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Comparative Study of Acoustic and Perceptual Analysis of Voice in Healthy Women, Women with Hypothyroidism and Hyperthyroidism in Kerala

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ABSTRACT

Thyroid disorders, primarily hypothyroidism and hyperthyroidism, represent the most prevalent endocrine conditions affecting the laryngeal system and inducing vocal changes through distinct pathophysiological mechanisms. Standard protocols prioritize metabolic and cardiovascular stability, while frequently undermining the individual's communicative quality of life (QoL). Therefore, a standard voice assessment should be included in routine evaluation. The present study aimed to evaluate and compare the acoustic and perceptual voice characteristics in young adult females aged 18–35 years diagnosed with hypothyroidism and hyperthyroidism against healthy women in Kerala. A total of 45 female participants were selected and divided equally into three groups: Group 1 (15 healthy women), Group 2 (15 women with hypothyroidism), and Group 3 (15 women with hyperthyroidism). Acoustic analysis was conducted using PRAAT software (version 6.4.56) to extract fundamental frequency (F0), jitter%, shimmer%, harmonics-to-noise ratio (HNR), and noise-to-harmonics ratio (NHR) from sustained /a/ vowels. Perceptual assessment was independently completed by a speech-language pathologist (SLP) utilizing the standardized 4-point GRBAS scale. The results revealed that F0 was highest in healthy controls (213.93 Hz), intermediate in women with hyperthyroidism (180.07 Hz) and lowest in women with hypothyroidism (167.60 Hz). Frequency and amplitude perturbations increased sharply in both clinical groups, peaking in hypothyroidism (Jitter: 1.44%; Shimmer: 4.46%) followed by hyperthyroidism (Jitter: 1.33%; Shimmer: 3.83%). Spectral measures confirmed severe glottal inefficiency in hypothyroidism, which showed the lowest HNR (14.63 dB) and highest NHR (0.30). Perceptually, 100% of controls presented normal voice quality, while women with hypothyroidism demonstrated the highest rates of moderate-to-severe dysphonia, roughness, breathiness, and asthenia. Women with hyperthyroidism predominantly displayed mild-to-moderate vocal changes.

Both hypothyroidism and hyperthyroidism result in distinct, objective and quantifiable vocal deviations detectable via acoustic and perceptual protocols. SLPs serve an essential role in the multi-disciplinary management of endocrine disorders, utilizing multi-dimensional voice analysis to diagnose voice deviations due to laryngeal tissue changes early, track treatment efficacy and provide targeted, evidence-based vocal rehabilitation.

Keywords: Thyroid disorders, women with hypothyroidism, women with hyperthyroidism, acoustic analysis, perceptual analysis, Kerala

INTRODUCTION

The thyroid gland, situated in the anterior neck, is an endocrine organ that influences multiple organ systems and functions, such as cardiac output, thermoregulation, tissue oxygenation, fetal development, nervous system stimulation and reproductive health (Chaker et al, 2017). It structurally wraps around the cricoid cartilage and upper tracheal rings (Allen & Fingeret, 2025).

Thyrotropin-releasing hormone (TRH) secreted by the hypothalamus, prompts the pituitary gland to release thyroid-stimulating hormone (TSH). TSH in turn stimulates the thyroid to produce iodothyronines, including free thyroxine (T4), triiodothyronine (T3) and reverse T3 (rT3) (Dhir et al, 2024). The levels of T4 and T3 in the blood are regulated within a fairly narrow range through a refined feedback system involving the thyroid gland, pituitary gland and hypothalamus (Brahmaiah et al, 2013). The healthy thyroid gland secretes roughly 7% triiodothyronine and 93% thyroxine (Khan et al, 2002). These hormones have a various effect on the body but the major fundamental role is to stimulate metabolism. It also has a significant influence on voice production.

The endocrine system has a profound influence on vocal quality, with thyroid hormones playing a uniquely direct role in laryngeal function. Consequently, pathological conditions of the thyroid and parathyroid glands represent the most prevalent endocrine disorders underlying clinical phonation disturbances. The main cause of thyroid disease is the improper working of thyroid gland.

Thyroid diseases are among the most prevalent endocrine diseases and Kerala is no exception. A community-based survey conducted in Cochin, and indexed in Medline revealed that thyroid function abnormalities were present in 19.6% of the adult population (Menon et al, 2009).

In India, about 42 million people suffer from thyroid disease, making it the most common endocrine disorder (Abirami et al, 2024). Thyroid and parathyroid gland disorders represent the most prevalent endocrine conditions leading to voice disturbances. Females are also reported to have a higher incidence of thyroid disorders (15.86%) compared with males (5.02%), and in India, thyroid problems are estimated to affect approximately 11% of the population (Unnikrishanan et al, 2013).

Thyroid disorders arise from multifactorial etiologies, including autoimmune processes, iodine imbalance, genetic predispositions, environmental toxins, and iatrogenic factors. Autoimmunity is the most common cause such as Hashimoto's thyroiditis (chronic lymphocytic thyroiditis) drives >90% of hypothyroidism cases via antibody-mediated destruction of thyroid tissue (e.g., anti-thyroid peroxidase [anti-TPO] and anti-thyroglobulin antibodies) (Caturegli et al., 2014).

Iodine deficiency, though rarer in iodized-salt regions like India, causes goitrous hypothyroidism, while excess iodine can precipitate hyperthyroidism. Genetic factors (e.g., mutations in TSH receptor or thyroid peroxidase genes) and environmental triggers (radiation, smoking, stress) also contribute. Iatrogenic causes include post-thyroidectomy hypothyroidism, lithium/amiodarone therapy, or radioactive iodine for hyperthyroidism. Infiltrative diseases (e.g., amyloidosis) and congenital defects (e.g., dyshormonogenesis) are less common.

Thyroid diseases are broadly classified into hyperthyroidism, characterized by excessive thyroid hormone production leading to accelerated metabolism, and hypothyroidism, marked by insufficient hormone output resulting in slowed bodily functions. (Kanase et al., 2021).

Thyroid disorders can be primary when they originate from an intrinsic pathology within the gland itself

or secondary when the dysfunction results from external factors affecting the gland (Alyahya et at, 2021). Hyperthyroidism includes conditions like Graves' disease, the most common cause involving autoimmune stimulation of the thyroid; toxic multinodular goiter; and toxic adenoma, where nodules overproduce hormones. Hypothyroidism encompasses primary forms such as Hashimoto's thyroiditis (an autoimmune attack on the gland), iodine deficiency and thyroiditis, as well as secondary types due to pituitary or hypothalamic dysfunction. Additional structural and etiological thyroid disorders include goiter (enlargement of the gland), thyroid nodules (benign or malignant lumps), thyroiditis (inflammation in acute, subacute, or chronic forms), and thyroid cancer (e.g., papillary, follicular, or medullary types) (Dhir et al, 2024).

Untreated or poorly managed thyroid disease, whether hyperthyroidism or hypothyroidism can lead to many serious health complications, including heart problems, bone issues, fertility problems, and in severe cases, life-threatening conditions.

Thyroid disorders disrupt hormone balance, influencing nearly every body system through altered metabolism and energy regulation. Hypothyroidism reduces heart rate, stiffens arteries, raises blood pressure, and elevates cholesterol, increasing risks of heart disease and stroke ,whereas Hyperthyroidism speeds heart rate, causes irregular rhythms like atrial fibrillation, and heightens cardiovascular strain. Low thyroid hormones impair brain function, leading to depression, memory issues, brain fog, and neuropathy symptoms like numbness. Hyperthyroidism may trigger anxiety, tremors, and irritability. Hypothyroidism causes muscle weakness, cramps, joint pain, and stiffness, complicating daily movements. Hyperthyroidism promotes muscle wasting, weakness, and osteoporosis by hindering calcium absorption Hypothyroidism slows digestion, resulting in constipation and bloating. Hyperthyroidism speeds transit causing diarrhoea.

Thyroid disorders also majorly affect the voice, with hypothyroidism causing hoarseness, vocal fatigue, pitch deepening, and cord swelling due to fluid buildup or goiter pressure on the recurrent laryngeal nerve. Hyperthyroidism leads to reduced pitch, trembling, roughness, or breathiness often improving post-treatment.

People of all ages are prone to have thyroid disorders. Thyroid disease in more frequently observed in women than men. In women, the intersection of high thyroid-disease prevalence, elevated vocal-load occupations (such as teaching, nursing and customer-service roles) and greater reporting of voice symptoms makes them particularly vulnerable to the communicative and psychosocial effects of thyroid-related dysphonia.

The human voice is exceptionally susceptible to systemic endocrine shifts. The larynx is a primary target tissue for thyroid hormones, a relationship confirmed by the presence of thyroid receptors in both male and female larynx of human cadavers. Among the endocrine system that modulate vocal function, thyroid hormones have been demonstrated to directly impact laryngeal tissue and overall vocal function (Kakadia et al, 2013). Change in voice quality is a commonly noted symptom in individuals with thyroid dysfunction. Voice changes may occur even in the cases of mild thyroid failure since thyroid hormone receptors have been found in the larynx, which proves that the thyroid hormone acts in the laryngeal tissue (Altman et al, 2003).

The higher vulnerability to voice problems in women may be partly attributed to thyroid-related conditions. Thyroid hormones regulate fluid retention in the vocal folds by modulating polysaccharide levels, thereby helping to maintain normal thickness of the vocal-fold layers. When thyroid dysfunction co-occurs with voice disorders, the vocal-fold mucosa is altered, placing the laryngeal system at greater

risk for voice changes.

