estrogen and progesterone. Although testosterone is considered a male hormone, females also produce and need a small amount of this, too.

Fluctuations in the levels of female reproductive hormones are thought to alter the voice and cause the typical changes that occur throughout the premenstrual period, pregnancy, and menopause.

Female body goes through dramatic hormonal changes during menopause, reducing the amount of hormones it produces, particularly estrogen and progesterone. The ovaries produce estrogen and progesterone. Hormone therapy can be used as a supplement when the ovaries no longer produce enough estrogen and progesterone.

Hysterectomy is also called as surgical menopause. If a hysterectomy leaves one or both ovaries intact, there's a risk that women will go through menopause within five years of the procedure. Despite the fact that hormone levels drop after menopause, the ovaries can continue to produce testosterone for up to 20 years. A hysterectomy is a surgical procedure to remove the womb (uterus). Hysterectomy is common in women among the age group of 40-50 years. This surgery is done by a gynaecologist. It ends menstruation and the ability to become pregnant. A hysterectomy may also include the removal of

additional organs and tissues, such as the ovaries and/or fallopian tubes, depending on the cause for the procedure.

There are different types of hysterectomy:

- A supracervical hysterectomy occurs when the top section of the uterus is removed but the cervix is left behind.
- A total hysterectomy occurs when the uterus and cervix are removed.
- The uterus, cervix, fallopian tubes (salpingo), and ovaries (oophorectomy) are all removed during a total hysterectomy with bilateral salpingo-oophorectomy.
- A radical hysterectomy with bilateral salpingo-oophorectomy is the surgical removal of the uterus and the ovaries.

In India, the prevalence of hysterectomy surgery is 3.2 percent, with the greatest prevalence estimates in four states: Andhra Pradesh, Bihar, Gujarat, and Telangana, and lower prevalence estimates in the other north-eastern Indian states. Hysterectomy was more common in rural India than in metropolitan India.

There are several reasons for hysterectomy these include:

- Heavy periods – which can be caused by fibroids.
- Pelvic pain – which may be caused by endometriosis, unsuccessfully treated pelvic inflammatory disease (PID), adenomyosis or fibroids.
- Prolapse of the uterus.
- Cancer of the womb, ovaries or cervix.

Pelvic organ prolapses, urine incontinence, anal incontinence, bowel dysfunction, pelvic organ fistula, and renal cell cancer are some of the long-term complications of hysterectomy.

A woman will experience the full effects of menopause right after a hysterectomy, which means that they will be coping with a significant hormonal imbalance. This is rarely comfortable transition for women, and it can have severe physical and mental consequences. In addition to recovering after surgery, the effects of rapid menopause can be difficult for women to cope with on their own, and many will turn to hormone replacement treatment to make the transition easier. Estrogen levels fall after the ovaries are removed (oophorectomy) during a hysterectomy. Estrogen therapy (ET) is the treatment that replaces some or all of the estrogen produced by the ovaries until

menopause.

Hormones are chemicals found in our bodies. These are body's messenger system for numerous systems and functions, including the menstrual cycle, is made up of these substances. When hormones are too much or too little, an imbalance occurs. To function effectively, the body requires precise hormone levels. Even a tiny imbalance can have a big impact, especially when it comes to the menstrual cycle.

Female vocal folds and laryngeal function have been shown to be affected by sex hormone variations. Laryngeal alterations occur throughout life, starting with hormone arousal throughout adolescence, fluctuating systematically during the reproductive years with the menstrual cycle, and then changing again with the fall of hormonal activity during menopause.

The tone of the voice depends on the levels of the hormones estrogen, progesterone, and testosterone. Throat dryness, voice discomfort, fatigue, frequent throat clearing, lower voice frequency level, increased roughness and hoarseness are some of the voice changes found in post-menopausal women.

The purpose of a voice evaluation is to determine the cause, symptoms, and consequences of a vocal issue and is appropriate for a variety of illnesses and can detect issues such as vocal abnormalities, abuse, and misuse. Auditory-perceptual assessment of voice quality, acoustic assessment of voiced sound production, aerodynamic assessment of subglottal air pressures, glottal air flow rates during voicing, and endoscopic imaging of vocal fold tissue vibration are the four most common approaches for clinically assessing the various aspects of voice function.

West (1984) investigated the influence of changes in hormonal levels on selected acoustic and perceptual characteristics of voice. Three women underwent hysterectomy with ovarian function reserved and were control subjects. Three women underwent hysterectomy plus bilateral oophorectomy (surgical menopause) and served as experimental subjects. Control subjects revealed no significant changes in hormone levels. Acoustic changes in voice were observed. The experimental subjects did not demonstrate the expected significant decreases in estrogen concentration, and no systematic pattern of acoustic or perceptual voice change was identified. After two

months (controls) or with estrogen replacement (experimental), voice changes were seen. However, they followed no definite pattern, and no observable hormonal influence was apparent. Therefore, the results of this study neither confirms no refute the effects of hormonal variation on voice. Perhaps more sensitive acoustic measures may reflect laryngeal changes accompanying hormonal variation.

Kim, Shin, Ark, Lee, Jeon, Ahn, Thibeault and Lee (2020) determined the effect of sex hormone on the vocal fold, changes of the extracellular matrix (ECM) in vocal fold lamina propria were assessed in orchiectomized (ORX) and ovariectomized (OVX) rats. Hence, they concluded that no changes of the ECM-related genes in the vocal fold lamina propria were observed in ORX groups with reduced testosterone. However, changes of several ECM-related genes were observed in OVX groups with decreased estrogen. These results indicate that the vocal fold is an estrogen-sensitive target organ and that decreased estrogen, not testosterone, can affect the expression of several ECM-related molecules of vocal fold.

REVIEW OF LITERATURE

INTRODUCTION:

The element of speech that supplies the speaker with a vibratory signal on which the speech is transmitted is referred to as voice. It is the sound generated by the lungs and vocal folds in the larynx or voice box in humans and other vertebrates. When the vocal folds are brought close together, airflow from the lungs produces the voice. (National Institute on Deafness and other Communication Disorders, NIDCD, 2017).

The characteristics of voice are its intensity, frequency, and harmonics. The harmonics are hormonally dependent. Hormones play a role in the harmonics. This is frequently highlighted by the changes that occur throughout female puberty; within the female, the action of estrogens at puberty, along with progesterone, develops the features of the feminine voice, with roughly one-third less than a toddler. From childhood until menopause, estrogens, progesterone, and testosterone all have an impact on the female voice. These hormones are the most important component in influencing how the voice changes over time. (Abitbol, Abitbol & Abitbol,1999).

