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# Assessment of Thyroid Dysfunction in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Prevalence Study

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## ABSTRACT

**Background:** Hyperglycemia is the hallmark of the metabolic abnormalities in diabetes mellitus (DM) because of dysfunctional pancreatic beta cells. After diabetes, thyroid dysfunction (TD) is the second most common endocrine disorder. DM and thyroid dysfunction can interact with each other in many ways. Several authors studied the association between T2DM and thyroid dysfunction, hence it is of great importance to evaluate the prevalence of thyroid dysfunction among T2DM patients to help better control and reduce complications of diabetes.

**Objective:** The current study was done to detect the prevalence of thyroid dysfunction among patients with T2DM recently diagnosed within 5 years duration or less attending the Endocrinology and Diabetes Unit at Mansoura Specialized Medical Hospital.

**Patients and Methods:** This was a Cross-Sectional study conducted on a total of 106 patients with T2DM recently diagnosed within 5 years duration or less. The study included male and female adult Egyptian patients aged 30-60 years within the period from July 2021 to March 2022, their diagnosis of DM was based on the American Diabetes Association criteria for T2DM.

**Results:** Out of 106 recently diagnosed T2DM patients, the prevalence of thyroid dysfunction was 6.6%. Hypothyroidism (4.7%) was more common in the study subjects in comparison with hyperthyroidism (1.9%). Subclinical hypothyroidism was the commonest type of thyroid dysfunction among the studied subjects. Thyroid dysfunction was significantly more prevalent among female patients ($p = 0.01$). There was no significant association between thyroid dysfunction and HbA1c, age, BMI, duration, or complications of diabetes.

**Conclusion:** TD frequently develops among recently diagnosed patients with T2DM, with hypothyroidism more frequent than hyperthyroidism and subclinical hypothyroidism being the commonest type. The female gender could be considered a predictor and risk factor for thyroid dysfunction.

**Keywords:** Type 2 diabetes, Thyroid dysfunction, Hypothyroidism, Hyperthyroidism, Poorly controlled diabetes, TSH.

## INTRODUCTION

DM and TD are the most common endocrinopathies, which usually co-exist and mutually affect each other. Several studies revealed an association between DM and TD. TD, which is often defined as an abnormal thyroid test result, is more common in T2DM individuals compared to non-diabetics and can adversely affect metabolic control [(1)]. The relationship between TD and T2DM has also been recommended, however the potential causative mechanisms are intricate and have not been fully illustrated [(2)]. Confirmed correlations including abnormal biochemical pathways, abnormal genetic expressions, and hormonal imbalances, can explain their pathophysiological correlation [(3)].

Hypothyroidism, as the main form of TD in diabetics, could result in a reduction in insulin synthesis. Hyperthyroidism enhances the responsiveness of beta-cells to catecholamines or glucose because of increased their mass and increased insulin clearance [(4)]. Moreover, hypo- and hyperthyroidism can affect insulin metabolism resulting in insulin resistance (IR) [(5)].

On the other hand, DM can impair TD by altering thyroid stimulating hormone (TSH) concentrations at the hypothalamic level and by inhibiting thyroxin (T4) conversion to tri-iodothyronine (T3) in peripheral tissues [(1)]. The consequence of hyperinsulinemia/IR, in thyroid cell proliferation, which manifested as increased thyroid size and nodules has been also reported [(6)]. Detecting TD in T2DM cases will guide the clinician to provide the proper treatment for metabolic abnormalities as thyroid disorders like hypothyroidism will delicately affect the achievement of the glycaemic target and other comorbidities [(7)].

## AIM OF THE STUDY

In our current study, we aimed to explore the prevalence and possible impact of thyroid dysfunction among recently diagnosed T2DM patients within 5 years duration or less attending the Endocrinology and Diabetes Unit at Mansoura Specialized Medical Hospital, Mansoura University, Egypt.

## PATIENTS AND METHODS

### Study design

This was a cross-sectional study included 106 T2DM patients diagnosed within 5 years duration or less within the period between July 2021 and March 2022. Both males and females adult patients aged 30-60 years were included and recruited from patients attending the Endocrinology and Diabetes Unit at Mansoura Specialized Medical Hospital, Mansoura University, Egypt.

The diagnosis of DM was based on the American Diabetes Association criteria for T2DM [(8)].