Endocrine disruptions like hypothyroidism frequently provoke tissue irritation. Its symptoms are subtler than those of hyperthyroidism and prominently feature voice alterations. In primary hypothyroidism, TSH levels are above the reference range due to hypofunction of thyroid gland and the thyroxin levels are below or within the normal range. Even mild thyroid insufficiency can trigger voice changes which results due to myxedema (swollen) of vocal folds, as thyroid hormone receptors exist in laryngeal tissue, confirming direct hormonal action there (Goyal & Kumawat, 2025). Hoarseness is reported to be the primary voice complaint of hypothyroidism (Unlu et al, 2021). Common manifestations include lowered pitch, roughness, diminished range and vocal fatigue (Melnick, 2011).

The vocal symptoms may be due to the vocal fold edema from mucopolysaccharide buildup in the lamina propria, cricothyroid muscle edema and vocal fold constriction by enlarged thyroid gland (Altman et al, 2003). The endocrine imbalance in hypothyroidism frequently result in soft tissue and mucosal modifications within the larynx that may affect phonation (Andrews, 2006). Because the human voice remains highly susceptible to hormonal changes, deficiencies in thyroid hormones systematically cause a gradual, progressive hoarseness and restricted functional pitch range both of which serve as clinical markers of primary hypothyroidism (Harikumar et al, 2016).

Excess thyroid hormone in hyperthyroidism or overproduction leads to hyperkinesia, elevated blood pressure, tachycardia, exophthalmos, sweating, weight loss, and generalized weakness and fatigue. And it also induces dysphonia, most notably through reduced fundamental frequency (F0). Additional symptoms encompass hoarseness, roughness, voice loss, tremulousness, decreased intensity and audible breathing. Generalized fatigue and weakness may lead to phonasthenia (Kovacic, 2018). Often observed symptom of hyperthyroidism is muscle weakness that can impair the function of laryngeal muscles ultimately affecting voice parameters (Kamiński et al, 2022). The most prevalent change is the reduction of the fundamental frequency (F0) of the voice (Ibrahimagić et al, 2019).

When compared to sudden onset of hyperthyroidism, the clinical progression of hypothyroidism is typically subtle and insidious with early variations in voice quality serving as one of its most frequently documented clinical manifestations (Cobin et al, 2012). Watt et al (2000) demonstrated voice changes are present in 27% of patients with hyperthyroidism and in 2%-98% of patients with hypothyroidism.

Untreated hyper- or hypothyroidism can lead to chronic voice changes that affect quality of life (QoL), self-confidence, and occupational participation. In females, even when hormonal parameters are within reference ranges, subtle voice changes may persist, suggesting that functional and laryngeal adaptation after thyroid fluctuation must also be considered.

A standard medical assessment typically involves blood tests measuring TSH which is elevated in hypothyroidism and suppressed in hyperthyroidism, free thyroxine which is low in hypothyroidism and high in hyperthyroidism. Imaging such as ultrasound for nodules/goiter, radioactive iodine uptake scan or thyroid scintigraphy and biopsy done using fine-needle aspiration for suspicious nodules. And also, a clinical evaluation is done to review the symptoms, a physical examination and ENT laryngoscopy for voice-related laryngeal changes.

Traditional clinical protocols have focused mainly on metabolic and cardiovascular stability and have often overlooked communicative well-being. While systemic manifestation and overall health consequences of thyroid disorders are well documented, research regarding their specific impact on voice characteristics remains limited and hence a standard voice assessment should complement routine evaluations (Stogowska et al, 2022).

The profiling and documenting of these voice changes by Speech-Language Pathologists (SLPs) are essential for understanding the physiological basis and for further management. SLPs utilize a comprehensive, multi-modal approach to evaluate voice changes in thyroid disorders, combining perceptual, acoustic, aerodynamic and endoscopic methods for robust pre- and post-treatment profiling.
A standardized acoustic and perceptual voice analysis thus provides a crucial bridge between endocrine medicine and voice. Acoustic analysis of voice is the most widely utilized, non-invasive vocal assessment method which is used extensively in dealing with professional voice users and others clinical populations for voice diagnosis, therapy and research. It provides fundamental, objective data that helps in the diagnosis and treatment of individuals with voice disorders. By analyzing sustained vowel production, it enables clinician to understand fundamental frequency (F0), intensity and the filter characteristics (formant frequencies, jitter, shimmer and so on). The acoustic parameters most commonly used in acoustic analysis of voice include fundamental frequency (F0), jitter, shimmer and harmonic to noise ratio (HNR) and noise to harmonic ration (NHR).
To generate these multi-dimensional voice profiles, SLPs utilize advanced computer-based software programs that are available for voice analysis such as PRAAT, Dr. Speech, LingWAVES, Computerized speech lab (CSL) and the Multi-Dimensional Voice Profile (MDVP) which generate comprehensive acoustic profiles. Among these software, PRAAT is preferred because it is designed to cater to diverse needs with a user-friendly interface, numerous default options that facilitate learning through experimentation, searchable manual and various possibilities for analysis, manipulation and labelling. These features allow for tracking errors across atypical voice signals (Goldman, 2004).
Acoustic analysis using software such as PRAAT (Boersma & Weenink, 2011) is utilized to quantify perturbations from sustained vowels (/a/, /i/ and /u/) and connected speech by evaluating F0, Jitter (cycle-to-cycle frequency variation >1.2% abnormal) and shimmer (amplitude variation >5%), Noise-to-Harmonic Ratio (NHR >0.2) and harmonics-to-noise ratio. To capture these parameters, the clinician typically records a individual performing certain tasks such as sustained phonation which provide a stable window to calculate F0, Jitter, shimmer. To systematically differentiate pathological dysphonia from typical vocal variations, clinicians evaluate objective findings against established normative data. While the norms for healthy females are characterized by jitter less than 1.0%, shimmer less than 3.5%, NHR less than 0.15 (Baken & Orlikoff, 2000).
A comprehensive voice evaluation requires pairing acoustic analysis with validated perceptual tools. Perceptual assessment bridges the gap between acoustic data and how voice actually impacts an individual's communication. The formal perceptual assessment typically involves the use of a protocol to systematically describe and quantify voice characteristics. Several standardized perceptual assessments are widely recognized including Consensus Auditory-Perceptual Evaluation of voice (CAPE-V), Voice handicap index (VHI), Voice related quality of voice (VRQoL), Voice symptom scale (VoiSS) and GRBAS (Grade, Roughness, Breathiness, Asthenia and Strain).
For clinical and academic research, the GRBAS scale (Hirano, 1981) has been used, as it is widely considered the golden standard due to its ease of clinical use and high correlation with objective acoustic parameters.
GRBAS rating scale is a validated 4-point Likert-scale. The scale is assigned on a score of 0-3 where, 0 indicates a normal or typical voice, 1 represents slight deviation, 2 denotes moderate impairment and 3 signifies severe vocal impairment which evaluate five vocal characteristics. The five characteristics are grade (G) which reflects the degree of hoarseness serving as a measure of overall voice quality, roughness

(R) that denotes audible irregularity of vocal fold vibration directly mirroring acoustic jitter and uneven vocal fold vibrations, breathiness (B) captures the perceptual consequence of air leakage through inadequate glottal closure that correlates with a lower HNR, asthenia (A) characterizes the weakness depicting a voice that perceptually lacks power and strain (S) represents the auditory perception of vocal hyperfunction indicating excessive muscular effort (Junuzović-Žunić et al, 2019).

Systematic acoustic and perceptual analysis of voice in women with hypothyroidism and hyperthyroidism offers a sensitive, objective and clinically relevant means of characterizing thyroid-related voice changes, understanding their impact on communication and quality of life (QoL) and guiding holistic management of these highly prevalent endocrine conditions.

SLPs play a key role in assessing thyroid-related voice changes through perceptual and instrumental methods. SLPs play a key role in this multidisciplinary approach, using combined acoustic, perceptual, and aerodynamic methods to detect early or subtle dysphonia that may not be evident on routine endocrine or ENT evaluation, monitor pre- versus post-treatment changes in voice following hormone-replacement or antithyroid therapy, differentiate between hormonally-mediated dysphonia and co-existing structural or functional voice disorders and inform voice-therapy planning and provide patient-centered counselling about vocal hygiene and effort-reduction techniques.

WESTERN LITERATURE

Mohammadzadeh et al (2011) compared multiple voice parameters between a control group and 120 symptomatic primary hypothyroid patients (106 females and 14 males). The results showed that regardless of gender, hypothyroid patients experienced a significant decrease in both mean and minimum F0 as well as an increased peak-to-peak amplitude variation, shimmer, NHR. Additionally, the patients also reported a high prevalence of dryness in the larynx, globus sensation (sensation of lump in the throat).

Allison (2011) conducted a comparative analysis of vocal characteristics between hypothyroid patients and health control group using the CAPE-V and findings revealed a significant difference across all the six parameters evaluated by CAPE-V. Specifically, the parameters of overall severity and roughness were highly pronounced markers of dysphonia when compared to the healthy control group.

Bone et al (2012) examined the auditory perceptual voice characteristics in 96 individuals with thyroid disease before they underwent thyroid surgery by using the perceptual voice profile and results revealed that majority of participants has slight to mild severity and approximately 8% demonstrated distinct, clinically auditory perceptual abnormalities. These findings support the need for auditory-perceptual ratings to be incorporated as part of pre-operative multidimensional assessment of voice in patients with thyroid disease.

