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Original Research Article

A Study of Thyroid Hormone Level Variations with Respect to Age, Gender, and Season in Bharuch, Gujarat

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Abstract

Background: Thyroid hormones play a vital role in maintaining normal reproductive function. Triiodothyronine (T3) and thyroxine (T4) regulate the growth, development, and metabolic activity of the ovaries, uterus, and placenta by binding to specific receptors present in these tissues. Consequently, thyroid dysfunction may lead to reproductive disturbances such as subfertility, infertility, menstrual irregularities, anovulation, spontaneous abortion, and delayed intrauterine development.

Materials and Methods: A cross-sectional study was conducted over a one-year period from January 2025 to January 2026 among patients attending a tertiary care hospital in Bharuch, Gujarat, who underwent thyroid hormone testing. Secondary data pertaining to age, gender, and serum levels of TSH, T3, and T4 were collected and analyzed.

Results: Thyroid-stimulating hormone (TSH) concentrations demonstrate an elevation during colder environmental conditions and a decline in warmer temperatures, thereby exhibiting an inverse correlation with ambient temperature. These observations imply that TSH secretion is responsive to thermal variations. Furthermore, in women of reproductive age, both TSH and thyroid hormone levels may undergo seasonal oscillations, with TSH values frequently increasing during the winter months. Additionally, statistically significant alterations in thyroid hormone profiles are evident among both males and females across various age groups in different seasonal contexts.

Conclusion: It can be inferred from the findings that age, gender, and seasonal variation exert a significant and measurable influence on the circulating levels of thyroid hormones, including T3, T4, and thyroid-stimulating hormone (TSH).

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Introduction

Seasonal dynamics in biological functions of mammals is regulated by melatonin-mediated circannual fluctuations in the secretion of thyroid-stimulating hormone (TSH) and thyroid hormones. Most anatomical and molecular structures responsive to photoperiod and melatonin secretion changes and the associated receptors are preserved in modern humans.

This work aimed to determine the seasonal dynamics of TSH and thyroid hormone levels (total triiodothyronine (T3) & thyroxine (T4), and to investigate the dependence of these variations on gender, age and amplitude of meteorological fluctuations.[1,2] These hormones markedly enhance the basal metabolic rate and contribute to thermogenesis. In the complete absence of these hormones, the basal metabolic rate may decline by approximately 40–50% below normal levels. [3] Additionally, they play a crucial role in cerebral growth and neurological development.

Triiodothyronine (T3) and thyroxine (T4) are synthesized within the thyroid gland, a process that is dependent on adequate iodine availability, which varies according to factors such as growth, body mass, age, sex, and the nutritional status of the individual. Climatic conditions and disease states further influence iodine requirements. [4] Thyroid-stimulating hormone (TSH), also referred to as

thyrotropin, is secreted by the anterior pituitary gland. Thyroid function is regulated by TSH, and its secretion is, in turn, modulated by the hypothalamus. Sex has been shown to exert a significant influence on circulating thyroid hormone concentrations. [5]

In many Asian populations, women often bear a greater burden of economic and domestic responsibilities compared to men. Socioeconomically disadvantaged and illiterate women, along with their children, are therefore at an increased risk of nutritional deficiencies, including iodine deficiency disorders such as goiter, anemia, and other related conditions.

Advancing age is associated with a decline in thyroid hormone levels in both sexes; however, this reduction is more pronounced in females than in males. [7]

Seasonal variation in thyroid function has also been documented, with comparatively elevated levels of T3 and T4 observed during the autumn and winter months, as opposed to spring and summer. [6] Despite these observations, the combined influence of age, sex, and seasonal factors on thyroid hormone levels has been inadequately investigated in the western region of India. Consequently, the present study was undertaken to further elucidate and expand upon existing research concerning these determinants of thyroid hormone variability.

Materials and Methods

This cross-sectional study was conducted over a one-year period from January 2025 to January 2026 among patients attending a tertiary care hospital in Bharuch, Gujarat, who underwent thyroid hormone testing. Secondary data pertaining to age, gender, and serum levels of TSH, T3, and T4 were collected and analyzed.

Collection of Blood Samples: Venous blood samples were collected from the antecubital vein of subjects who presented to the hospital for clinical conditions unrelated to thyroid or other associated endocrine disorders. The collected blood was allowed to clot, following which serum was separated by centrifugation at 2000 revolutions per minute for a duration of five minutes.

Hormonal Estimation: The separated serum samples were subjected to quantitative analysis for triiodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone (TSH) using an immunoassay analyzer based on the chemiluminescent immunoassay (CLIA) technique.

Statistical Analysis: Statistical evaluation of the data was performed using the chi-square test, with analyses carried out using the Statistical Package for the Social Sciences (SPSS) software,

Results

Normal hormone levels vary between genders[7]. The gender distribution in the present study is presented in (TABLE 1), where males accounted for 27.79% and females for 72.21% of the participants. The average TSH level was higher in females compared to males, whereas T4 levels were slightly higher in males. T3 levels were nearly identical in both genders.