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**Exclusion criteria:** Patients with type 1 DM, previous thyroid diseases, a history of other chronic diseases (liver cell failure and chronic kidney disease), patients taking any medications that can interfere with thyroid function tests (amiodarone, lithium, interferon, glucocorticoids, dopamine agonists, etc.), patients with previous thyroid surgery or previous neck irradiation, and pregnant or lactating females.

**Methods**

All patients were subjected to history taking in the form of personal history (name, age, gender, residence, occupation, and special habits), history of diabetes (duration, treatment, micro- and macrovascular complications, and comas), current symptoms of thyroid dysfunction (sleep, bowel habits, weight changes, etc.), presence of any medical comorbidities (hypertension, liver disease, chronic kidney disease, and heart disease), drug history, and history of any surgery.

The clinical examination included general examination (pulse, blood pressure, height, weight, and lower limb examination) and local thyroid examination (inspection, palpation, and auscultation). The investigations included fasting blood glucose test (FBG), 2-hour postprandial blood glucose test, HbA1c, thyroid stimulating hormone (TSH), freeT4 and freeT3 (if there is an abnormal TSH level), and thyroid ultrasound (if there is palpable goiter and/or nodules). A longitudinal and transverse ultrasound of thyroid gland was performed for selected patients with clinical and laboratory abnormalities using the ultrasound machine (Logic E9) at Specialized Medical Hospital.

Every patient was subjected to anthropometric measurements such as height, weight, and body mass index (BMI) was calculated using the standard equation: BMI=weight (kg)/height ($m^2$). A study population with a BMI of between 18.5 and 24.9 $kg/m^2$ were classified as normal, while patients who had a BMI of $\geq$ 30 $kg/m^2$ were classified as obese.

Blood pressure (BP) was measured in the right and left arms in sitting position using a mercury sphygmomanometer, after five minutes of rest then the highest measurement was taken. Normal blood pressure was defined as a systolic BP less than 130 mmHg, and/or a diastolic BP less than 80 mmHg. If not, considered to be hypertensive [9]. Mean arterial blood pressure (MAP) underwent calculation based on the formula (MAP=Diastolic BP + 1/3 pulse pressure).

**Blood sampling and Biochemical Measurements**

Following overnight fasting, venous samples were obtained from patients via venipuncture under aseptic conditions to assess blood glucose levels and HbA1c.This technique was performed by C311 device made in Germany at Specialized Medical Hospital. Thyroid function was evaluated by analyzing serum concentrations of TSH, free T3, and free T4 using C411 device made in Germany at Specialized Medical Hospital. Normal value for TSH was (0.4-4 mIU/l), freeT3 (1.4-4.2 pg/ml), and freeT4 (0.8-2.2ng/dl).

The functional interpretation of the thyroid profile was as follows: Primary hypothyroidism if TSH was more than 4 mIU/l and FT3 and FT4 values were lower than the normal range, subclinical hypothyroidism if TSH was more than 4 mIU/l and FT3 and FT4 were within normal range. Primary hyperthyroidism was recognized if FT3 and FT4 were more than normal range with TSH was below 0.4 mIU/l, while subclinical hyperthyroidism was recognized if TSH was below 0.4 mIU/l, but FT3 and FT4 were in the normal range.

**Ethical approval:**

**The study was approved by the IRB of the Faculty of Medicine, Mansoura University. The researcher explained the aim of the study to all participants who were free to participate in the study and had the right to withdraw at any time. Ethics, values, culture, and beliefs of participants were respected. The Declaration of Helsinki for human beings, which is the international medical association's code of ethics, was followed during the conduct of this study.**

***Statistical Analysis***

SPSS software, version 18, was used to analyse the data (SPSS Inc., PASW Statistics for Windows, Chicago: SPSS Inc.). Numbers and percentages were used to represent qualitative data. The means and medians for quantitative data were not normally distributed. Standard deviations for normally distributed data after the Kolmogorov-Smirnov test has determined that the data are normal. A result's significance was established at 0.05 level. To compare qualitative data between groups, Monte Carlo, Chi-Square, and Fischer exact tests were used. For the comparison of two researched groups and more than two studied groups, respectively, the Kruskall-Wallis and Mann Whitney U tests were used for non-normally distributed data. For the comparison of two independent groups with normally distributed data, the student t-test was used. When comparing more than two independent groups, the One Way ANOVA test was used, and the Post Hoc-Tukey test was used to identify pairwise comparisons. The strength and direction of a linear correlation between two non-normally distributed continuous variables and/or ordinal variables were assessed using the Spearman's rank-order correlation.