Costa and Pernambuco (2014) investigated vocal self-assessment and auditory-perceptual assessment of voice in 40 females with a mean age of 49.5 years diagnosed with thyroid disease. They found that 19 (47.5%) reported complaints of dysphonia and that patients with vocal complaints had worse scores on self-assessment.

Kovačić (2018) investigated subjective voice complaints and acoustic voice parameters in 18 women within the age range of 20 to 56 with hyperthyroidism and found that patients often report hoarseness, voice fatigue, and lowering of voice pitch, which are mirrored by objective acoustic deviations, particularly lower fundamental frequency and reduced laryngeal efficiency. The study concluded that voice changes should be regarded as a potential clinical feature of hyperthyroidism and that subjective

complaints correlate with measurable acoustic dysfunction.

Junuzović-Žunić et al (2019) investigated acoustic, perceptual using GRBAS rating scale and aerodynamic voice parameters in 20 female patients with hypothyroidism and 27 female patients with hyperthyroidism, assessed before and six months after starting drug therapy. They reported that both hypothyroid and hyperthyroid women showed significant improvement in perceptual voice characteristics (roughness, breathiness, strain) after six months of hormone-replacement or antithyroid treatment, while acoustic changes were more limited and mainly involved perturbation and noise-harmonics measures in hypothyroid patients and MPT in hyperthyroid patients.

Unlu (2022) evaluated and compared acoustic and perceptual using the GRBAS rating scale and VHI-10 in 26 females newly diagnosed with subclinical hypothyroidism and 26 with overt primary hypothyroidism in comparison with healthy controls. They indicated that overt hypothyroidism has a statistically significant decrease in frequency parameters (fundamental frequency Fo, highest frequency Fhi, and lowest frequency Flo) compared to controls (p values around 0.002 to 0.01). They also concluded that primary hypothyroidism does not exert a significant effect on clinician-rated perceptual voice parameters until T4 levels are actively depleted, no alterations on the GRBAS rating scale are found. Although the subclinical hypothyroid group compared to control showed no significant differences on the GRBAS rating scale, individuals with overt hypothyroidism showed vocal changes and a higher VHI-10 index was reported, reflecting patients' subjective voice assessment was significantly increased in the overt hypothyroidism group compared to controls.

Afsah et al (2022) evaluated voice changes in patients with hypothyroidism Despite the absence of perceptual voice changes in our patients with hyperthyroidism, subtle changes in the acoustic and aerodynamic parameters could be detected with a trend towards laryngeal dysfunction. The results revealed that MPT and HNR were significantly lower and shimmer was significantly higher in hyperthyroid patients when compared to the reference group. Pitch and jitter were also higher in hyperthyroid patients, but the difference was not statistically significant.

INDIAN LITERATURE

Gupta et al (1977) conducted a study to systematically examined the nasal, pharyngeal and laryngeal effects of hypothyroidism and findings reported that increased vocal fold mass can cause hoarseness in about 40.9% of cases and vocal fatigue in about 25.8%.

Dodderi et al (2018) conducted a retrospective study of 11 years in a tertiary-care hospital in Mangaluru and reported an overall prevalence of 21.4% for voice disorders among 4,765 communication-disordered patients. In the adult subgroup, adult females showed a higher prevalence (85.04%) compared with adult males (61.7%), suggesting that adult women are disproportionately affected by voice disorders in this Indian clinical population.

Krishnan et al (2019) investigated 50 hypothyroid cases against 50 controls and the results revealed that voice changes and fatigue were the most common complaints. Subjective voice problems were reported by 32% of hypothyroid cases. Compared with controls, hypothyroid patients showed prolonged MPT and s/z ratio. Acoustic voice analysis also revealed a significant increase in jitter, shimmer along with a significantly lower DSI among the cases when compared to controls. GRBAS scores indicated mild to severe abnormalities in the parameters when two groups were compared.

Rani et al (2026) conducted a study to objectively evaluate voice changes in 30 newly diagnosed females with primary hypothyroidism ages 18-50 years and measure the recovery following 3 months of

Levothyroxine therapy. PRAAT and VHI-10 was used and the results demonstrated a statistically significant reversal of baseline vocal deviations, with a notable increase in mean F0 from 173.2 Hz to 192.4 Hz alongside improvements in jitter, shimmer, HNR, MPT and patient perceived QoL as indicated by VHI. These findings highlighted the role of objective acoustic analysis as a tool for tracking vocal function in hypothyroid patients.

NEED OF THE STUDY

Thyroid disorders, particularly hypothyroidism and hyperthyroidism are among the most prevalent endocrine conditions. In India, approximately 32 million people suffer from thyroid disorders and are still not adequately identified and treated. Females are more frequently affected than males and their risk increase with age (Rashid & Ali, 2025). In females with thyroid disorders, hormonal imbalance leads to physiological and structural changes in vocal folds such as lamina propria swelling in hypothyroidism and laryngeal muscle weakness in hyperthyroidism.

Most existing studies primarily focus on post-thyroidectomy complications like recurrent laryngeal nerve or superior laryngeal nerve paralysis and their subsequent effects on voice. The necessity in examining these two disorders lies in their opposite pathophysiological effects, as both can impair vocal quality but through different mechanisms. Despite various research focusing on thyroid disorders identification and management, fewer or limited studies have been carried out to assess the comparison of the acoustic and perceptual characteristics of thyroid related voice changes in young women with hypothyroidism and hyperthyroidism in Kerala. The aim of the present study is to evaluate and compare the acoustic analysis and perceptual voice characteristics using GRBAS rating scale in young females with hypothyroidism and hyperthyroidism. Hence, routine voice assessment and intervention along with regular follow up by SLPs is necessary to help these individuals improve their QoL.

METHOD

AIM

The aim of the present study is to evaluate and compare the acoustic analysis and perceptual characteristics of voice using GRBAS in young adult females aged 18-35 diagnosed with hypothyroidism and hyperthyroidism.

PARTICIPANTS

- A total of 45 females (15 diagnosed with hypothyroidism and 15 diagnosed with hyperthyroidism for a duration of ≤ 5years) and 15 females with normal thyroid function taken from Thalassery in the Kannur district of Kerala. Clinical confirmation of thyroid function, serum TSH and T4 levels from medical record were verified using the participants' medical records to confirm hypothyroidism, hyperthyroidism and normal thyroid function.
- Group 1: 15 females with normal thyroid function
- Group 2: 15 females diagnosed with hyperthyroidism
- Group 3: 15 females diagnosed with hypothyroidism

Inclusion criteria:

- Participants within the age range of 18-35 years
- Participants diagnosed with primary hypothyroidism
- Participants diagnosed with primary hyperthyroidism

- Participants with no complaints of voice problems, upper respiratory tract infection, allergies and respiratory dysfunction.
- No history of oromotor, communicative or cognitive impairments.

Exclusion criteria:

- Participants with any neurological involvement, articulatory deficits and any speech, language and hearing impairment (HI).
- Participants who have undergone vocal surgeries.
- History of smoking

INSTRUMENTATION AND TOOLS:

Acoustic Analysis was done using PRAAT (version 6.4.56) software. It is a free computer software for voice analysis (Boersma & Weenink, 1991). The acoustic parameters chosen for the present study were fundamental frequency (F0), jitter %, shimmer %, harmonics-to-noise ratio (HNR), noise-to-harmonics ratio (NHR).

Perceptual assessment was carried out by using the standardized GRBAS scale (Hirano, 1981) which is a clinician-based scale and is the gold standard in perceptual analysis of voice quality. Each voice sample was rated across five parameters: Grade (overall degree of voice quality), Roughness (perceived irregularity in voice), Breathiness (audible air escape in voice), Asthenia (weakness in voice) and Strain (perception of excessive vocal effort). Each parameter is quantified on a 4-point Likert scale, where from 0 = normal, 1 = slight, 2 = moderate and 3 = severe.

PROCEDURE

The study was carried out in 2 phases:

Phase 1: Acoustic analysis

For acoustic analysis of voice, participants were instructed to be seated comfortably and recordings were made using a microphone attached to DELL Laptop in a quiet environment. The placement of microphone was 3 cm away from mouth of the participants. Participants were asked to take a deep breath and produce a sustained phonation of /a/ vowel at a comfortable pitch and loudness for as long as possible. This was demonstrated by examiner for all participants.

Phase 2: Perceptual analysis

For perceptual analysis, the recorded voice samples were evaluated by a speech language pathologist using the GRBAS rating scale.

STATISTICAL ANALYSIS

The data was subjected to statistical analysis and quantitative data was summarized by mean and standard deviation. Mean scores across different age groups were compared using one-way analysis of variance (ANOVA), followed by Bonferroni post hoc analysis for pairwise comparisons. Comparison of categorical variables between groups was carried out using the Kruskal Wallis test and Man Whitney test with adjusted p value. The p value < 0.05 was considered significant. Data was analyzed using the SPPS software (version 23.0).

ETHICAL CONSIDERATION

The present study was carried out by obtaining consent from the individuals ensuring their permission to

assess their medical records. The objectives of the study, method and duration of the assessment procedures were clearly explained to all the female participants with thyroid disorders prior to testing. They were also assured that their participation was entirely voluntary and that strict confidentiality would be maintained regarding their medical history. A written format of the ethical consent is included in the Appendix.