Table 1: Gender-Wise Analysis of T3, T4, and TSH Concentrations

Gender	Male	Female
TSH µU/L	1.23±1.2	2.15±1.67
T3 ng/dl	2.82±1.06	2.34±0.8
T4 ng/dl	1.56±0.45	1.25±0.65

Table 2: Age and Sex wise distribution of hormone

Sex	Age in Years	TSH (µU/L)	T3 (ng/dl)	T4 (ng/dl)
Female	<20	1.15±0.34	1.94±0.54	1.67±0.56
	20-40	2.38±1.27	3.07±0.94	1.40±0.48
	41-60	1.71±1.51	2.35±0.69	1.49±0.45
	>60	0.46±0.59	2.94±1.66	1.40±0.95
Male	<20	0.43±0.00	1.90±0.00	2.14±0.00
	20-40	2.43±1.38	2.51±0.40	1.25±0.27
	41-60	1.71±1.84	2.42±0.47	1.59±0.63
	>60	2.27±1.85	2.54±0.47	1.14±0.26

For comparative evaluation of hormonal profiles, the study cohort was stratified by gender and further categorized into distinct age groups. The serum concentrations of thyroid hormones and TSH among males across different age categories (TABLE 2) demonstrate that TSH levels peak in the second age group and reach their nadir in the fourth group, while remaining nearly comparable in the first and third groups. Serum T3 concentrations are lowest in the first age group and attain maximum values in the second group, thereafter exhibiting relative stability in the third and fourth groups. In contrast, T4 levels are highest in the first age group and remain relatively consistent across

the subsequent groups. Among females, age-wise stratification of thyroid hormone levels (TABLE 2) indicates that serum TSH concentrations are minimal in the first age group and maximal in the second group. A decline is observed in the third group, followed by a subsequent rise in the fourth group. Furthermore, as depicted in TABLE 3, serum T3 levels are lowest in the first group and remain comparatively stable across the second, third, and fourth groups. Conversely, T4 concentrations are highest in the first group and lowest in the third group, while demonstrating relative stability in the second and fourth age groups.

Table 3: Seasonal variation in T3, T4 & TSH

Season	TSH (µU/L)	T3 (ng/dl)	T4 (ng/dl)
Winter	2.85±1.42	2.74±0.58	1.17±0.22
Autumn	2.17±1.11	2.25±0.39	1.19±0.25
Summer	2.10±1.12	2.45±0.45	1.56±0.32
Monsoon	1.50±1.10	2.64±0.26	1.39±0.35

The seasonal influence on the circulating concentrations of T3, T4, and TSH is illustrated in TABLE 3. The findings demonstrate that serum TSH levels attain their minimum values during the monsoon season and reach their maximum during winter. In summer and autumn, TSH concentrations remain nearly comparable, with a marginal elevation observed in autumn relative to summer.

Serum T3 concentrations exhibit minimal seasonal fluctuation, maintaining relative stability throughout the year; however, the highest levels are recorded in winter and the lowest in autumn. Similarly, serum T4 levels show only slight seasonal variation, remaining largely consistent across seasons, with comparatively lower values in winter and peak concentrations observed during summer.

Discussion

Considering the frequency and severity of thyroid dysfunctions, diagnosis, treatment, and monitoring of disease progression are very important for public health [7]. Thyroid hormones regulate various physiological processes, and their serum concentrations must be sufficient for the proper function of the whole organism, especially the reproductive system. Maternal thyroid dysfunctions may cause subfertility or infertility, menstrual irregularities, anovulation, abortion, premature delivery, and intrauterine developmental delay [2]. Therefore, TSH values in women during the reproductive period should be evaluated carefully and appropriately. One of the best indicators that can be used for this purpose is serum TSH, and knowing the factors that may affect its concentration is very important in managing patients. TSH levels are known to be affected by many factors, including age, gender, ethnicity, iodine status, and season.

The gender-based variation in the mean concentrations of the evaluated thyroid hormones (Table 1) indicates that minor fluctuations within the physiological reference range are evident in serum T4 levels in both sexes, with males demonstrating a marginally elevated concentration compared to females. In contrast, serum T3 levels appear to be nearly equivalent between genders, whereas TSH concentrations are slightly reduced in males relative to females, though remaining within normal limits. These findings are consistent with earlier investigations conducted by Razzak et al., Muslim and Khalil et al., and Franklyn et al., which suggest that increased levels of sex hormones in males enhance the circulating concentration of thyroxine-binding globulin (TBG), thereby contributing to a corresponding rise in total serum T4 levels. Nevertheless, certain studies have reported discordant observations, indicating comparatively higher T4 levels in females than in males, while demonstrating that T3 and TSH concentrations are not significantly modulated by gender. [8]

The concentrations of thyroid hormones and TSH across different age strata in both males and females are illustrated in Table 2. Among females, TSH levels are observed to be minimal in the first age category and maximal in the second age category.

With respect to triiodothyronine (T3), the lowest values are evident in the first age group for both sexes. In females, T3 concentrations subsequently increase and remain relatively stable across the succeeding age groups. Conversely, in males, T3 levels peak in the second age group and then demonstrate relative stability throughout the third and fourth decades. Regarding serum thyroxine (T4), both genders display the highest concentrations in the first age group, with levels remaining comparatively consistent across the second, third, and fourth groups. The seasonal influence on the concentrations of T3, T4, and TSH is presented in Table 3. The data indicate that TSH levels are elevated during the winter and autumn seasons compared to summer and the monsoon period. In contrast, T3 concentrations remain relatively consistent throughout the year, exhibiting a marginal increase in winter and a slight decline in autumn. Similarly, serum T4 levels demonstrate

minimal seasonal fluctuation, though they tend to be somewhat lower in winter and modestly higher during summer. Overall, these findings suggest that seasonal variations exert an effect on T3, T4, and TSH levels, consistent with the observations reported by Khan et al. [9]

Conclusion

It can be inferred from the findings that age, gender, and seasonal variation exert a significant and measurable influence on the circulating levels of thyroid hormones, including T3, T4, and thyroid-stimulating hormone (TSH).

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