**RESULTS**

The mean (SD) age of the studied cases was 48.01 ± 7.55 ranging from 30 to 60 years, 53.8% were females and 46.2% were males, the mean body mass index was 25.98 (1.61) ranging from 23 to 32.24 $kg/m^2$, 11.3% were smokers, and the median parity was 3 ranging from nullipara to 8.

The median diabetes duration was 36 months ranging from 1 to 60 months and 74.5% of the studied cases were on oral treatment and 25.5% on insulin treatment. 88.7% had microvascular complications, 21.7% had macrovascular complications, and 1.9% had diabetic coma. 3.8% had increased sleep hours, 86.8% had no weight change, 6.6% increased weight and 6.6% also decreased weight. 22.6% had bowel changes, 56.1% had regular menses, 40.4% were post-menopausal, and 39.6% had hypertension. The mean arterial blood pressure was 93.39 ± 9.58 ranging from 69.9 to 119.8 mmHg, 1.9% had eye signs (exophthalmos), 8.5% had an abnormal thyroid examination, 46.7% had a free neck ultrasound, 46.7% had nodules, and 6.6% had goiter.

**Table (1)** showed a significant difference between patients with normal and abnormal thyroid function in terms of sex distribution, with TD affecting 12.3% of female cases and none of the male cases (p = 0.01). A non-significant association existed between abnormal thyroid function and age, body mass index (BMI), or smoking.

**Table (1):** Relationship between sociodemographic characteristics and thyroid abnormality

| | **N=106** | **Abnormal thyroid function N=7** | **Normal N=99** | **test of significance** |
|---|---|---|---|---|
| **Age/years** | 48.01±7.55 | 47.14±4.29 | 48.07±7.73 | t=0.313<br>p=0.755 |
| **Sex**<br>**Female**<br>**Male** | <br>57<br>49 | <br>7(12.3%)<br>0 | <br>50(87.7%)<br>49(100%) | <br>$X^2$=6.44<br>**p=0.01*** |
| **BMI (kg/m$^2$)** | 25.98±1.61 | 26.28±2.11 | 25.96±1.58 | t=0.512<br>p=0.610 |
| **Smoker** | 12 | 0 | 12(100%) | $X^2$=0.957<br>p=0.328 |
| **Parity** | 3(0-8) | 3(2-5) | 3(0-8) | Z=0.637<br>P=0.524 |

Parameters described as mean±SD, median (min-max), number (%), used test: $X^2$:Chi-Square test t:Student t test , Z:Mann Whitney U test.

Table (2) demonstrated a non-significant difference between cases with normal and abnormal thyroid function as regards diabetic characteristics, duration (p = 0.391) and microvascular complications (p = 0.798).

**Table (2):** Relationship between diabetic characteristics and thyroid abnormality

| | **N=106** | **Abnormal thyroid function N=7** | **Normal N=99** | **test of significance** |
|---|---|---|---|---|
| **DM duration / months** | 36(1-60)<br>(24-60) | 36(2-60)<br>(6-42) | 36(1-60)<br>(24-60) | Z=0.858<br>P=0.391 |
| **DM treatment**<br>**Oral**<br>**Insulin** | <br>79<br>27 | <br>5(6.3%)<br>2(7.4%) | <br>74(93.7%)<br>25(92.6%) | <br>$X^2$=0.038<br>p=0.846 |
| **Microvascular complications** | 94 | 6(6.4%) | 88(93.6%) | $X^2$=0.07<br>p=0.798 |
| **Macrovascular complications** | 23 | 0 | 23(100%) | $X^2$=2.08<br>p=0.150 |
| **Diabetic coma** | 2 | 0 | 2(100%) | $X^{2FET}$=0.144<br>p=1.0 |

Parameters described as mean ± SD, median (min-max), number (%), used test: $X^2$ : Chi-Square test FET:Fischer exact test t:Student t test , Z:Mann Whitney U test.

**Table (3)** demonstrated a statistically significant difference in weight alteration between cases with normal and abnormal thyroid function, with 28.6% of cases with weight gain had abnormal thyroid function (p = 0.046).