Estrogen and progesterone are the two main female sex hormones. Although testosterone is thought to be a masculine hormone, females make and require a tiny amount of it as well. The female hormone estrogen is the most important. These are produced mostly by the ovaries, with minor amounts made by the adrenal glands and fat cells. The vocal cord is an important target of gonadal hormones and expresses both androgen and estrogen receptors. Androgens are known to exert a profound effect on the development, structure, and function of the human larynx by causing hypertrophy of thyroarytenoid muscles, which results in lowering of the voice pitch.

Fluctuations in the levels of female reproductive hormones are thought to alter the voice and cause the normal changes that occur throughout the premenstrual period, pregnancy, and menopause. The larynx contains cells that react to estrogens specifically. The larynx's stratified squamous epithelium undergoes structural and functional changes in response to hormone stimulation, which alters biomechanical and muscular stimulation. The epithelium's histologic features are likewise influenced by the main hormonal activity. Laryngeal epithelium undergoes specific changes depending on whether estrogen or progesterone is predominant. Dominant estrogen stimulation results in a thickened superficial epithelium of the vocal folds while predominant progesterone has been associated with development of the intermediate layer of the vocal folds.

Menopause occurs when the secretion of the ovarian hormones oestrogen and progesterone decreases, resulting in the cessation of monthly cycles. Although menopause is a natural part of women's lives, individual experiences differ, and some women seek medical guidance for symptom management. Menopause can occur in their 40s or 50s.

Hormone production in the ovaries slows down during the perimenopause period, which precedes menopause. Estrogen levels start to vary, but progesterone levels begin to fall steadily. Estrogen and progesterone levels have remained relatively stable. This usually occurs around the age of 50. However, just like other aspects of life, these hormones vary greatly. When estrogen and progesterone levels fall during menopause, the female voice undergoes the most dramatic modifications.

The uterus is surgically removed during a hysterectomy. Hysterectomy is performed to treat uterine problems such as heavy menstrual bleeding, uterine fibroids, endometriosis, or cancer. A hysterectomy may sometimes include the removal of additional organs and tissues, such as the ovaries (Oophorectomy) and/or fallopian tubes, depending on the cause for the procedure (Salpingectomy).

Hysterectomy is associated to an earlier menopause onset, and women who have their ovaries surgically removed have surgical menopause. The ovaries produce the majority of the oestrogen in the body until menopause. The estrogen levels diminish when the ovaries are removed (oophorectomy) during a hysterectomy.

Farquhar, Sadler, Harvey and Stewert (2005) determined whether hysterectomy causes an earlier onset of menopause. FSH levels were assessed after hysterectomy for five years and compared to a control group. One FSH value of at least 40 IU was used to define menopause. As a result, the researchers concluded that hysterectomy is linked to the beginning of menopause being early.

What is Hysterectomy?

The uterus is surgically removed during a hysterectomy. The uterus is a hollow muscular organ that nourishes the developing baby during pregnancy. The cervix, ovaries (oophorectomy), fallopian tubes (Salpingectomy), and other surrounding structures are also removed. A gynaecologist is usually the one who performs this surgery. Uterine fibroids that cause pain, bleeding, or other issues, uterine prolapse (when the uterus slides from its normal position into the vaginal canal), cancer of the uterus, cervix, or ovaries, Endometriosis, Abdominal vaginal bleeding, Chronic pelvic pain, Adenomyosis, or uterine thickening are all reasons for surgery. The removal of the uterus (as well as the ovaries) prevents the patient from having children (Hoffman, 2021).

In hysterectomy, if the ovaries are removed (oophorectomy) sudden menopause occurs and if the ovaries are not removed, they may enter menopause at an earlier age than would have otherwise. Most people surveyed after a hysterectomy improved or cured their main problem (e.g., pain or heavy periods). For hysterectomy, depending upon the surgeon’s experience and the patient’s overall health surgeons use different approaches for the surgery.

Types of hysterectomy:

Depending upon the reason for the hysterectomy and extent of removal of the uterus and other adjacent structures there are different types of hysterectomy surgeries,

i. A supracervical or subtotal hysterectomy removes only the upper part of the uterus, while keeping the cervix in place. It is indicated, if the patient is in poor condition and to control bleeding, supracervical amputation of the cervix is done.

ii. A total hysterectomy removes the whole uterus and cervix. It is usually the preferred option over a subtotal hysterectomy as there is no risk of developing cervical cancer at a later stage as the cervix is removed in this surgery

iii. A radical hysterectomy removes the whole uterus, tissue on the sides of the uterus, the cervix, and the top of the vagina. It is done when cancer is present in the uterus.

Radical hysterectomy is classified into five:

a) Class I: Extrafascial hysterectomy is done for cervical cancer stage IA1.

b) Class II: Modified radical hysterectomy, is done for cervical cancer stage IA2.

c) Class III: Radical hysterectomy is done for cervical cancer stage IB TO IIA.

d) Class IV: Radical hysterectomy with removal of three-fourth of the vagina and complete ureteric dissection.

e) Class V: Class IV procedure with resection of the terminal ureter, a segment of bladder and rectum. Class IV and V procedures are performed for selected anterior central recurrences.

iv. Panhysterectomy is the removal of the uterus along with removal of tubes and ovaries of both sides. The term hysterectomy with 'Bilateral Salpingo-Oophorectomy' is preferred.

Salpingo-Oophorectomy is the commonest surgery performed concurrently with hysterectomy-abdominal, vaginal, or laparoscopic. It is the removal of a normal ovary along with the tube to pre-empt later problems in a peri-or post-menopausal woman who is undergoing pelvic surgery. It is done to prevent the development of benign or malignant ovarian tumors in peri-and post-menopausal women undergoing hysterectomy.

v. Extended hysterectomy is Panhysterectomy plus removal of a cuff of the vagina

In a total hysterectomy with salpingo- oophorectomy, the uterus plus one (unilateral) or both (bilateral) ovaries and fallopian tube are removed.

Prevalence

The statistical concept referring to the number of cases of a disease that are present in a particular population at a given time is referred to as the prevalence. To inform researchers, guideline developers, and policymakers about the burden of disease, and thereby supporting the process of identification of priorities in healthcare, prevention, and policy prevalence studies are used. These studies are important for the development of health economics models (Harder, 2014).

Hysterectomy is one among the most performed gynaecological surgical procedure worldwide. The prevalence of hysterectomy in the modern world ranges from 10% to 20% among women in the latter half of the reproductive span.

National surveillance data from USA showed that 6,00,000 hysterectomies were performed yearly of which approximately 90% were done for benign conditions.

Hysterectomy rates in Australian women aged 25 and above have decreased in the first decade of the twenty-first century, according to the study. However, rates appear to have levelled out in the recent five years. (Wilson, Pandeya & Mishra, 2017).