RESULTS AND DISCUSSION

The present study aimed to evaluate and compare the acoustic and perceptual characteristics of young adult females with hypothyroidism and hyperthyroidism by analyzing voice parameters such as Fundamental frequency (F0), Jitter%, Shimmer%, Harmonic to noise ratio (HNR) and Noise to harmonic ratio (NHR). PRAAT voice analysis software was used to record the phonation of a vowel /a/. Perceptual analysis was carried out by using GRBAS rating scale. The results obtained were statistically analyzed and the results are as follows.

Table 4.1 shows the comparison of F0 across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		Mean	Std. Deviation	95% Confidence Interval for Mean		To test across the groups-ANOVA test		Bonferroni post hoc analysis-p value		
				Lower Bound	Upper Bound	F value	P	Group 1 vs Group 2	Group 1 vs Group 3	Group 2 vs Group 3
F0 (Hz)	HEALTHY WOMEN (GROUP 1)	213.93	7.76	209.64	218.23	64.182	0.0001 HS	0.0001 HS	0.0001 HS	0.015 S
	WOMEN WITH HYPOTHYROIDISM (GROUP 2)	167.60	14.40	159.63	175.57					
	WOMEN WITH HYPERTHYROIDISM (GROUP 3)	180.07	11.64	173.63	186.52					

*HS - Highly Significant, S - Significant

Figure 4.1 shows F0 for healthy women, women with Hypothyroidism and women with Hyperthyroidism

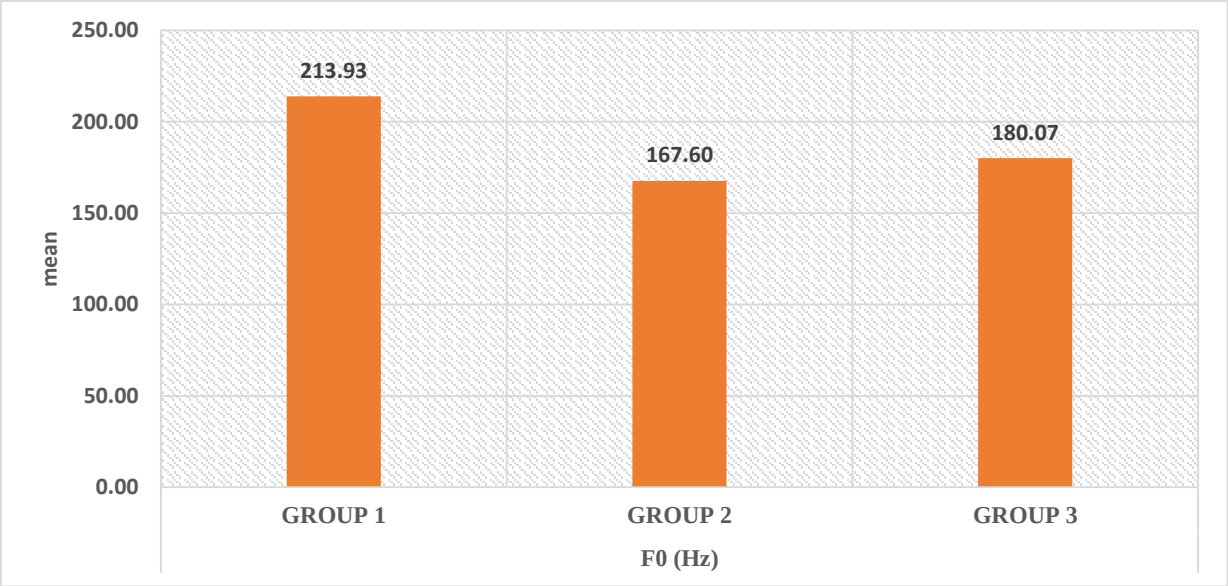

Table 4.1 and figure 4.1 revealed that mean F0 was highest in healthy women (213.93 Hz) followed by women with hyperthyroidism (180.07 Hz) and lowest in women with hypothyroidism (167.60 Hz). Highly significant differences were observed between healthy women and women with hypothyroidism, as well as between healthy women and women with hyperthyroidism. Significant differences were noticed between women with hypothyroidism and women with hyperthyroidism.

Table 4.2 shows the comparison of Jitter across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		Mean	Std. Deviation	95% Confidence Interval for Mean		To test across the groups-ANOVA test		Bonferroni post hoc analysis-p value		
				Lower Bound	Upper Bound	F value	P	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3
Jitter (%)	HEALTHY WOMEN (GROUP 1)	0.56	0.11	0.49	0.62	12.319	0.0001 HS	0.0001 HS	0.001 HS	1.000 NS
	WOMEN WITH HYPOTHY	1.44	0.70	1.06	1.83					

	ROIDISM (GROUP 2)									
	WOMEN WITH HYPERTHYROIDISM (GROUP 3)	1.33	0.59	1.00	1.65					

*HS - Highly Significant, NS - Non Significant

Figure 4.2 shows the Jitter% for healthy women, women with Hypothyroidism and women with Hyperthyroidism

Table 4.2 and figure 4.2 showed that the mean Jitter% was highest in women with hypothyroidism (1.44%) followed closely by women with hyperthyroidism (1.33%) and was lowest in healthy women (0.56%). Hence, highly significant differences were noticed between healthy women and women with hypothyroidism, as well as between healthy women and women with hyperthyroidism. However, no significant differences were observed between women with hypothyroidism and hyperthyroidism.

Table 4.3 shows the comparison of Shimmer% across healthy women, women with Hypothyroidism and women with Hyperthyroidism

	Mean	Std. Deviation	95% Confidence Interval for Mean		To test across the groups-ANOVA test		Bonferroni post hoc analysis-p value		
			Lower Bound	Upper Bound	F value	P	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3

Shimmer (%)	HEALTHY WOMEN (GROUP 1)	0.96	0.26	0.82	1.10	22.380	0.0001 HS	0.0001 HS	0.001 HS	0.800 NS
	WOMEN WITH HYPOTHYROIDISM (GROUP 2)	4.46	2.29	3.19	5.73					
	WOMEN WITH HYPERTHYROIDISM (GROUP 3)	3.83	1.29	3.11	4.55					

*HS - Highly Significant, NS - Non Significant

Figure 4.3 shows the Shimmer% for healthy women, women with Hypothyroidism and women with Hyperthyroidism

Table 4.3 and figure 4.3 depicted that the mean Shimmer% was highest in women with hypothyroidism (4.46%) followed closely by women with hyperthyroidism (3.83%) and was lowest in healthy women (0.96%). Highly significant differences were noticed between healthy women and women with hypothyroidism, as well as between healthy women and women with hyperthyroidism. However, statistically no significant differences were observed between women with hypothyroidism and hyperthyroidism.

Table 4.4 shows the comparison of HNR across healthy women, women with Hypothyroidism and women with Hyperthyroidism

	Mean	Std. Deviation	95% Confidence	To test across the groups-ANOVA test	Bonferroni post hoc analysis-p value

*HS - Highly Significant, NS - Non Significant

				Interval for Mean						
				Lower Bound	Upper Bound	F value	p	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3
HNR (dB)	HEALTHY WOMEN (GROUP 1)	21.36	1.56	20.50	22.22	20.602	0.0001 HS	0.0001 HS	0.118 NS	0.0001 HS
	WOMEN WITH HYPOTHYROIDISM (GROUP 2)	14.63	3.35	12.78	16.49					
	WOMEN WITH HYPERTHYROIDISM (GROUP 3)	19.09	3.45	17.18	21.01					

Figure 4.4 shows the HNR for healthy women, women with Hypothyroidism and women with Hyperthyroidism

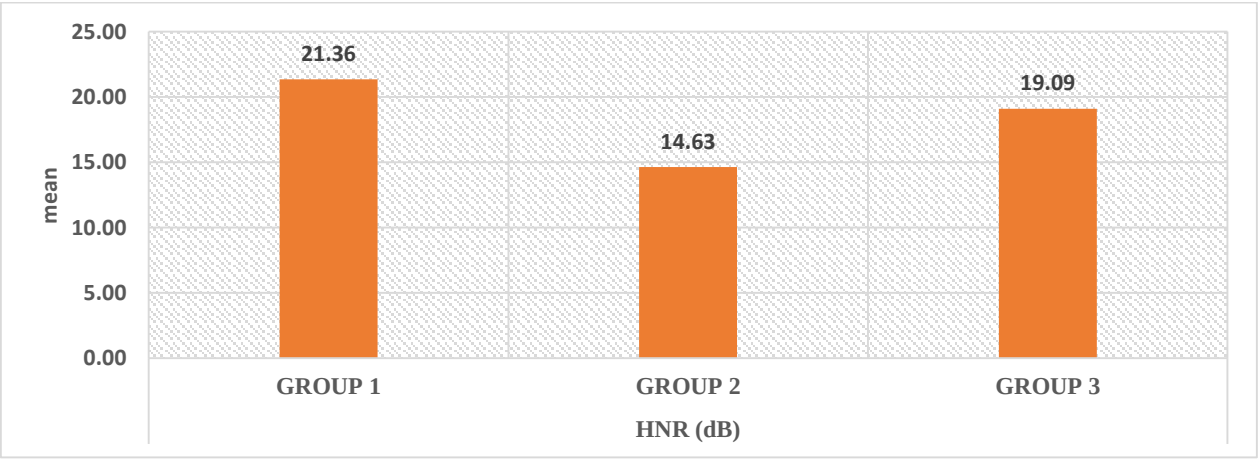

Table 4.4 and figure 4.4 revealed that the mean HNR was highest in healthy women (21.36 dB), followed by women with hyperthyroidism (19.09 dB) and was lowest in women with hypothyroidism (14.63 dB). A highly significant difference was found between healthy women and women with hypothyroidism, as well as between women with hypothyroidism and women with hyperthyroidism, while no significant differences was observed between healthy women and women with hyperthyroidism.

