ISSN 0973-2063 (online) 0973-8894 (print)

Bioinformation 22(10): 6794-6798 (2026)

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BIOINFORMATION
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BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(10)

Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026

DOI: 10.6026/973206300226794

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

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Edited by Vini Mehta
E-mail: vmehta@statsense.in
Citation: Harshavardhan *et al.* Bioinformation 22(10): 6794-6798 (2026)

Association of thyroid dysfunction with metabolic syndrome: A cross-sectional study

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ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 6794-6798 (2026)
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Abstract:
Thyroid dysfunction may contribute to cardiometabolic risk, but its association with metabolic syndrome remains clinically important. This cross-sectional study evaluated 153 adults attending a tertiary care hospital using serum thyroid stimulating hormone, free triiodothyronine and free thyroxine levels, with metabolic syndrome defined by National Cholesterol Education Program Adult Treatment Panel III criteria. Metabolic syndrome was significantly more prevalent in hypothyroidism (61.0%) than euthyroidism (31.9%) or hyperthyroidism (27.8%; p=0.003), with hypothyroid participants also showing higher fasting blood glucose, waist circumference and triglycerides and lower high-density lipoprotein cholesterol. Serum thyroid-stimulating hormone showed positive relationships with waist circumference and triglyceride levels, supporting an association between hypothyroidism and adverse cardiometabolic risk. These findings advance knowledge by highlighting early thyroid function assessment as a potential strategy for improved cardiometabolic risk classification and management.

Keywords: Thyroid dysfunction, metabolic syndrome (MetS), thyroid stimulation **(**TSH), dyslipidaemia, hypothyroidism

Background:
The metabolic syndrome (MetS) is a collection of inter-dependent metabolic abnormalities which comprises central obesity, insulin resistance, impaired glucose metabolism, dyslipidaemia and hypertension. It has been acknowledged as a significant public health issue, increasing substantially the risk of type 2 diabetes mellitus and cardiovascular disease, as well as all-cause mortality. Metabolic syndrome has been increasing in incidence worldwide and, as obesity rates continue to rise, sedentary lifestyles and changes in diet are believed to be significant contributing factors, making a proactive approach to identifying some of the risk factors involved a first priority **[1].** The thyroid hormones are vital for energy expenditure, maintaining glucose homeostasis, lipid metabolism, thermogenesis as well as cardiovascular functions. The basal metabolic rate, insulin sensitivity, body weight and serum lipid concentrations may be affected by even slight changes in thyroid hormone levels. Thus, thyroid dysfunction is increasingly being recognized as a possible factor contributing to the development of metabolic abnormalities and cardiovascular risk **[2].** Kisova *et al.* (2025) reviewed evidence linking hypothyroidism and higher-normal TSH levels with metabolic syndrome, highlighting possible age- and sex-related differences **[3].** Some clinical data have demonstrated strong correlations between thyroid dysfunctions and metabolic syndrome components. Overt or subclinical hypothyroidism has been linked to high BMI, obesity, dyslipidaemia, hypertension and with abnormal glucose metabolism. The exact mechanisms are not fully understood, but decreased thyroid hormone levels could contribute to metabolic syndrome by increasing adiposity, insulin resistance, endothelial dysfunction and low-grade chronic inflammation **[4].** It has been well established that hypothyroidism has a negative effect on lipid metabolism both by lowering hepatic LDL levels and by increasing lower lipid levels, leading to a decrease in lipid clearance and deranged lipid metabolism and increasing triglycerides, low-density lipoprotein cholesterol and total cholesterol levels. Thyroid dysfunction also affects blood pressure control by changes in vascular resistance and cardiovascular performance, which leads to greater cardiovascular risk for those with thyroid dysfunction **[5].** Epidemiological studies have shown an increase in thyroid stimulation (TSH) levels to be correlated with increased body mass index (BMI), waist circumference, insulin resistance and metabolic syndrome (MS) even among those with euthyroid thyroid function tests. These findings imply that modest alterations in the function of the thyroid can have physiologically important metabolic implications **[6].** Metabolic dysfunction and its association with thyroid dysfunction are also emerging as a problem in recent Indian studies. In a pan-India study of 432 patients with metabolic syndrome, Deshmukh *et al.* (2018) reported thyroid dysfunction in 28% of participants, with hypothyroidism being the predominant disorder **[7].** There is growing evidence hypothyroidism is common in patients with obesity, dyslipidaemia and impaired glucose metabolism, which highlights the need for early screening for thyroid abnormalities in those at risk of developing the metabolic syndrome. Due to ethnicity, iodine intake in foods and water, environmental influences and diagnostic criteria, the association between thyroid dysfunction and metabolic syndrome is complex and not consistent across different populations **[8, 9].** In addition, data from the east are still rather scarce. Inconsistent reports have also been published on the relationship between hyperthyroidism, subclinical thyroid dysfunction and metabolic syndrome, so more research is needed **[10].** Therefore, it is of interest to assess the association between thyroid dysfunction with metabolic syndrome and to see the correlation between the thyroid hormone with individual parameters of metabolic syndrome in adults from a tertiary care center.