India:

In India the prevalence of hysterectomy operation was 3.2%, state wise prevalence estimates were highest in four states, Andhra Pradesh, Bihar, Gujarat, and Telangana and less in the other north-east Indian states. The prevalence of hysterectomy was more in rural India than in urban India.

People with low education, people from hindu religion, caste groups in India, jobs such as sales job, agriculture and service sector, women coming under middle wealth index, those who had marriage before 20 years of age, those who had more no: of pregnancies, sterilized women and insured women all had higher prevalence of hysterectomy in India compared to women who were not under these categories.

Why is hysterectomy done?

Hysterectomy is performed in women because of one of the following reasons:

i. Endometriosis: When hormonal treatments aren't sufficient to fix the expansion of a uterine lining on the surface of the uterus, hysterectomy is performed.
ii. Uterine cancer: A full hysterectomy is done in cases when the tumor cannot be removed cleanly from the uterus.
iii. Uterine fibroids: Newer treatment options provide an alternative for the hysterectomy surgery in this case, but traditionally to address the health complication fibroids are surgically removed.
iv. Uterine prolapse: It is when a part of the uterus falls into the vagina, a partial or complete hysterectomy surgery is done in this case. Prolapses are common in women who had multiple vaginal births.
v. Complications during delivery: Complications of childbirth or ruptured uterus may lead to an emergency hysterectomy.
vi. Adenomyosis: When the uterus is thickened or enlarged, here the endometrial tissues grow into the muscle of the uterus.
vii. Other reasons include, heavy menstrual bleeding, transgender (trans) male affirmation, severe developmental disabilities, postpartum or chronic pelvic pain.

Excessive menstrual bleeding/pain, fibroids/cysts, and uterine disorder, that is, rupture and uterine prolapse are the main reasons for a hysterectomy that is reported by women aged 30-49 (Shekhar, Paswan & Singh, 2019).

Removal of ovaries is often recommended simultaneously with hysterectomy to reduce the future risk of ovarian cancer and prophylactic oophorectomy. Gynaecological ailments such as fibroids, dysfunctional uterine bleeding, and uterine prolapse are some of the common medical indications of a hysterectomy and most of the hysterectomies are performed for benign gynaecological reasons (Prusty, Choithani & Gupta, 2018).

Bukovsky, Halperin, Schneider, Golan, Hertzianu and Herman (1995) in a randomized prospective study, researchers evaluated the residual ovarian function after abdominal hysterectomy with the preservation of one or both ovaries. Thirty-five Percent of individuals who had an abdominal hysterectomy with unilateral oophorectomy had

decreased ovarian function six months later. Six months later, none of the patients with both preserved ovaries had reduced ovarian function. When prolonged ovarian function is needed after abdominal hysterectomy, preservation of both ovaries appears to be more advantageous.

Long term consequences

Surgical menopause, although different from a naturally occurring menopausal state it is a sudden hormonal shock to the body that causes rapid onset of menopausal symptoms such as hot flashes, Pelvic organ Prolapse (occurs as a long-term complication), night sweats, vaginal dryness, difficulty sleeping, mood swings and irritability, weight gain, hair loss, loss of bone density, rapid heartbeat, laryngeal mucosa, and functional changes. When the ovaries are removed during the surgery (oophorectomy) it causes signs of early menopause and hormonal variations.

Hysterectomy is also associated with a long-term risk of cardiovascular and metabolic conditions. Both unilateral and bilateral oophorectomy preceding the onset of menopause is associated with an increased risk of cognitive impairment or dementia. Those who are pre-menopausal at the time of the operation (oophorectomy) may be particularly vulnerable to psychological distress and take longer to recover post-operatively.

Patterns of hormonal changes across age

The endocrine glands produce and release hormones into the blood stream, these hormones are chemical messengers which helps regulate many bodily processes, such as appetite, sleep, and growth. Sex hormones play a very important role in sexual development and reproduction. The main glands that produce sex hormones are the gonads and the adrenal glands, gonadal hormones include the estrogen and progesterone in ovaries of females. Sex hormones play a crucial role in a person's general health.

Sex hormones levels fluctuate throughout a person's life. There are various factors that can affect the levels of sex hormones in women which includes age, menstruation, pregnancy, and menopause.

i. Puberty

In females, the ovaries and adrenal glands are the primary producers of sex hormones such as oestrogen, progesterone, and tiny amounts of testosterone. Females start puberty between the ages of 8 and 13, and it lasts until they are 14 years old. The pituitary gland produces more luteinizing hormone and follicle-stimulating hormone (FSH) throughout puberty, which increases the synthesis of estrogen and progesterone.

In females, increased estrogen and progesterone levels start the development of secondary sexual traits. Gonadotropin-releasing hormone (GnRH) is a unique hormone produced by the hypothalamus region of the brain during the early stages of puberty in both males and females. When GnRH reaches the pituitary gland, it releases two hormones into the bloodstream: Luteinizing hormone and follicle stimulating hormone. Luteinizing hormone and Follicle stimulating hormone are two hormones that stimulate the ovaries in females and aid in the development of the female body.

ii. Menstruation

The first menstruation is called menarche which typically occurs between the age of 12 to 13 years. But menarche occurs any time between 8 and 15 years.

After menarche, regular menstrual cycles occur until menopause. Estrogen levels rise and fall twice during the menstrual cycle. Estrogen levels rise during the mid-follicular phase and then drop precipitously after ovulation. This is followed by a secondary rise in estrogen levels during the mid-luteal phase with a decrease at the end of the menstrual cycle. The secondary rise in estradiol parallels the rise of serum progesterone and 17α-hydroxyprogesterone levels.

The female voice undergoes cyclic variations during the menstrual cycle, with the follicular phase characterised by higher estrogen levels and much reduced progesterone levels. Vocal fold edema and increased blood flow to the tissues are caused by a combination of hormones. Polysaccharides in the vocal folds break down and bind water more readily, causing the vocal folds to become more fluid-filled. The vessels in the nasal passageways dilate as well, causing alterations in patency and voice perception.

Progesterone levels rise faster than estrogen levels during the luteal phase, the second half of the menstrual cycle. Progesterone inhibits proliferation by promoting sloughing of the laryngeal epithelium. It also makes glandular secretions more viscous, reducing vibratory effectiveness and perhaps increasing cell injury. The variations in voice that occur throughout the menstrual cycle are caused by these alterations (Kadakia, Carlson & Sataloff, 2013).

Because fluid moves from the interior of the cells and capillaries to the outside during the premenstrual period due to elevated estrogen levels, there is greater edema. This edema might also be to blame for some of the vocal changes that occur before menses. In roughly one-third of singers, dysphonia can affect voice effectiveness and clarity. Abdominal cramps during the menstrual cycle can sometimes make phonation difficult by interfering with support. (Kadakia, Carlson & Sathaloff, 2013).