Table 4.5 shows the comparison of NHR across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		Mean	Std. Deviation	95% Confidence Interval for Mean		To test across the groups-ANOVA test		Bonferroni post hoc analysis-p value		
				Lower Bound	Upper Bound	F value	p	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3
NHR	HEALTHY WOMEN (GROUP 1)	0.02	0.00	0.02	0.03	81.145	0.0001 HS	0.0001 HS	0.0001 HS	0.0001 HS
	WOMEN WITH HYPOTHYROIDISM (GROUP 2)	0.30	0.07	0.26	0.34					
	WOMEN WITH HYPERTHYROIDISM (GROUP 3)	0.18	0.07	0.14	0.22					

*HS - Highly Significant

Figure 4.5 shows the mean value of NHR for healthy women, women with Hypothyroidism and women with Hyperthyroidism

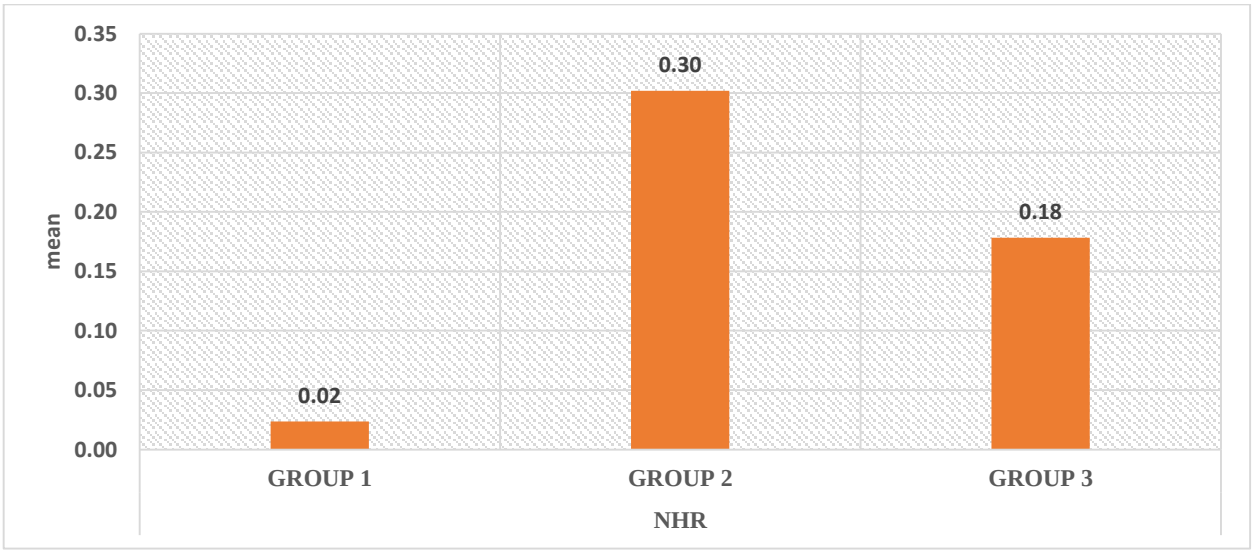

Table 4.5 and figure 4.5 depicted that the mean NHR was highest in women with hypothyroidism (0.30%) followed by women with hyperthyroidism (0.18%) and was lowest in healthy women (0.02%). Highly significant differences were found between healthy women and those with hypothyroidism, as well as between healthy women and women with hyperthyroidism. In addition, a highly significant difference was also observed between women with hypothyroidism and hyperthyroidism.

Perceptual analysis was carried out by using GRBAS rating scale

Table 4.6 shows comparison of Grade across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		GROUP								
		HEALTHY WOMEN (GROUP 1)		WOMEN WITH HYPOTHYROIDISM (GROUP 2)		WOMEN WITH HYPERTHYROIDISM (GROUP 3)		To compare across the groups-Kruskal wallis test	Post Hoc analysis -Wilcoxon signed test p value(adjusted)		
		Count	Column N %	Count	Column N %	Count	Column N %	p value	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3
Grade	0	15	100.0%	4	26.7%	5	33.3%	0.0001 HS	0.0001 HS	0.0001 HS	0.236 NS
	1	0	0.0%	3	20.0%	6	40.0%				
	2	0	0.0%	5	33.3%	3	20.0%				
	3	0	0.0%	3	20.0%	1	6.7%				

*HS - Highly Significant, NS - Non significant

Figure 4.6 shows Grade for healthy women, women with Hypothyroidism and women with Hyperthyroidism

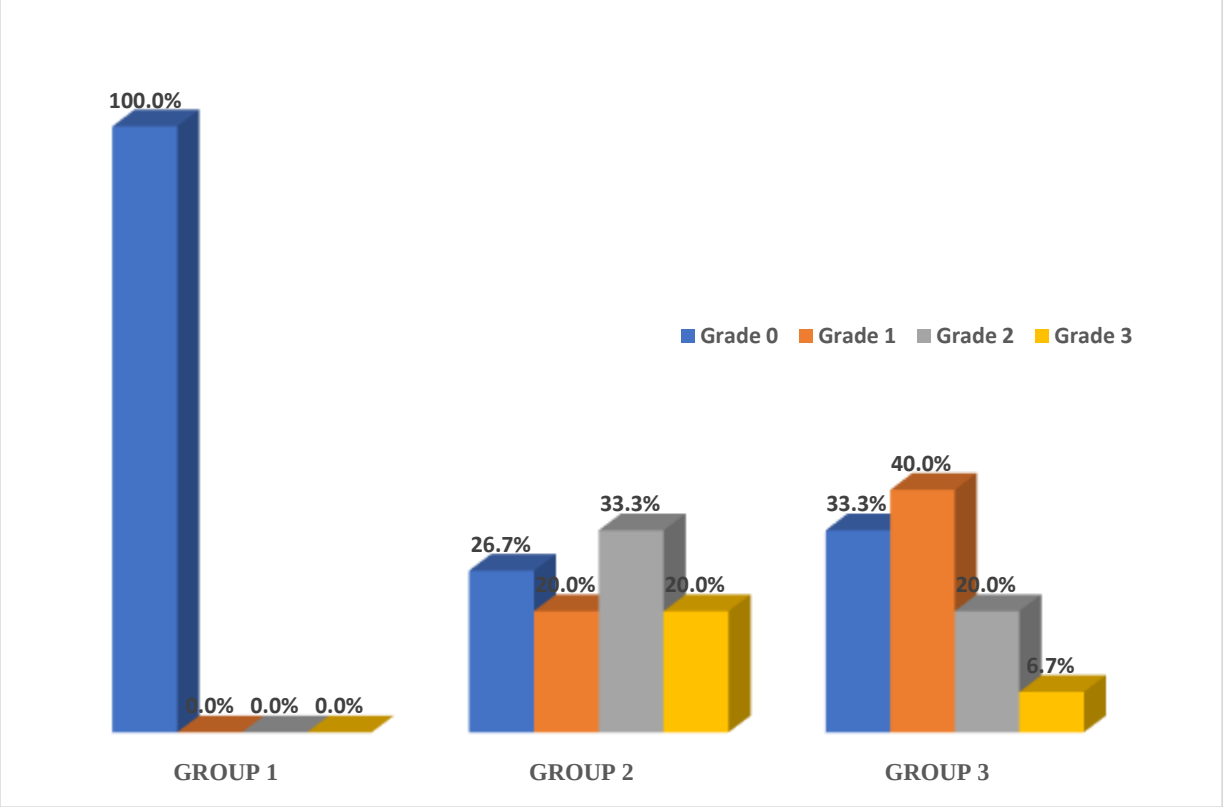

Table 4.6 and figure 4.6 indicated that all individuals in the healthy women (100%) presented with normal voice quality (Grade 0). For women with hypothyroidism, mild dysphonia (Grade 1) was noted in 20.0%, moderate dysphonia (Grade 2) in 33.3% and severe dysphonia (Grade 3) in 20.0%. For women with hyperthyroidism, mild dysphonia (Grade 1) was observed in 40.0%, moderate dysphonia (Grade 2) in 20.0% and severe dysphonia (Grade 3) in 6.7%. Highly significant differences was observed when comparing healthy women to women with hypothyroidism and healthy women to women with hyperthyroidism. However, no statistically significant difference in grade was observed between women with hypothyroidism and hyperthyroidism.