Materials and Methodology:

Study design:
This study is a cross sectional study with the objective to look at the association between thyroid dysfunction and metabolic syndrome among adult patients attending the Department of General Medicine of hospital.

Study setting:
This study was carried out in Department of General Medicine, All India Institute of Medical Sciences (AIIMS), Patna, Bihar, India.

Study duration:

This study was carried out during a 6 month period.

Sample size:
The total numbers of adult participants were 153 in the study.

Study population:
Consecutive sampling was performed to recruit the adult patients who attending the General Medicine outpatient department.

Inclusion criteria:
[1] Adults (18 years and older).
[2] Those who are willing to give written informed consent.
[3] No previously diagnosed thyroid disease.

Exclusion criteria:
[1] Pregnancy.
[2] History of thyroid surgery.
[3] Consumption of thyroid hormone replacement medication(s) or antithyroid medication(s).
[4] Known malignancy.
[5] Chronic liver disease.
[6] Chronic kidney disease.
[7] Acute severe condition/infection.
[8] Known cardiovascular disease.

Data collection:
Demographic data (age, gender, smoking history, alcohol use, dietary questionnaires, physical activity, family history) were obtained based on a structured questionnaire after obtaining written informed consent.

Anthropometric measurements included:
[1] Height
[2] Weight
[3] Body Mass Index (BMI)
[4] Waist circumference
[5] Standard sphygmomanometer was used for measuring the blood pressure after proper rest.

Laboratory investigations:
Venous blood was taking after the period of fasting which lasted for 8 to 12 hours and estimation of the following parameters was done:
[1] Thyroid-stimulating hormone (TSH)
[2] Free thyroxine (FT4)
[3] Free triiodothyronine (FT3)
[4] Fasting blood glucose
[5] Serum triglycerides
[6] HDL cholesterol
[7] Standardized automated laboratory methods were used for all biochemical investigations.

Classification of thyroid function:
The participants were divided into three groups:
[1] Euthyroid
[2] Hypothyroid
[3] Hyperthyroid
Serum TSH, FT4 and FT3 levels were used as a basis to be evaluated according to the laboratory reference ranges.

Diagnosis of metabolic syndrome:
The diagnosis of metabolic syndrome was based on the NCEP ATP III criteria. The patients were diagnosed with having metabolic syndrome if three or more of the following were present:

[1] Waist circumference >102 cm (men) and >88 cm (women)
[2] Blood pressure reading of ≥130/85 mmHg, or taking blood pressure medicines
[3] Fasting blood glucose >100mg/dL, or treatment for diabetes.
[4] Triglycerides ≥150 mg/dL
[5] HDL cholesterol <40 mg/dL (men) or <50 mg/dL (women)

Outcome measures:
Primary outcome:
Correlation of thyroid function and metabolic syndrome.

Secondary outcomes
[1] Correlation of Thyroid hormone with individual MetS component
[2] Relationship of thyroid dysfunction with anthropometric parameters.
[3] Some standalone risk factors for metabolic syndrome.

Statistical analysis:
Data were entered in to Microsoft Excel and analysed in SPSS version 27.0. Data for continuous variables were summarized as the mean value ± standard deviation and for categorical variables they were numerated and given in frequency and percentage. Comparisons between categorical variables were done with chi-square test. Independent Student's t-test: This test was used to compare continuous variables between two groups. One-way ANOVA was used to compare metabolic parameters between the groups of euthyroid, hypothyroid and hyperthyroid. Further multivariate linear regression was done following adjusting for age, gender, BMI and physical activity. Pearson correlation test was used to find out relations between thyroid hormone levels and metabolic syndrome components. A p-value < 0.05 was defined as being statistically significant.