Celik, Atespare, Boyanci, Celibi and Yelken (2013) reported on teenage female voice and speech changes during menstruation, after menstruation, mid-menstrual cycle, and pre-menstruation during different stages of the menstrual cycle. Perceptual evaluation techniques showed significant alterations in different phases of the menstrual cycle (GRBAS and VHI).

Meurer, Garcez, Corleta and Capp (2007) They studied the voice intensity and stability of fundamental frequency, formants and diadochokinesis, vocal modulations, rhythms, and speed of speech in adolescents during the follicular and luteal phases of the menstrual cycle, and concluded that the adolescents had similar voice fundamental frequency and intensity, formants, speed of speech, and suprasegmental speech parameters.

iii. Perimenopause

Menopause is preceded by perimenopause, which is a period of transition. It might start in your late thirties or early fifties. Because fewer ovulations occur during the second part of the menstrual cycle, hormone levels vary, and less progesterone is generated. Periods can be irregular, missed, or thick with clots. Symptoms are caused by a shift in the estrogen-to-progesterone ratio; therefore, the imbalance is the source of the symptoms.

iv. Menopause

Menopause that occurs naturally in the early 50s and is not brought on by surgery or another medical issue is considered normal. In the absence of any procedure or medical condition that may cause bleeding to stop naturally, menopause is defined as a year without monthly bleeding. As menopause approaches, the ovaries produce less estrogen. When this happens, the menstrual cycle begins to shift. It may grow erratic before coming to a halt. Physical changes might occur when the body adjusts to altered hormone levels.

Estrogen is no longer generated by the ovaries during menopause, which generally occurs in the late 40s to early 50s, and is instead produced in lesser levels by the adrenal glands and adipose tissue. Estrogen is still generated in little levels in the body. The absence of progesterone, which occurs during a period of oestrogen dominance and low progesterone, is the most important hormone alteration of menopause.

Mustaffa and Sammarraie (2020) studied the secondary amenorrhea and its relationship to the physiological and hormonal status of women and found that there were high significant differences in serum levels of LH, FSH, and E2 hormones and decrease in the levels of the hormones E2 and Progesterone in the serum of most patients.

Impact of hormones on voice

The hormonal impact on voice lasts throughout a person's life and differs between males and females. The hormonal receptors located inside the vocal folds and apparatus mediate the significant impact of sex hormones on voice characteristics.

Female vocal cords are short and thin, resulting in rapid vibration and a higher pitch in their voice. Females' pitch decreases as they become older, whereas males' pitch increases. Female voices have a greater resonance than male voices due to their shorter vocal tracts.

The hormonal environment of the body has major effects on the sound quality of the voice (Kadakia, Carlson & Sataloff 2013). Hormone receptors are found in the nucleus and cytoplasm of cells in the vocal fold with statistically significant differences in age and gender distribution (Newman, Butler, Hammond & Gray, 2000).

Hormonal imbalances occur when levels are too high or too low, or when female reproductive maturation is missing or aberrant. Changes in habitual pitch and pitch range have the biggest and most consistent impact on voice quality. Virilization refers to the aberrant production of androgenic hormones in females, which results in masculine gender traits. Low pitch, hoarseness, and voice cracks are some of the vocal consequences.

Menopause is the most frequent result of aging-related hormonal changes. Women's ovaries begin to produce less estrogen and progesterone at the age of 50, and the pituitary gland tries to compensate by releasing more follicle stimulating hormone (FSH).

After menopause, the symptoms of ageing, as well as hormonal changes, become apparent. The vocal apparatus stiffens as laryngeal muscles shrink, cartilages harden and eventually ossify, vocal folds thicken, and collagenous fibres decrease in number.

Although estrogen or other hormone treatment can help improve voice quality, pitch alterations are typically permanent. Due to the established sexual hormone cycles linked with menstruation, oral contraceptive usage, pregnancy, and menopause, females are more sensitive to hormonal alterations than males. Although oestrogen or other hormone treatment can help improve voice quality, pitch alterations are typically permanent. Due to the established sexual hormone cycles linked with menstruation, oral contraceptive usage, pregnancy, and menopause, females are more sensitive to hormonal alterations than males.

Lindholm, Vilkman, Raudaskoski, Luukkonen and Kauppila (1997) studied the effect of post menopause and postmenopausal hormone replacement therapy (HRT) on the measured fundamental frequency (F0) and sound pressure level (SPL) of sustained phonation and speaking voice samples and on subjective vocal/laryngeal symptoms. The mean F0 and SPL decreased significantly in the group with no HRT in spontaneous speech and reading samples as did SPL in the normal phonation sample. In both groups with HRT, the mean F0 decreased significantly only in the spontaneous speech sample and the decrease was smaller than in the group with no HRT. The changes in the measured voice values and the subjective symptoms experienced suggest that at least the early postmenopausal years are associated with vocal changes and that HRT counteracts this phenomenon.

Caruso, Roccasalva, Sapienza, Zappala, Nuciforo and Biondi (2000) investigated the effects of estrogen replacement therapy (ERT) on laryngeal cytology in surgically induced postmenopausal women. In the control group, both smears showed aspects of atrophy, dystrophy. The ERT group had a subjectively better quality of voice than the control group. This study confirms that the larynx is an estrogen target, as are vaginal cells. ERT may provide prevention and treatment of dystrophic pathologies of the vocal cords in postmenopausal women.

Derksen, Brolmann, Wiegerinck, Vader and Heintz (1998) the hypothesis was tested that following a simple hysterectomy; FSH levels will rise in premenopausal individuals. Conclusion: After measuring serum FSH levels before and after uterine surgery and comparing hysterectomized patients with patients who had endometrial ablation, researchers discovered a significant increase in FSH levels in both groups up to one year after surgery, indicating impaired ovarian function.

Laughlin, Connor, Silverstein and Muhlen (2000) Examined the cross-sectional association of hysterectomy and oophorectomy status, chronological age, and years since menopause with plasma levels of total and bioavailable testosterone and estradiol, androstenedione, estrone, and sex hormone-binding globulin (SHBG) in community-dwelling postmenopausal women who were not using estrogen replacement therapy. Testosterone levels were reduced by more than 40% in hysterectomized women with bilateral oophorectomy compared to those in intact women, with intermediate levels observed in hysterectomized women with ovarian conservation. Androstenedione levels were about 10% lower in hysterectomized women with or without ovarian conservation compared to those in intact women. Total estradiol levels tended to be lower in bilaterally oophorectomized women. Levels of bioavailable estradiol, estrone, and SHBG did not differ by hysterectomy and oophorectomy status. These results demonstrate that the postmenopausal ovary remains a critical source of androgen throughout the lifespan of older women.