**Table (3):** Relationship between medical history and thyroid abnormality

| | **N=106** | **Abnormal thyroid function N=7** | **Normal N=99** | **test of significance** |
|---|---|---|---|---|
| **Sleep hours changes** | | | | |
| **No** | 91 | 6(6.6%) | 85(93.4%) | $^{MC}$=2.97 |
| **Increase** | 4 | 1(25%) | 3(75%) | p=0.226 |
| **Decrease** | 11 | 0 | 11(100%) | |
| **Weight change** | | | | |
| **No** | 92 | 5(5.4%) | 87(94.6%) | $X^{2MC}$=6.18 |
| **Gain** | 7 | 2(28.6%) | 5(71.4%) | **p=0.046*** |
| **Loss** | 7 | 0 | 7(100%) | |
| **Bowel changes** | | | | |
| **No** | 82 | 5(6.1%) | 77(93.9%) | $X^2$=0.150 |
| **Yes** | 24 | 2(8.3%) | 22(91.7%) | p=0.698 |
| **Menses** | n=57 | | | |
| **Reg** | 32 | 5(15.6%) | 27(84.4%) | $^{MC}$=0.887 |
| **Irregular** | 2 | 0 | 2(100%) | p=0.642 |
| **Post menopause** | 23 | 2(8.7%) | 21(91.3%) | |
| **MAP** | 93.39±9.58 | 91.27±5.03 | 93.54±9.82 | t=0.604 p=0.547 |
| **Hypertension** | 42 | 1(2.4%) | 41(97.6%) | $X^2$=2.01 p=0.156 |

Parameters described as mean ± SD, number (%), used test: MC: Monte Carlo test, $X^2$ : Chi-Square test t:Student t test.

Table (4) showed that a significant relationship was detected between the presence of eye signs (exophthalmos) and thyroid dysfunction, with all cases with eye signs had thyroid dysfunction (p = 0.004). No statistically significant correlation was detected between thyroid dysfunction and HbA1c (p = 0.859). A higher median TSH was detected among cases with abnormal thyroid function.

**Table (4):** Relationship between clinical and laboratory findings with thyroid abnormality

| | **N=106** | **Abnormal thyroid function N=7** | **Normal N=99** | **test of significance** |
|---|---|---|---|---|
| **Eye signs (Exophthalmos)** | 2 | 2(100%) | 0 | $X^{2FET}$=28.83 **p=0.004*** |
| **Thyroid examination** | | | | |
| **Normal** | 97 | 6(6.2%) | 91(93.8%) | $X^2$=0.324 |
| **Abnormal** | 9 | 1(11.1%) | 8(88.9%) | p=0.569 |
| **Fasting blood glucose** | 190.63±45.31 | 172.86±33.93 | 191.88±46.42 | t=0.673 p=0.503 |
| **Post prandial blood glucose** | 262.51±62.40 | 252.86±58.71 | 263.19±63.32 | t=0.270 p=0.788 |
| **HbA1c (%)** | 8.53±2.11 | 8.39±1.29 | 8.54±2.01 | t=0.178 p=0.859 |
| **<7** | 27 | 0 | 27(100%) | $X^2$=2.56 |
| **≥7** | 79 | 7(8.9%) | 72(91.1%) | p=0.109 |
| **Neck US** | n=15 | | | |
| **Free** | 7 | 4(57.1%) | 3(42.9%) | MC=2.37 |
| **Goiter** | 1 | 1(100%) | 0 | p=0.305 |
| **Nodule** | 7 | 2(28.6%) | 5(71.4%) | |
| **TSH (mIU/L)** | | 5.33±1.23 | 1.66±0.41 | Z=6.25 P<0.001* |

Parameters described as mean±SD, number (%), used test: MC:Monte Carlo test , $X^2$ :Chi-Square test t:Student t test , Z:Mann Whitney U test

**Table (5)** illustrates the statistically significant association between TD and the sex of studied cases; with all the thyroid dysfunction cases were females (p = 0.04); 8.8% had subclinical hypothyroidism, 3.5% had overt hyperthyroidism, and none of the studied males had abnormal thyroid function.