Table 4.7 shows comparison of Roughness across healthy women, women with Hypothyroidism and women with Hyperthyroidism

	GROUP									
	HEALTHY WOMEN (GROUP 1)		WOMEN WITH HYPOTHYROIDISM (GROUP 2)		WOMEN WITH HYPERTHYROIDISM (GROUP 3)		To compare across the groups-Kruskal wallis test	Post Hoc analysis -Wilcoxon signed test p value(adjusted)		
	Count	Colum	Count	Column N %	Count	Column N %	p value	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3

			n N %								
Roughness	0	15	100.0%	4	26.7 %	5	33.3 %	0.0001 HS	0.0001 HS	0.0001 HS	0.200 NS
	1	0	0.0 %	3	20.0 %	6	40.0 %				
	2	0	0.0 %	6	40.0 %	4	26.7 %				

*HS - Highly Significant, NS - Non significant

Figure 4.7 shows Roughness for healthy women, women with Hypothyroidism and women with Hyperthyroidism

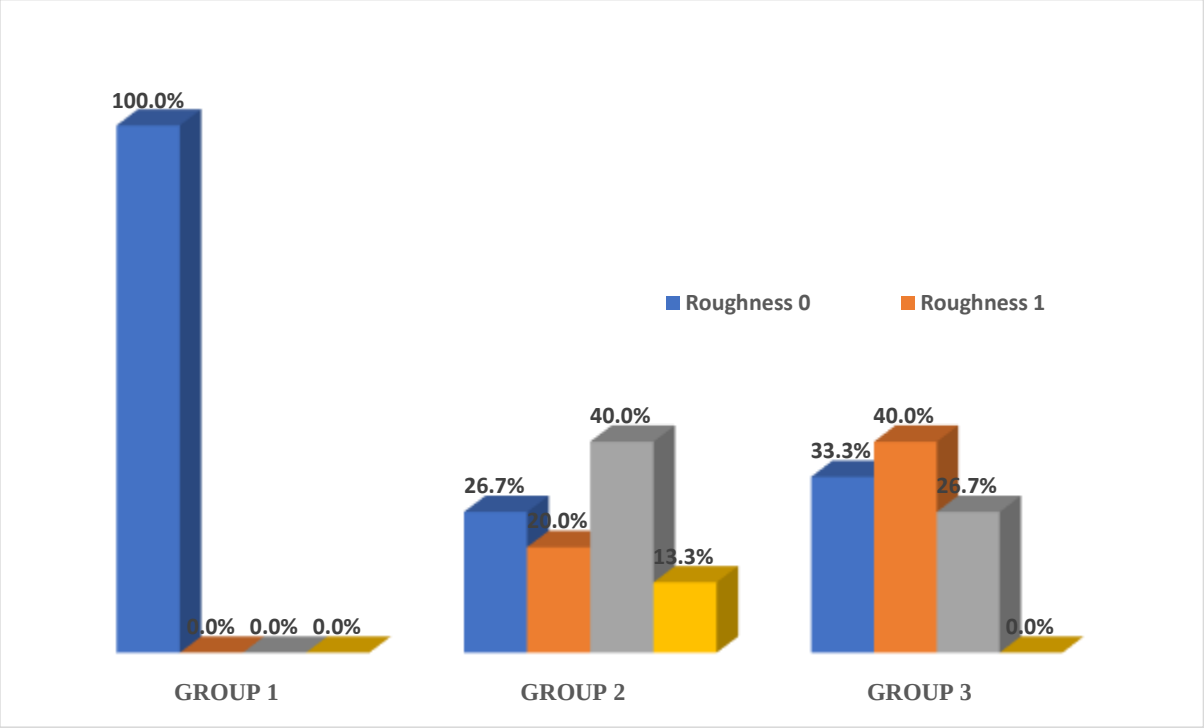

Table 4.7 and figure 4.7 revealed that all individuals in the healthy women (100%) presented with no roughness (Roughness 0). For women with hypothyroidism, mild roughness (Roughness 1) was noted in 20 % and moderate roughness (Roughness 2) in 40 % of the sample. For women with hyperthyroidism, mild roughness (Roughness 1) was observed in 40 % and moderate roughness (Roughness 2) in 26.7% of the participants. Highly significant differences were observed between healthy women and women with hypothyroidism as well as between healthy women and women with hyperthyroidism. However, for women with hypothyroidism and hyperthyroidism there was no significant difference in roughness.

Table 4.8 shows comparison of Breathiness across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		GROUP								
		HEALTHY WOMEN (GROUP 1)		WOMEN WITH HYPOTHYROIDISM (GROUP 2)		WOMEN WITH HYPERTHYROIDISM (GROUP 3)		To compare across the groups- Kruskal wallis test	Post Hoc analysis -Wilcoxon signed test p value(adjusted)		
		Count	Column N %	Count	Column N %	Count	Column N %	p value	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3
Breathiness	0	15	100.0%	5	33.3%	7	46.7%	0.0001 HS	0.0001 HS	0.0001 HS	0.377 NS
	1	0	0.0%	5	33.3%	5	33.3%				
	2	0	0.0%	5	33.3%	3	20.0%				

*HS - Highly Significant, NS - Non significant

Figure 4.8 shows Breathiness for healthy women, women with Hypothyroidism and women with Hyperthyroidism

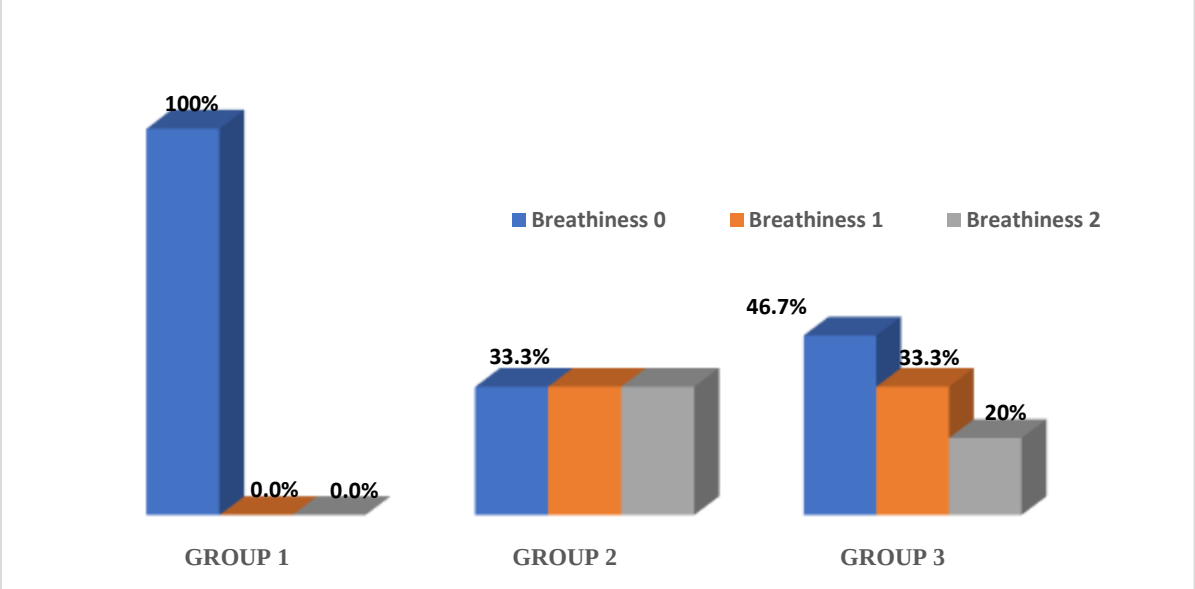

Table 4.8 and Figure 4.8 depicted that all healthy women (100%) presented with normal vocal quality regarding breathiness (Breathiness 0). For women with hypothyroidism, mild breathiness (Breathiness 1) was noted in 33.3% and moderate breathiness (Breathiness 2) in 33.3%. For women with hyperthyroidism, mild breathiness (Breathiness 1) was observed in 33.3% and moderate breathiness (Breathiness 2) in 20.0% of the participants. Highly significant differences were observed when comparing healthy women

to women with hypothyroidism and healthy women to women with hyperthyroidism. However, no significant difference in breathiness severity was observed between women with hypothyroidism and women with hyperthyroidism.

Table 4.9 shows comparison of Asthenia across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		GROUP								
		HEALTHY WOMEN (GROUP 1)		WOMEN WITH HYPOTHYROIDISM (GROUP 2)		WOMEN WITH HYPERTHYROIDISM (GROUP 3)	To compare across the groups- Kruskal wallis test	Post Hoc analysis -Wilcoxon signed test p value(adjusted)		
		Count	Column N %	Count	Column N %	Count	Column N %	p value	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3
Asthenia	0	15	100.0%	6	40.0%	9	60.0%	0.0001HS	0.004 HS	0.007 HS	0.249 NS
	1	0	0.0%	5	33.3%	4	26.7%				
	2	0	0.0%	4	26.7%	2	13.3%				

*HS - Highly Significant, NS - Non significant

Figure 4.9 shows Asthenia for healthy women, women with Hypothyroidism and women with Hyperthyroidism