Kim, Shin, ark, Lee, Jeon, Ahn, Thibeault and Lee (2020) Determined the effect of sex hormone on the vocal fold, changes of the extracellular matrix (ECM) in vocal fold lamina propria were assessed in orchiectomized (ORX) and ovariectomized (OVX) rats. Hence, they concluded that No changes of the ECM-related genes in the vocal fold lamina propria were observed in ORX groups with reduced testosterone. However, changes of several ECM-related genes were observed in OVX groups with decreased estrogen. These results indicate that the vocal fold is an estrogen-sensitive target organ and that decreased estrogen, not testosterone, can affect the expression of several ECM-related molecules of vocal fold.

i. Infancy

Infants use voice to signal distress and discomfort and to emit cries for help. The first cry at birth is the dramatic use of voice an individual will ever make. The fundamental frequency continues to decrease with age and by 5 years the child's speaking voice settles under the influence of median pitch. The voice range for both sexes remains constant at about two and a half octaves between 6 and 16 years (Aronson,1980).

In early infancy, (Sex hormone-binding globulin) SHBG concentrations rose in both sexes, the highest values being seen in girls. In infant girls, levels of T (Testosterone) and the FAI (free androgen index, FAI) were constantly low The FAI in male infants is about one order of magnitude larger than that in female infants currently (Bolton, Tapanainen, Koivisto & Vihko, 1989).

ii. Puberty

The female body develops and matures into adulthood during the puberty period. Puberty begins when the hormonal signals from the brain to the sexual organs, the ovaries in females (Grady, 2009).

Hormonal changes in females during the period 8-14 years there is sudden increase in rate of growth and size. The voice of girls matures due to enlargement of the larynx consistent with the general body growth.

In females, the elevated estrogens and progesterone have minimal effect on the voice during puberty. The importance of hormonal influence on the female voice is appreciated during the cyclical changes of the menstrual cycle. Within the female, the impact of estrogens at puberty, together with the progesterone, produces the characteristics of the feminine voice.

iii. Menopause

Voice is very sensitive to subtle adjustments in the body. Small reductions of the hormones associated with menopause can create noticeable changes in the vocal cords. The larynx is strongly impacted by the levels of hormones it is a hormonal target. The tone of your voice depends on the levels of the hormones estrogen, progesterone, and testosterone. At menopause, the hormones fade and are no longer in balance. As a result, the voice changes, sometimes considerably.

Women experience vocal changes, particularly lowering of fundamental frequency during menopause. This is due to the secretion of excessive androgenic hormones after menopause, the glottal membrane becomes thicker, increasing the size-mass of the folds, and lowering of voice pitch and sometimes vocal roughness.

Menopause can cause muscle and mucosal atrophy, as well as fluid retention and enlargement of the vocal folds, as well as increased mucosal viscosity. Menopause-related vocal discomfort has been linked to dryness, throat clearing, a lower fundamental frequency, a smaller frequency range, decreased intensity, and increased roughness and hoarseness. (Steinhauer, 2015).

Structure changes in the female vocal fold during menopause may reduce fundamental frequency and decrease voice endurance. Hormone levels have a significant influence on the larynx, which is the hormonal target. The hormones oestrogen, progesterone, and testosterone influence the tone of the voice. Hormones diminish and become unbalanced throughout menopause. As a result, the tone of the voice shifts.

The levels of estrogen and progesterone decrease after menopause, but the levels of FSH (Follicle Stimulating Hormone) and LH (Luteinizing Hormone) remain high, causing ovarian androgen production to continue. Prior to menopause, women have extra peripheral fat, which allows more androgens to be converted to estrogen, maintaining

estrogen's effects on the body. Some women, on the other hand, have a lower capacity to do so and, as a result, have higher amounts of androgen. Androgens alter the voice by deepening it and causing permanent changes (Kadakia, Carlson & Sataloff, 2013).

The prevalence of voice complaints associated with menopause ranges from 17% to 77%. Literature on the effects of menopause on voice function indicates that menopause can affect laryngeal tissues and result in muscular and mucosal atrophy, fluid retention and swelling of the vocal folds and increased viscosity of the mucosa. Vocal discomfort associated with menopause has been associated with the perception of dryness, throat clearing, a lower fundamental frequency, reduced frequency range, reduced intensity and increased roughness and hoarseness (Steinhauer, 2015).

Dhaeseleer, Evelien, Depypere, Herman, Claeys, Sofie, Wuyts, Floris, De Ley, Sophia, Lierde and Kristiane (2011) measured and described the effects of menopause on vocal characteristics by comparing premenopausal and postmenopausal women (not taking hormone therapy) and concluded that postmenopausal women not taking hormone therapy had a good overall voice quality. However, in comparison with premenopausal women, they showed a lower habitual F0 in continuous speech.

Sovani and Mukundan (2010) Investigated the impact of menopause and professional voice use, and their interaction effect, on the voice. Results suggest that F_o, SF_o and MPT reduce post menopause while NHR and VTI increase. Some changes are accelerated in teachers as compared to clerks while some are decelerated. VHI scores of teachers are significantly greater than clerks, though not significantly different across menopause. Thus, the presence or absence of voice use in one’s profession differentially affects postmenopausal changes.

Simpson, Maclnnis, English, Gertig, Morris and Giles (2005) compared the distribution of estradiol levels between women with a hysterectomy and ovarian conservation and women with an intact uterus. For women less than 55 years of age, observed that those with a hysterectomy and ovarian conservation had slightly higher estradiol levels compared with those with an intact uterus after adjustment for age, body mass index, smoking status and alcohol intake confidence interval. For women who were 55 years or greater, the distribution of estradiol levels varied little by hysterectomy status.

Oyarzun, Sepulveda, Valdivia, Roa, Cantin, Truijillo, Zavando and Galdames (2011) determined the effect of induced menopause on the morphological parameters of the vocal fold mucosa in rats. Results indicate that there were alterations in the number of cell layers that constitute the epithelium, as well as features, such as cellular cohesion and increased extracellular matrix. Changes in the characteristics of the epithelium covering the vocal folds can be related to clinical abnormalities, such as reduced voice quality and degeneration of the vocal folds in postmenopausal women.

West (1984) investigated the influence of changes in hormonal levels on selected acoustic and perceptual characteristics of voice. Three women underwent hysterectomy with ovarian function reserved and were control subjects. Three women underwent hysterectomy plus bilateral oophorectomy (surgical menopause) and served as experimental subjects. Control subjects revealed no significant changes in hormone levels. Acoustic changes in voice were observed. The experimental subjects did not demonstrate the expected significant decreases in estrogen concentration, and no systematic pattern of acoustic or perceptual voice change was identified. After two months (controls) or with estrogen replacement (experimentals), voice changes were seen. However, they followed no definite pattern, and no observable hormonal influence was apparent. Therefore, the results of this study neither confirms no refute the effects of hormonal variation on voice. Perhaps more sensitive acoustic measures may reflect laryngeal changes accompanying hormonal variation.