Results:
A total of 153 participants were included, with a mean age of 44.6 ± 12.4 years; 82 (53.6%) were female. Based on thyroid-function tests, 94 (61.4%) were euthyroid, 41 (26.8%) were hypothyroid and 18 (11.8%) were hyperthyroid **(Table 1).** Participants with hypothyroidism were older and had higher BMI and waist circumference than those with euthyroidism or hyperthyroidism. Metabolic syndrome was present in 25 (61.0%) participants with hypothyroidism, compared with 30 (31.9%) euthyroid and 5 (27.8%) hyperthyroid participants; the difference was statistically significant (p = 0.003) **(Table 2).** Mean waist circumference, systolic and diastolic blood pressure,

triglycerides and fasting blood glucose were significantly higher in the hypothyroid group, whereas HDL cholesterol was significantly lower ($p < 0.05$ for all comparisons) **(Table 3).** After adjustment for age, sex, BMI and physical activity, hypothyroidism was independently associated with higher waist circumference ($p = 0.005$), higher triglycerides ($p = 0.004$), lower HDL cholesterol ($p = 0.046$) and higher fasting glucose ($p = 0.014$). Hyperthyroidism was not independently associated with any metabolic-syndrome component **(Table 4).** TSH showed significant positive correlations with waist circumference ($r = 0.36$) and triglycerides ($r = 0.31$), while FT4 showed a significant negative correlation with fasting blood glucose ($r = −0.29$). These findings suggest that lower thyroid function, particularly hypothyroidism, was associated with a less favourable metabolic profile **(Table 5).**

Table 1: Demographic and clinical characteristics according to thyroid function

Characteristic	Euthyroid (n=94)	Hypothyroid (n=41)	Hyperthyroid (n=18)	Total (n=153)
Age (years), Mean ± SD	42.8 ± 11.9	48.6 ± 12.7	41.5 ± 10.8	44.6 ± 12.4
Male, n (%)	44 (46.8)	17 (41.5)	10 (55.6)	71 (46.4)
Female, n (%)	50 (53.2)	24 (58.5)	8 (44.4)	82 (53.6)
BMI (kg/m²), Mean ± SD	26.9 ± 3.8	30.7 ± 4.6	27.5 ± 3.5	28.2 ± 4.3
Waist circumference (cm), Mean ± SD	91.4 ± 8.6	99.8 ± 10.5	92.7 ± 7.9	94.2 ± 9.6

Table 2: Prevalence of metabolic syndrome according to thyroid function

Thyroid Function	Metabolic Syndrome n (%)	No Metabolic Syndrome n (%)	Total
Euthyroid	30 (31.9)	64 (68.1)	94
Hypothyroid	25 (61.0)	16 (39.0)	41
Hyperthyroid	5 (27.8)	13 (72.2)	18
Total	**60 (39.2)**	**93 (60.8)**	**153**

Chi-square = 11.86, p = 0.003

Table 3: Comparison of metabolic syndrome components among thyroid function groups

Variable	Euthyroid	Hypothyroid	Hyperthyroid	F-value	p-value
Waist circumference (cm)	91.4 ± 8.6	99.8 ± 10.5	92.7 ± 7.9	13.84	<0.001
Systolic BP (mmHg)	119.2 ± 11.8	126.4 ± 12.6	121.3 ± 11.4	4.18	0.017
Diastolic BP (mmHg)	77.8 ± 8.6	82.4 ± 9.3	79.2 ± 8.1	3.11	0.047
Triglycerides (mg/dL)	151.8 ± 28.5	181.6 ± 39.8	156.2 ± 30.6	6.92	0.001
HDL cholesterol (mg/dL)	49.8 ± 11.2	43.9 ± 9.6	47.2 ± 9.4	4.01	0.020
Fasting blood glucose (mg/dL)	95.8 ± 13.8	108.4 ± 18.6	100.8 ± 15.9	5.42	0.005

Table 4: Multivariate regression analysis showing association between thyroid dysfunction and metabolic syndrome components

Variable	Hypothyroidism (β ± SE)	Hyperthyroidism (β ± SE)	p-value (Hypothyroidism)	p-value (Hyperthyroidism)
Waist circumference	5.8 ± 2.0	1.4 ± 2.5	0.005	0.412
Triglycerides	27.6 ± 9.5	−8.2 ± 12.4	0.004	0.507
HDL cholesterol	−4.8 ± 2.4	−5.9 ± 3.2	0.046	0.071
Fasting glucose	11.9 ± 4.8	−2.7 ± 5.7	0.014	0.641

Table 5: Pearson's correlation between thyroid hormones and metabolic syndrome components

Thyroid Hormone	Waist Circumference	Fasting Blood Glucose	Triglycerides	HDL Cholesterol
TSH	**0.36***	0.19	**0.31***	−0.24
FT4	−0.21	−0.29*	−0.18	0.14
FT3	0.17	0.08	0.05	−0.09

**p < 0.05*

Discussion:

The objective of the present study was to assess the relationship between thyroid disorder and metabolic syndrome in the adult population presented in tertiary care centre. The results indicated that hypothyroidism was strongly correlated with the presence of metabolic syndrome and its components, namely, increased waist circumference, hypertension and hypertriglyceridemia, decreased levels of HDL cholesterol and elevated blood glucose. Moreover, the levels of serum TSH were positively correlated with abdominal obesity and serum TG and serum FT4 was negatively associated with fasting blood glucose, indicating that thyroid function was an important regulator of metabolic health. The prevalence of metabolic syndrome was significantly higher in the hypothyroid group (61.0%) than among both the euthyroid (31.9%) and hyperthyroid (27.8%) groups' responders of present study. Vishwanath *et al.* (2019) also reported more frequent thyroid dysfunction, predominantly subclinical hypothyroidism, among patients with metabolic syndrome. Increased waist circumference was significantly associated with higher TSH levels **[10]**. Similarly, Saini *et al.* used their findings to show that thyroid dysfunction is often accompanied by obesity, dyslipidaemia and hypertension; this implies that thyroid dysfunction can significantly increase the risk of developing metabolic syndrome and cardiovascular disease **[11].** Kim *et al* also reported that alterations in level of thyroid hormones affects the lipid metabolism and insulin severity, which increase the likelihood of developing of MetS even patients have mild thyroid dysfunction **[12].** Hypothyroid had significant greater waist circumference, higher blood pressure, higher triglyceride levels, lower HDL cholesterol and higher fasting blood glucose levels as compared to the Euthyroid. The results of the present study corroborate the study conducted by Mehran *et al.* which focused on the correlation between serum TSH levels and lipid profile as a risk factor for metabolic syndrome, suggesting that thyroid dysfunction is involved with various factors that constitute the metabolic syndrome **[13].** Abha *et al.* (2023) reported higher TSH and triglyceride levels and lower HDL cholesterol in participants with metabolic syndrome. These findings support an association between thyroid function and metabolic abnormalities **[14].** Also,

Amouzegar *et al.* showed that increase in insulin resistance, obesity and metabolic syndrome was linked to both overt and subclinical hypothyroidism highlighting the role of these thyroid functions in metabolic regulation. In the present study multivariate regression analysis revealed that hypothyroidism remained independently related to higher WC, higher TG, lower HDL and higher FBG levels after controlling for the parameters including age, gender, BMI and exercise factor **[15].** Similar results were obtained by Vajdi *et al.*, who found that thyroid dysfunction is an independent risk factor for the development of metabolic syndrome and that elevated level of TSH was independently significant in relation to abdominal obesity and dyslipidemia despite controlling for possible confounding variables **[16].** In a large Chinese population, He *et al.* (2021) found associations between hypothyroidism and several metabolic syndrome components. The associations differed by sex and menopausal status **[17].** Similarly, hypothyroidism was found to be an important risk factor for metabolic syndrome and associated cardiovascular risk factors, as reported by Alwan *et al.* **[18].** Again, leading to proper early hypotheses and management of thyroid dysfunction. In the current study, correlation analysis indicated a positive correlation between waist circumference and triglyceride level in the serum, FT4 and fasting blood glucose level in the serum, while there was a positive correlation between serum TSH and serum triglyceride. The observations suggest that advancing Thyroid dysfunction is linked with increasing metabolic abnormalities. In contrast, Minu *et al.* (2026) found no statistically significant correlations between thyroid function tests and individual metabolic syndrome components in a Kerala hospital-based study. This suggests that the strength of these associations may vary across populations **[19].** Consistent results were observed in adults with metabolic syndrome by means of correlation with elevated TSH with insulin resistance, abdominal obesity and dyslipidaemia, as reported by Alsulami *et al.* **[20].** Zhong *et al.* also showed that thyroid hormone disturbance regulates glucose and lipid metabolism through various molecular mechanisms, including those of the adipose tissue and hepatic lipid biosynthesis, as well as insulin signaling pathways, thus promoting the development of metabolic syndrome **[21].** The thyroid's link with CMR has remained strong in recent years. Alwan *et al.* showed that hypothyroidism is a risk factor for cardiovascular disease due to its harmful effects on obesity, dyslipidaemia and blood glucose **[18].** Likewise, thyroid dysfunction was shown to independently be a risk factor for metabolic abnormalities by Pleić *et al.* making thyroid hormone a part of metabolic risk assessment **[22].** In addition, Peng *et al.* stressed the role of thyroid hormone dysfunction in insulin resistance, chronic inflammation and lipid metabolism suggesting a mechanistic link between thyroid dysfunction and metabolic syndrome **[23].**

Conclusion:

We show a significant association between thyroid dysfunction, particularly hypothyroidism and the other components of metabolic syndrome such as increased triglycerides and waist circumference, especially hypothyroidism. There was an association between hyperthyroidism and a reduction in HDL these results suggest the importance of monitoring thyroid function in individuals at risk for metabolic syndrome.

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