**Table (5):** Relationship between sociodemographic characteristics and thyroid dysfunction among studied cases

| | N=106 | overt hyperthyroidism (N=2) | normal (N=99) | subclinical hypothyroidism (N=5) | test of significance |
|---|---|---|---|---|---|
| **Age/years** | 48.01±7.55 | 47.0±2.82 | 48.07±7.73 | 47.20±5.07 | F=0.049<br>P=0.952 |
| **Sex**<br>**Female**<br>**Male** | <br>57<br>49 | <br>2(3.5%)<br>0 | <br>50(87.7%)<br>49(100%) | <br>5(8.8%)<br>0 | <br>MC=6.44<br>P=0.04* |
| **BMI (kg/m$^2$)** | 25.98±1.61 | 25.20±1.69 | 25.96±1.58 | 26.71±2.27 | F=0.760<br>P=0.470 |
| **Parity** | 3(0-8) | 5(4-5) | 3(0-8) | 3(2-4) | KW=3.29<br>P=0.193 |
| **Smoker** | 12 | 0 | 12(100%) | 0 | MC=0.957<br>P=0.620 |

Parameters described as mean ± SD, median (min-max), number (%), used test: MC: Monte Carlo test, F: One Way ANOVA test , KW: Kruskall Wallis test.

Table (6) showed that all cases with eye signs had subclinical hypothyroidism with a significant correlation between them (p < 0.001). There was no significant correlation between thyroid dysfunction and the presence of thyroid nodules or goiter (p = 0.306).

**Table (6):** Relationship between clinical, local examination, and laboratory findings with thyroid dysfunction

| | N=106 | overt hyperthyroidism (N=2) | normal (N=99) | subclinical hypothyroidism (N=5) | test of significance |
|---|---|---|---|---|---|
| **Eye signs (Exophthalmos** | 2 | 0 | 0 | 2(100%) | MC=41.18<br>P<0.001* |
| **Thyroid examination**<br>**Normal**<br>**Abnormal** | <br>97<br>9 | <br>2(2.1%)<br>0 | <br>91(93.8%)<br>8(88.9%) | <br>4(4.1%)<br>1(11.1%) | <br>MC=1.06<br>P=0.589 |
| **Fasting blood glucose** | 190.63±15.22 | 157±34.51 | 191.88±46.11 | 179.20±25.03 | F=0.291<br>P=0.748 |
| **Post prandial blood glucose** | 262.51±62.53 | 268±64.32 | 263.19±61.72 | 246.80±42.65 | F=0.069<br>P=0.933 |
| **HbA1c (%)** | 8.53±2.10 | 7.40±0.57 | 8.54±2.11 | 8.78±1.32 | F=0.280<br>P=0.756 |
| **<7**<br>**≥7** | 27<br>79 | 0<br>2(2.5%) | 27(100%)<br>72(91.1%) | 0<br>5(6.3%) | MC=2.56<br>p=0.278 |
| **Neck US**<br>**Free**<br>**Goiter**<br>**Nodule** | n=15<br>7<br>1<br>7 | <br>2(28.6%)<br>0<br>0 | <br>3(42.9%)<br>0<br>5(71.4%) | <br>2(28.6%)<br>1(100%)<br>2(28.6%) | <br>MC=4.82<br>P=0.306 |

Parameters described as mean ± SD, median (min-max), number (%), used test: MC: Monte Carlo test, F: One Way ANOVA test

Table (7) demonstrated that a significant negative association was detected between age and T3 level (r = -.558, p = 0.013). No other statistically significant association was detected between thyroid hormone level and age, diabetes duration, mean BP, fasting and postprandial glucose level, HbA1c, and body mass index (p > 0.05).

**Table (7): Association between thyroid hormones and age, diabetes duration, BMI, and laboratory findings among studied cases**

| | | TSH | T3 | T4 |
|---|---|---|---|---|
| Age (years) | R | .004 | **-.558*** | -.218 |
| | P | .966 | **.013** | .370 |
| DM Duration (months) | R | .003 | .100 | .101 |
| | P | .972 | .685 | .680 |
| MAP | R | -.073 | -.077 | -.279 |
| | P | .460 | .753 | .247 |
| FBG (mmol/L) | R | -.029 | .185 | .077 |
| | P | .766 | .447 | .756 |
| PPG | R | -.018 | .176 | .274 |
| | P | .857 | .472 | .257 |
| HBA1C (%) | R | -.057 | -.032 | -.220 |
| | P | .559 | .898 | .365 |
| BMI ($Kg/m^2$) | R | .122 | -.035 | -.023 |
| | p | .212 | .886 | .926 |

r: Spearman correlation coefficient, *statistically significant.