The literature on the effects of menopause on the voice and larynx was examined in order to give a critical overview of the menopausal voice, its genesis, and treatment possibilities. Laryngeal alterations such as edema, muscular and mucosal dystrophy, and atrophy were discovered in postmenopausal women. The most significant acoustic changes in postmenopausal women's voices are a narrowing of the vocal frequency range, a lower fundamental frequency, and a greater frequency disruption (Dhaeseleer, Depeypere, Claeys, Borsel & Lierde, 2009).

FSH and LH levels are extremely high right after menopause begins, causing ovarian androgen production to continue. The vocal apparatus stiffens as laryngeal muscles shrink, cartilages harden and eventually ossify, vocal folds thicken, and collagenous fibres decrease in number. (Kadakia, Carlson & Sataloff, 2013).

Study by Hamdan, Ziade, Tabet, Btaiche,Fakhri, Yatim, Sarieddine and Seoud, (2017) compared the prevalence of phonatory symptoms in menopausal women compared to pre-menopausal women with body mass index (BMI) as a confounding variable. The result shows that there was a significant higher prevalence of throat clearing and dryness in the menopausal compared to pre-menopausal group. When BMI was taken into account, there was no statistically significant difference in the prevalence of any of the phonatory symptoms in menopausal women with high BMI and pre-menopause.

Ghaemi, Dehqan, Bakhtiari and Scherer (2020) evaluated the vocal changes in the Iranian pregnant women according to trimesters both objectively and subjectively. Results showed that decreased MPT increased S/Z ratio, mild to moderate edema, and a deterioration of the VHI-30 score noticeably occurred during the third trimester. The results suggest significant vocal changes toward less stable phonation during the third trimester of pregnancy.

Salturk, Kumral, Bekiten, Atar, Aydogdu, Yildirim, Kilic and Uyar (2016) evaluated vocal changes in pregnancy according to trimesters both objectively and subjectively. The fundamental frequency (F0), jitter, shimmer, noise-to-harmonics ratio (NHR), and minimum and maximum pitch were determined during acoustic voice analysis. Laryngological examination was evaluated via reflux finding score (RFS). Voice Handicap Index 10 (VHI-10) was used for subjective analysis. Results showed that MPT is decreased during the third trimester, although acoustic parameters did not differ. VHI-10 results deteriorated in the third trimester significantly.

ASSESSMENT OF VOICE

Problems of voice include pain, discomfort while speaking, and difficulty controlling the loudness, pitch, and quality of voice. These problems can be assessed using some common approaches of voice.

A voice assessment is used to identify the cause, symptoms, and impact of the voice. The four most common approaches for clinically assessing the various aspects of voice production include:

1. Auditory perceptual assessment of voice

2. Acoustic assessment of voice

3. Aerodynamic assessment of voice, and

4. Endoscopic imaging of vocal fold tissue vibration.

1. Case history:

A case history is a data relating to each case which is advisedly assembled on a standard form. The case sheet can be short and concise or in great detail.

2. Acoustic assessment of voice:

Acoustic analysis is a set of complicated yet fundamental principles that control the production and behaviour of sound waves. Acoustic measurements are important in the diagnosis of voice problems, but their relevance is determined by their link to perceptual voice quality and the degree to which they represent the individual's usual speaking patterns.

Acoustic measures provide fundamental, objective data that inform the diagnosis and treatment of people with voice disorders.

This analysis includes voice measures such as fundamental frequency, formant pattern and energies, Decibel level (a physical measure of sound pressure level that roughly correlates to perception of loudness), signal to noise ratio, jitter, and shimmer.

- Fundamental frequency (F0) in an acoustic spectrum refers to the lowest tone in a harmonic series. Using auditory perception, Fundamental frequency correlates with pitch.
- Jitter is the cycle-to-cycle variability of the period duration of the acoustic signal coming from voice production. When consecutive vibratory cycles of the vocal folds vary in frequency so that there is itch variation in a short- term speech signal, the phenomenon is referred to as itch perturbation or jitter.
- Shimmer is the cycle -cycle variability of the period amplitude of vocal cord vibration. It is the instability of the intensity of a short- term vocal signal and is comparable to frequency perturbation.

- Sound intensity, also known as acoustic intensity, is defined as the power carried by sound waves per unit area in a direction perpendicular to that area.
- Harmonic to Noise Ratio (HNR) measures the ratio between periodic and non-periodic components of a speech sound. It has become more and more important in the vocal acoustic analysis to diagnose pathologic voices. If the noise component increases and replaces the harmonic structure, the quantity of hoarseness is perceived. The more severe the hoarseness the greater the increase in aperiodic sound.
- Formants are frequency peaks in the spectrum which have high degree of energy.

i. PRAAT:

The software PRAAT is used for speech acoustic analysis. PRAAT is an extremely versatile speech analysis tool. Paul Boersma and David Weenink created and developed this computer software for phonetic speech analysis. It includes spectrographic analysis, articulatory synthesis, and neural networks, among other conventional and non-standard methods. PRAAT allows to record mono and stereo sounds, as well as modify and analyse data in terms of intensity, pitch height, duration, and formants.

3. Perceptual assessment of voice:

Voice perception assessment, also known as psychoacoustic evaluation, is subjective and based on comparisons with another voice or the listener's past perceptions of the same voice (Fex, 1992).

The auditory perceptual evaluation of a person's voice might be formal or casual. During the initial history, there is an informal component. It entails striking up a spontaneous discussion with the patient while gathering pertinent information. The quality of a person's voice, pitch range, resonance (normal, hypo, or hyper nasal), loudness, prosody, and articulation can all be evaluated.

The formal perceptual assessment typically involves the use of a protocol to systematically describe and quantify various features of the voice.

i. GRBAS:

GRBAS scale is examiner based and is the gold standard in perceptual analysis of voice. Developed in 1981, this scheme is not a complete perceptual evaluation protocol but specifically evaluates voice quality.

It assesses the following:

a) Grade (the overall degree of voice abnormality),
b) Roughness (perceived irregularity in voicing source),
c) Breathiness (audible air escape in voice),
d) Asthenia (voice weakness), and
e) Strain (perception of excessive vocal effort).

Each parameter is quantified on a 4-point scale, where 0 = normal, 1 = mild, 2 = moderate, and 3 = severe.