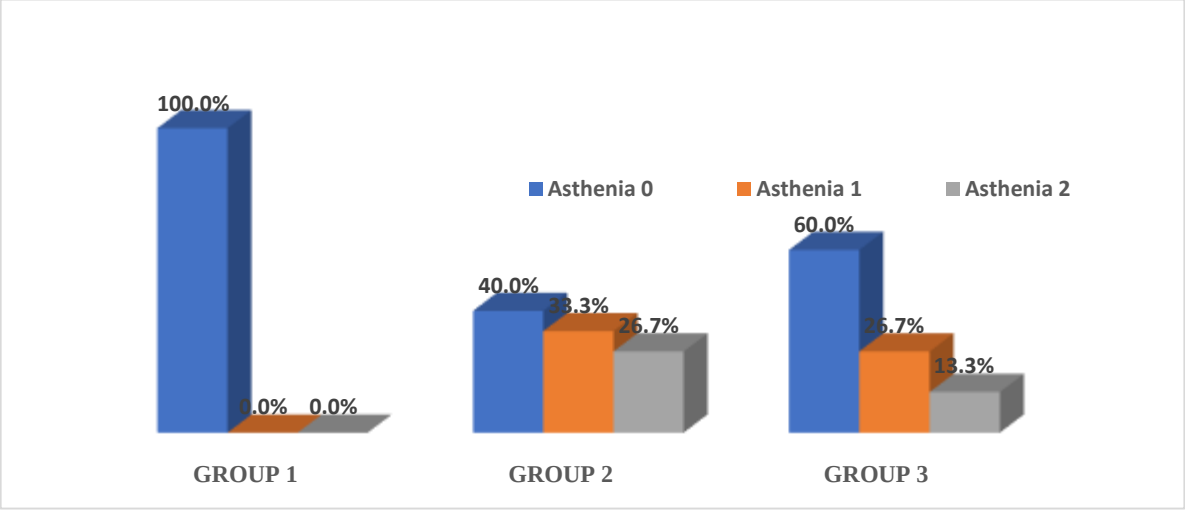

Table 4.9 and Figure 4.9 showed that all healthy women group (100%) presented with no asthenia in their voice quality (Asthenia 0). Among women with hypothyroidism, mild asthenia (Asthenia 1) was present in 33.3% and moderate asthenia (Asthenia 2) in 26.7%. For women with hyperthyroidism, 26.7% had mild asthenia (Asthenia 1) and 13.3% had moderate asthenia (Asthenia 2). Highly significant differences were

observed when comparing healthy women to women with hypothyroidism and healthy women to women with hyperthyroidism. Whereas, no significant difference in asthenia was observed between women with hypothyroidism and hyperthyroidism.

Table 4.10 shows comparison of Strain across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		GROUP									
		HEALTHY WOMEN (GROUP 1)		WOMEN WITH HYPOTHYROIDISM (GROUP 2)		WOMEN WITH HYPERTHYROIDISM (GROUP 3)		To compare across the groups- Kruskal wallis test	Post Hoc analysis -Wilcoxon signed test p value(adjusted)		
		Count	Column N %	Count	Column N %	Count	Column N %	p value	Group1 vs Group2	Group1 vs Group3	Group2 vs Group3
Strain	0	15	100.0%	7	46.7%	10	66.7%	0.0001,HS	0.0011 S	0.0016 S	0.321 NS
	1	0	0.0%	7	46.7%	4	26.7%				
	2	0	0.0%	1	6.7%	1	6.7%				

*S - Significant, NS - Non significant

Figure 4.10 shows Strain for healthy women, women with Hypothyroidism and women with Hyperthyroidism

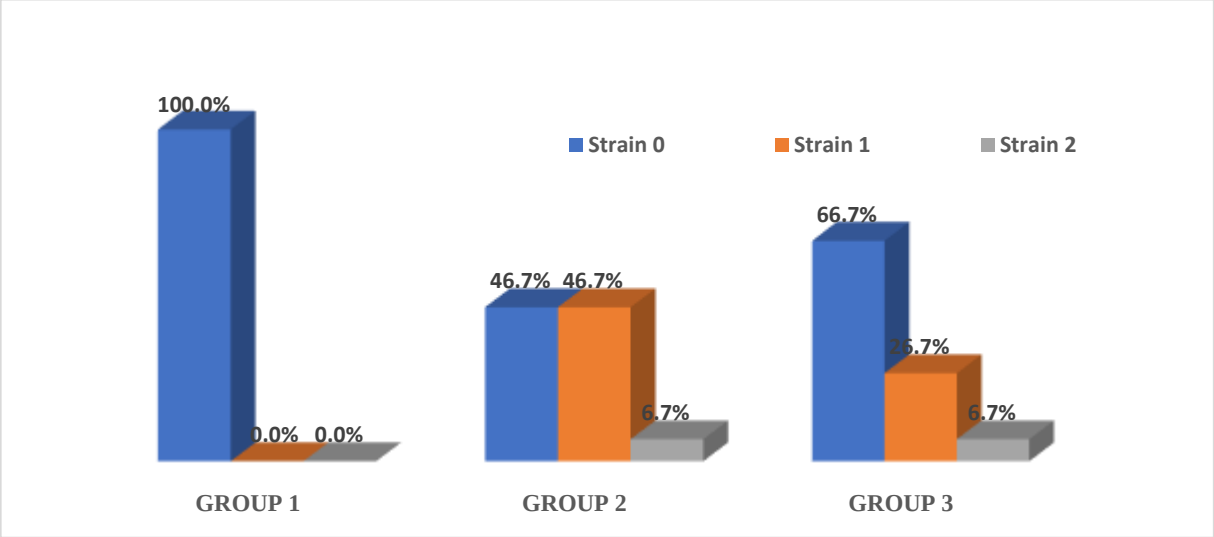

Table 4.10 and Figure 4.10 demonstrate that all healthy women (100%) had no perceptual strain in their voice quality (Strain 0). Among women with hypothyroidism, mild strain was reported in 46.7% and moderate strain in 6.7% of cases. In the hyperthyroid group, 26.7% displayed mild strain and 6.7%

moderate strain. Significant differences were found between healthy women and those with hypothyroidism and between healthy women and those with hyperthyroidism. However, difference between women with hypothyroidism and hyperthyroidism was not significant.

Table 4.11 shows the overall comparison of acoustic parameters across healthy women, women with Hypothyroidism and women with Hyperthyroidism

	HEALTHY WOMEN (Group 1)		WOMEN WITH HYPOTHYROIDISM (Group 2)		WOMEN WITH HYPERTHYROIDISM (Group 3)		Overall Mean	Overall Std Deviation	To compare across the groups - Kruskal wallis test Overall p value
	Mean	Std Deviation	Mean	Std Deviation	Mean	Std Deviation			
F0 (Hz)	213.93	7.76	167.60	14.40	180.07	11.64	187.20	22.81	0.0001 HS
Jitter (%)	0.56	0.11	1.44	0.70	1.33	0.59	1.11	0.66	0.0001 HS
Shimmer (%)	0.96	0.26	4.46	2.29	3.83	1.29	3.08	2.14	0.0001 HS
HNR (dB)	21.36	1.56	14.63	3.35	19.09	3.45	18.36	4.02	0.0001 HS
NHR	0.02	0.00	0.30	0.07	0.18	0.07	0.17	0.13	0.0001 HS

*HS - Highly Significant

Table 4.11 presents the comparison of the acoustic parameters across Healthy Women (Group 1), Women with Hypothyroidism (Group 2) and Women with Hyperthyroidism (Group 3). Healthy women (Group 1) showed the highest fundamental frequency (213.93 Hz), followed by women with hyperthyroidism (180.07) and reached its lowest value in women with hypothyroidism (167.60 Hz). This difference in F0 was highly significant across groups. Group 1 also demonstrated the lowest perturbation values, with jitter at 0.56% and shimmer at 0.96%. In contrast, perturbation increased sharply in women with hypothyroidism and hyperthyroidism, with the highest levels observed in women with hypothyroidism (Jitter: 1.44% ; Shimmer: 4.46%) closely followed by women with hyperthyroidism (Jitter: 1.33 % ; Shimmer: 3.83%). Both jitter and shimmer demonstrated highly significant differences across the group. In terms of vocal quality, healthy women (Group 1) displayed the highest HNR (21.36 dB) and lowest

NHR (0.02%). Conversely, in women with hypothyroidism group (Group 2) showed elevated noise levels with the lowest HNR (14.63 dB) and highest NHR (0.30%). Women with hyperthyroidism had intermediate values between the healthy controls and the hypothyroid group, with an HNR of 19.09 dB and an NHR of 0.18%. Both HNR and NHR also showed highly significant differences across all the groups.

Table 4.12 shows the overall comparison of perceptual GRBAS parameters across healthy women, women with Hypothyroidism and women with Hyperthyroidism

		HEALTHY WOMEN (Group 1)		WOMEN WITH HYPOTHYROIDISM (Group 2)		WOMEN WITH HYPERTHYROIDISM (Group 3)		Overall count		To compare across the groups- Kruskal wallis test
		Count	Column N %	Count	Column N %	Count	Column N %		Overall column N %	Overall p value
Grade	Grade 0	15	100.0 %	4	26.7%	5	33.3%	24	53.3 %	0.001 HS
	Grade 1	0	0.0%	3	20.0%	6	40.0%	9	20.0 %	
	Grade 2	0	0.0%	5	33.3%	3	20.0%	8	17.8 %	
	Grade 3	0	0.0%	3	20.0%	1	6.7%	4	8.9%	
Roughness	Roughness 0	15	100.0 %	4	26.7%	5	33.3%	24	53.3 %	0.001 HS
	Roughness 1	0	0.0%	3	20.0%	6	40.0%	9	20.0 %	
	Roughness 2	0	0.0%	6	40.0%	4	26.7%	10	22.2 %	
	Roughness 3	0	0.0%	2	13.3%	0	0.0%	2	4.4%	
Breathiness	Breathiness 0	15	100.0 %	5	33.3%	7	46.7%	27	60.0 %	0.001 HS