4. The vocal measures:

i. S/Z Ratio:

The S/Z Ratio is a simple method that evaluates how long a person can maintain the sound "s" and how long they can sustain the sound "z," then divides the two values to get a numerical ratio. This aids in determining the effectiveness of the respiratory and phonatory systems. The higher the number, the more likely the person is having trouble phonating, which involves vibrating the vocal folds (vocal cords) to generate so-called voiced speech sounds like vowels and voiced consonants (Williamson, 2014).

ii. Maximum phonation Time:

Maximum Phonation Time is a basic measure of glottic efficiency (MPT). The maximum time (in seconds) that a person can maintain a vowel sound generated on one deep breath at a generally acceptable pitch and volume is known as MPT. The maximum phonation time (MPT) is an approximate indicator of how fully closed the vocal cords are during this test. The tighter they are, the less air is wasted, and the sound can last longer.

Typically, The MPT is the longest duration ‘ah’ of the three attempts, the best of three attempts at sustaining a vowel is used as the person’s MPT (Williamson, 2014).

NEED OF THE STUDY:

Changes in the hormonal environment have a profound effect on voice. Menopause is a significant milestone in a woman's life. When oestrogen and progesterone levels decline during menopause, the female voice undergoes the most obvious changes. Because of the influence of hormones on the laryngeal tissues, a large number of studies have found voice problems related with menopause. The levels of FSH and LH are still quite high shortly after the start of menopause, causing ovarian androgen hormone production to continue.

Hysterectomy is associated with an earlier onset of menopause and has become the second most common surgery among women. When a woman has a total hysterectomy menopause will begin immediately after the procedure. Until menopause, the ovaries make most of the body's estrogen. When the ovaries are removed (oophorectomy) during a hysterectomy, estrogen levels drop hence, it is possible that there might be similar voice changes in women who have undergone hysterectomy as that of menopausal women. There are several studies on voice characteristics of women post-menopause but there are less studies of voice in women who have undergone hysterectomy. Hence, there is a need to study the voice characteristics in women who have undergone a Total Abdominal Hysterectomy with Bilateral Salpingo-Oophorectomy to explore whether Total Abdominal Hysterectomy with Bilateral Salpingo-Oophorectomy is associated with voice changes similar to those observed in menopausal women.

METHOD

Aim:

The aim of the study was to compare the voice characteristics of individuals who had undergone Total Abdominal Hysterectomy with Bilateral Salpingo-Oophorectomy (TAB+BSO) and normal controls.

Objectives:

1. To collect voice samples of participants from Group I and Group II. Group I, the experimental group, consisted of 21 women who have undergone total abdominal hysterectomy with bilateral salpingo -oophorectomy and Group II the control group consisted of 21, age and medical history matched women who have not undergone hysterectomy.
2. To do a perceptual evaluation of voice using GRBAS on participants of Group I and Group II.
3. To do the acoustic analysis of voice of participants forjko Group I and Group II.
4. To compare perceptual, acoustic and case history findings of participants in Group I and II.

Participants:

The participants consisted of two groups of women, Group I of 21 women who had undergone Total Abdominal Hysterectomy with Bilateral Salpingo-Oophorectomy (TAH+BSO) as experimental group aged 38-50 years, mean age 46.7 years, and Group II of 21 age and gender matched women who had not undergone hysterectomy as control group aged 38-50 years, mean age 46.7 years.

Inclusion criteria:

Women who had undergone Total Abdominal Hysterectomy with Bilateral Salpingo-Oophorectomy (TAH+BSO) between the age group of 38-50 years, 3 to 8 years prior.

Exclusion criteria: -

Subjects who had undergone hormone replacement therapy, and thyroidectomy were excluded from the study.

Table 3.1:

Mean age range of experimental and control group participants

Group	No: of subjects	Mean age in years
Experimental group	21	46.7 years
Control group	21	46.7 years

Materials:

1. Consent form
2. Case history
3. PRAAT software was used to collect the voice samples
4. GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain) was used for the perceptual evaluation of voice.

Procedure:

The purpose of the study was explained to the participants and written consent was obtained. Following this, a detailed case history was taken which consisted of the following sections - demographic data, medical history, voice complaints, vocal hygiene habits, lifestyle and dietary habits and environmental factors was taken.

The voice samples were collected using the laptop (Lenovo idea pad 330, Windows 10 Version 1909) with the Praat software (V 6.1.16). The participants were asked to phonate the vowels /a/, /i/ and /u/ for as long as they could, and the time was noted.

Three samples of /s/ and /z/ were recorded, and time was noted. Each subject was instructed to read the passage given to them, and the sample was recorded and analysed. Illiterate subjects were asked to self-introduce, the sample were recorded and analysed.

Analysis:

The voice samples that were collected, was analysed perceptually using GRBAS, and acoustically using PRAAT, and the data tabulated.

Statistical Analysis:

The data obtained were subjected to statistical analysis to determine the significant difference. Fisher's exact test was used to find the significant association between the case history of experimental or control group and Independent sample t test was used to find the significance difference in the average values of acoustic parameters between control and experimental group and average values of perceptual, MPT and s/z ratio between control and experimental group.

RESULTS

Aim:

The study aimed to compare the voice characteristics of individuals who have undergone Total Abdominal Hysterectomy with Bilateral Salpingo -Oophorectomy (TAH+BSO) and normal controls.

The results of the study were obtained using descriptive and inferential statistics. The results are presented below.

Table 4.1:

Shows the difference between the experimental and control group on the case history parameters.

Variables		Group		p-value
		Control	Experimental	
1. Dryness	Absent	17	10	0.052
	Present	4	11	
2. Cough	Absent	20	18	0.606
	Present	1	3	
3. Throat clearing	Absent	13	10	0.536
	Present	8	11	
4. Hydration	Absent	4	1	0.343
	Present	17	20	
5. Talking Loudly	Absent	17	21	0.107
	Present	4	0	
6. Healthy Diet	Absent	1	0	1.000
	Present	20	21	
7. Sleep	Absent	2	2	1.000
	Present	19	19	
8. Caffeine	Absent	19	18	1.000
	Present	2	3	
9. Spicy food	Absent	17	17	1.000
	Present	4	4	
10. Exercise	Absent	14	15	1.000
	Present	7	6	
11. Dust allergy	Absent	13	17	0.306
	Present	8	4	

From the Table 4.1, we see that the difference between the experimental and control group for the case history parameters such as, dryness, cough, throat clearing, hydration, talking loudly, healthy diet, sleep, caffeine spicy food, exercise, and dust allergy is not significant (0.052, 0.606, 0.536, 0.343, 0.107, 1.000,1.000,1.000,1.000,1.000, 0.306, $p>0.05$) respectively.

Table 4.2:

Shows the difference between the experimental and control group for acoustic evaluation.

N=42

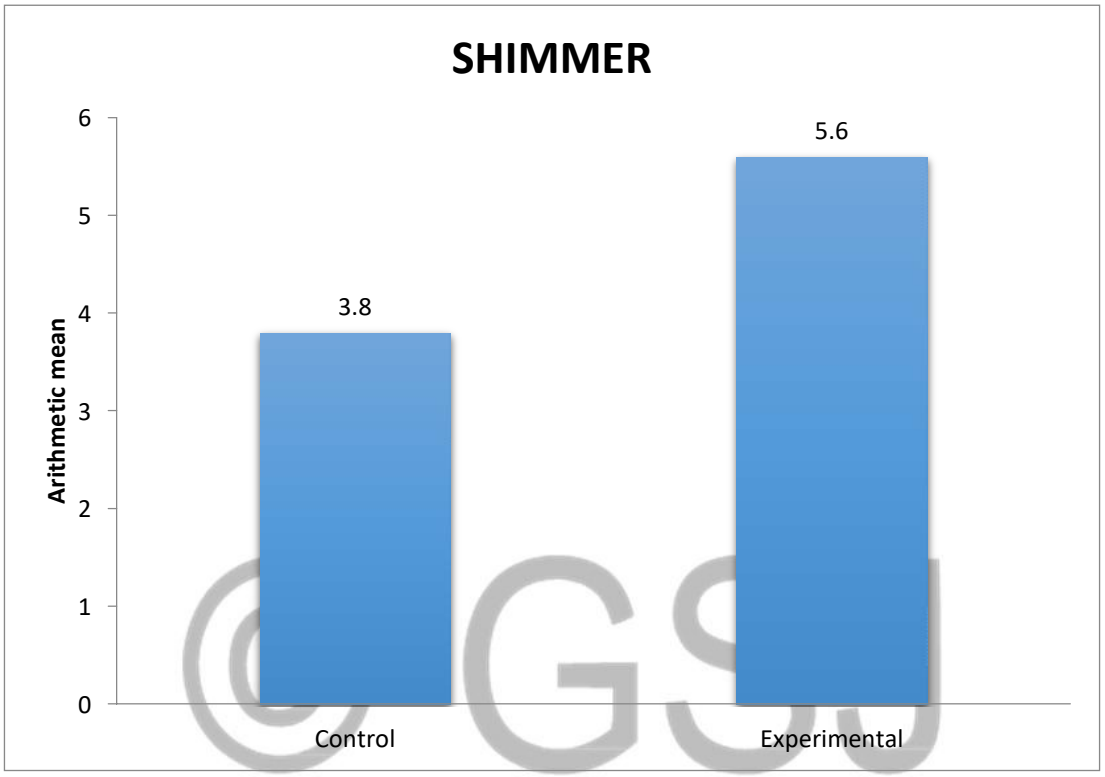
Variable	Esophageal varices	Mean	SD	t value	P value
Jitter	Control	0.33	0.12	1.18	0.245
	Experimental	0.402	0.2		
Shimmer	Control	3.8	1.1	2.18	0.04*
	Experimental	5.6	3		
F0	Control	205.8	26.9	0.569	0.573
	Experimental	200.9	28.8		
HNR	Control	22.4	1.8	1.84	0.076
	Experimental	20.7	3.9		
Intensity	Control	56.93	3.5	0.115	0.909
	Experimental	56.78	4.6		

*Significant

From the Table 4.2, we see that the difference between the experimental and control group for jitter, F0, HNR and intensity is not significant ($t = 1.18$, $t = 0.569$, $t = 1.84$, $t = 0.115$ $p<0.05$) respectively. However, for shimmer we see that there is a significant difference ($t = 2.18$, $p<0.05$) between the experimental and control groups.

Figure 4.1:

Shows the difference between the experimental and control group for shimmer.



From the above figure 4.1, we see that the difference between the experimental and control group for shimmer ($t = 2.18$, $p<0.05$) is significant.

Table 4.3:

Shows the difference between experimental and control group for MPD and S/Z ratio.

N=42

Variable	Esophageal varices	Mean	SD	t value	P value
MPT	Control	11.16	2.7	0.013	0.99
	Experimental	11.15	3.7		
S/Z ratio	Control	0.98	0.35	1.119	0.27
	Experimental	1.11	0.37		

From Table 4.3, we see that the difference between the experimental and control group for MPD and S/Z ratio, is not significant ($t = 0.013$, $t = 1.119$, $p<0.05$).

Table 4.4:

Shows the difference between the experimental and control group for perceptual evaluation.

N=42

Variable	Esophageal varices	Mean	SD	t value	P value
GRBAS	Control	0.72	0.5	0.447	0.657
	Experimental	0.66	0.3		

From Table 4.4, we see that the difference between the experimental and control group using GRBAS, is not significant ($t = 0.447$, $p<0.05$).

SUMMARY AND CONCLUSION

Aim:

To compare the voice characteristics of individuals who have undergone Total Abdominal Hysterectomy with Bilateral Salpingo-Oophorectomy (TAH+BSO) and normal controls.

Method:

Menopause will occur immediately after a woman has had a Total Hysterectomy with Bilateral Salpingo-Oophorectomy. The hormonal abnormalities that result may have an adverse effect on women's voices. There are very few researches on the relationship between hysterectomy and voice. As a result, research into the vocal characteristics of women who have had Total Abdominal Hysterectomy with Bilateral Salpingo-oophorectomy is needed to see if their voices have changed significantly.

The experimental group comprised of 21 women aged 38-50 who had Total Abdominal Hysterectomy with Bilateral Salpingo-Oophorectomy (TAH+BSO), whereas the control group consisted of 21 age and gender matched women who had not had hysterectomy. The purpose of the study was explained to the participants, and they filled a consent form. Following that, a thorough case history was gathered. The voice sample was then taken and analysed for acoustics, perceptual assessment, MPT, and S/Z ratio. To assess the significance of the difference, the data was statistically analysed.

Result:

The results show that there is no difference between the voice characteristics - perceptual and acoustic - of individuals who have undergone total hysterectomy and normal matched controls.

Implications:

Data suggest that there is no perceptual or acoustic change in voice characteristics between post-hysterectomy individuals and matched controls. The process of ageing also contributes to the known microstructural alterations of the vocal folds that lead to

pitch reduction in menopausal women, the predicted decrease of pitch in the hysterectomy group was not detected. Hysterectomy appears to have had no effect on the voice of women who have had a total hysterectomy in this study.

Limitations of the study:

- Study has been limited to 21 subjects in each group

Future direction:

- Study can be done on a larger population.
- Study can be done to compare the voice of persons who have undergone hysterectomy and post-menopausal women.

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