	Breathiness 1	0	0.0%	5	33.3%	5	33.3%	10	22.2%	
	Breathiness 2	0	0.0%	5	33.3%	3	20.0%	8	17.8%	
Asthenia	Asthenia 0	15	100.0%	6	40.0%	9	60.0%	30	66.7%	0.001 HS
	Asthenia 1	0	0.0%	5	33.3%	4	26.7%	9	20.0%	
	Asthenia 2	0	0.0%	4	26.7%	2	13.3%	6	13.3%	
Strain	Strain 0	15	100.0%	7	46.7%	10	66.7%	32	71.1%	0.001 HS
	Strain 1	0	0.0%	7	46.7%	4	26.7%	11	24.4%	
	Strain 2	0	0.0%	1	6.7%	1	6.7%	2	4.4%	

*HS - Highly Significant

Table 4.12 revealed the comparison of perceptual GRBAS rating scale across Healthy Women (Group 1), Women with Hypothyroidism (Group 2) and Women with Hyperthyroidism (Group 3). Group 1 presented entirely normal voice profiles with 100.0% of participants classified as Grade 0, Roughness 0, Breathiness 0, Asthenia 0 and Strain 0. For overall dysphonia severity, the highest level of impairment was observed in Group 2, where only 26.7% retained a normal voice (Grade 0), while 33.3% showed moderate dysphonia (Grade 2) and 20.0% experienced severe dysphonia (Grade 3). Similarly, Group 2 demonstrated the greatest degradation in vocal characteristics, exhibiting the highest rates of moderate-to-severe Roughness (40.0% Grade 2; 13.3% Grade 3), Breathiness (33.3% Grade 2) and Asthenia (26.7% Grade 2). While Group 3 also displayed notable vocal changes showing mild-to-moderate deviations such as Grade 1 dysphonia (40.0%), Roughness 1 (40.0%) and Breathiness 1 (33.3%).

DISCUSSION

The present study aimed to evaluate and compare the acoustic and perceptual voice characteristics among young adult females diagnosed with hypothyroidism and hyperthyroidism in comparison to healthy controls.

The findings revealed that both hypothyroidism and hyperthyroidism result in distinct, quantifiable vocal variations. In the acoustic analysis, healthy women had the highest mean fundamental frequency (F0 = 213.93 Hz), while women with hyperthyroidism showed a lower value (180.07 Hz) and women with hypothyroidism had the lowest value (167.60 Hz). The reduced pitch in hypothyroidism is explained by hormonal deficiency leading to myxedematous (edematous and swollen vocal folds) infiltration of the vocal folds, which increases their mass and slows vibration, which is accordance with the findings of Mohammadzadeh et al (2011). In women with hyperthyroidism, the pitch reduction is more likely related to vocal fatigue, weak respiratory support and fine tremors affecting the laryngeal muscles.

Perturbation measures also indicated greater voice instability in both groups. Jitter and shimmer were significantly higher in women with hypothyroidism and hyperthyroidism than in healthy women indicating that abnormal thyroid hormone levels disrupt stable vocal fold vibration. Similarly, noise-

related measures showed poorer voice quality in women with hypothyroidism who showed the lowest HNR and highest NHR, followed by women with hyperthyroidism, while healthy women showed greater HNR and lower NHR values. This suggests that hypothyroidism causes more severe glottal inefficiency, whereas hyperthyroidism likely produces noise through incomplete closure and muscle weakness.

Perceptual assessment using the GRBAS rating scale revealed clear differences in voice quality across the three groups. Healthy women (Group 1) showed completely normal vocal function, with 100% scoring Grade 0 on all parameters. In contrast, both thyroid disorder groups showed evidence of voice changes, with the greatest severity observed in women with hypothyroidism (Group 2) which had the highest levels of dysphonia as well as notable increases in roughness (Roughness 2: 40%; Roughness 3: 13.3%), breathiness (Breathiness 3: 33.3%) and asthenia (Asthenia 2: 26.7%). The women with hyperthyroidism (Group 3), however, showed mainly mild to moderate vocal changes where grade 1 dysphonia (40%), Roughness 1 (40%) and Breathiness 1 (33.3%), these findings of the current study are in close accordance with Ünlü (2022).

These patterns indicate a trend toward slight vocal changes in both hypothyroid and hyperthyroid groups. This may be due to the characteristics of the sample which consisted only of young adult females (aged 18-35) diagnosed with limited duration of both hypothyroidism and hyperthyroidism. As a result, the vocal fold changes may not have been progressed enough to produce significant perceptual differences between the groups.

These findings underscore the importance of early voice assessment, routine evaluation and regular follow up in individuals with hypothyroidism and hyperthyroidism, as subtle vocal changes may reflect underlying laryngeal effects of hormonal imbalance.

SUMMARY AND CONCLUSION

The thyroid gland is an endocrine gland located anteriorly which regulates vital processes including body temperature, cardiac output, nervous system stimulation while also exerting a significant influence on voice production. Hormonal regulation plays a crucial role in maintaining vocal quality and endocrine disruptions like thyroid disorders are associated with phonation abnormalities. Thyroid disorders such as hypothyroidism and hyperthyroidism primarily arise from malfunctioning of thyroid gland caused by multifactorial etiologies.

The present study aimed at comparing the acoustic and perceptual analysis of voice of young adult women aged 18-35 years across healthy women, women with hypothyroidism and women with hyperthyroidism. Participants included 45 females divided equally into three groups: 15 healthy women, 15 women with hypothyroidism and 15 women with hyperthyroidism.

For acoustic analysis of voice, all the participants were asked to phonate /a/ vowel in a quiet environment and were recorded. PRAAT software 6.4.56 version was used to extract voice related parameters. The acoustic parameters selected in the study were fundamental frequency (F0), jitter%, shimmer%, HNR and NHR. And for perceptual analysis, the recorded voice samples were evaluated by a SLP using the GRBAS rating scale.

The findings of the present study revealed that the F0 was highest in healthy women (213.93 Hz) followed by lower value in hyperthyroidism (180.07 Hz) and lowest in hypothyroidism (167.60 Hz). Both women with hypothyroidism and hyperthyroidism showed marked increase in jitter and shimmer levels in women with hypothyroidism displaying the highest values (jitter: 1.33%; shimmer: 4.46%) followed by women with hyperthyroidism (jitter: 1.33%; shimmer: 3.83%). For spectral measures, healthy women has better

voice quality with highest HNR (21.36 dB) and lowest NHR (0.02%) while women with hypothyroidism showed lowest HNR (14.63 dB) and highest NHR (0.30%). The women with hyperthyroidism demonstrated intermediate values (HNR: 19.09 dB; NHR: 0.18%). These findings indicated that women with hypothyroidism had more vocal variations when compared to healthy women.

On perceptual analysis using GRBAS rating scale, healthy women showed normal voice quality across the GRBAS scale. In contrast, 33.3 % women with hypothyroidism had moderate dysphonia and 20% showed severe voice change along with increased roughness, breathiness, asthenia and strain. Women with hyperthyroidism mostly showed mild to moderate changes with Grade 1 dysphonia (40%), Roughness 1(40%) and Breathiness 1(33.3%). While both the groups differed significantly from healthy women the differences between women with hypothyroidism and hyperthyroidism were not significant likely due to the young age of the women and limited duration of the thyroid disorders.

The present study emphasized that both hypothyroidism and hyperthyroidism result in distinct, measurable voice changes caused due to different pathophysiology specifically swollen vocal folds in hypothyroidism due to edema and neuromuscular weakness of larynx in hyperthyroidism. These objective and perceptual findings show that the laryngeal system is highly responsive to endocrine imbalance, even before symptoms become severe.

SLPs plays an important role in implementing objective and perceptual voice assessments, routinely use acoustic, perceptual and aerodynamic analysis (if needed), distinguish thyroid related voice changes and monitor treatment progress. Hence, early acoustic and perceptual voice assessment by SLPs is essential for identifying subclinical dysphonia, monitoring treatment response and separating endocrine-related changes from structural pathology.

LIMITATIONS OF THE STUDY

- The sample size of the study was limited.
- Study was only conducted in the age group of 18-35 years.
- The participants had a limited duration of thyroid disorders.

FUTURE DIRECTIONS

- The sample size of the study can be increased.
- Aerodynamic analysis can be done within the same age group.
- Study can be extended to other age groups and to male participants to evaluate age and gender related differences.
- Studies can be done to assess the voice changes in women with thyroid disorders diagnosed for more than 5-10 years and above.
- Studies can be done for assessing the voice changes by comparing male and female individuals diagnosed with hypothyroidism and hyperthyroidism.

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APPENDIX 1
CONSENT FORM

Student researcher:
Dear madam, I am student pursuing my master's degree in Dr M.V Shetty College of Speech and Hearing, Mangalore. For the purpose of my research, I would like your participation in this study. The details of the study are given below:
Purpose of the study:
The purpose of the study is to analyse the voice characteristics in women with hypothyroidism and hyperthyroidism compared with healthy women in Kerala.
Method:
Subjects between 18-35 years of age will participate in this study. Medical record of thyroid function along with audio recording of sound production using software PRAAT will be taken and done through personal interview.

Time demands:
20-30 minutes

If you agree to participate in the study, please sign below:

- I hereby consent to myself to being audiotaped, tested and/or observed.
- I have read and understood the background information that you have provided about the research.
- My participation is entirely voluntary

Place:
Date:
Signature of the participant:

APPENDIX 2
ASSESSMENT

Test administered:
GRBAS RATING SCALE

i. **GRADE :**
ii. **ROUGHNESS :**
iii. **BREATHINESS :**
iv. **ASTHENIA :**
v. **STARIN :**