## DISCUSSION

Hyperglycemia is the hallmark of the metabolic abnormalities in DM because of dysfunctional pancreatic beta cells. After diabetes, thyroid dysfunction (TD) is the second most common endocrine disorder [(10)]. DM and thyroid dysfunction can interact with each other in many ways. The abnormalities present in T2DM, such as enhanced insulin degradation, enhanced glucagon release, enhanced hepatic gluconeogenesis, and increased catecholamines levels have a significant role in the pathogenesis of hyperthyroidism [(11)]. In hyperthyroidism, increased hepatic glucose production and upregulated glycogenolysis result in glucose intolerance and subsequent worsening of hyperglycemia in diabetic patients [(12)].

Sometimes it is challenging to diagnose TD among diabetic patients based on clinical picture, since hyperthyroidism features might mimic hyperglycaemia features, such as weight loss in spite of polyphagia and tiredness. Also, hypothyroidism could be confused with diabetic nephropathy as the patient can present with gaining weight, puffy eyelids, oedema, pallor, and fatigue [(13)]. The prevalence of TD among T2DM individuals has gained significant attention in epidemiologic studies in the previous 10 years [(7)]. Numerous studies evaluated the relationship between T2DM and TD [(12)]. Furthermore, such studies found a high incidence of diabetic complications in TD patients. Therefore, it is important to evaluate TD prevalence among T2DM individuals to help good glycemic control and few complications [(10)].

In our cross-sectional study, we aimed to explore the prevalence and possible impact of thyroid dysfunction among 106 recently diagnosed (within 5 years duration) T2DM patients of both sexes.

During the conduction of this study, the incidence of TD in T2DM cases was 6.6%, with an overall prevalence of subclinical hypothyroidism of 4.7%, and an overt hyperthyroidism prevalence of 1.9% representing 28.6%. As in most previous studies, subclinical hypothyroidism was the commonest form of TD (71.4%). Our results are in accordance with **Warren *et al.*** [(14)] study that showed that TD were known in 6.2 % and newly diagnosed in 6.9 % of T2DM cases. On the contrary, **Zhu *et al.*** [(15)] found a greater prevalence (23.7%) of TD among T2DM cases. This was consistent with other reports which revealed that the prevalence of TD in T2DM cases was 26.7% [(16)] and 29% [(10)].Differences between the results of our study and other studies might be related to many factors (population diversity, differences in iodine intake, different diagnostic criteria of TD and different sensitivities of laboratory tests)[(17)]. Geographic location as well as ethnic characteristics are variation factors in epidemiologic studies [(18)]. Differences in methods of TSH quantification might also affect results [(19)]. Also, **Al-Geffari *et al.*** [(20)] showed that TD influences about 28.5% of Saudi T2DM patients, which is higher than that revealed by **Akbar *et al.*** [(21)] (16%) though Akbar study has a larger sample and an older cohort age when compared to other communities, as in the Scotland study [(22)] or the Jordanian study [(23)]. This can be clarified by the high prevalence of latent autoimmune DM in adults (LADA) in Saudi T2DM patients, reaching 26% who are not excluded from **Al-Geffari** [(20)] study. Moreover, some studies were conducted on certain age groups, such as **Zhu *et al.*** [(15)] study, which was conducted on Chinese elderly patients aged ≥ 60 years old.

Hypothyroidism was more frequent 4.7% compared with hyperthyroidism 1.9% in the studied cases similar to other studies [(15, 24)], while the same prevalence of both disorders was found by **Hmood *et al.*** [(25)]. It was advocated that chronic hyperglycaemic condition of T2DM initiates the onset of subclinical hypothyroidism [(25)]. The prolonged decrease in assimilation of peripheral glucose results in increased TSH release in spite of having normal values of thyroid hormones [(26)].

However, a non-significant relationship existed between TD and DM duration, which is consistent with other studies as a study conducted in Jordan [(16)]. Nevertheless, other reports found that TD patients had longer DM duration in comparison with those with normal thyroid profile [(10, 27)]. **Al-Geffari *et al.*** [(20)] stated that DM >10 years was a risk factor for hypothyroidism.

The patients' baseline characteristics demonstrated a mean age of 48.01±7.55 years, but

47.14±4.29 and 48.07±7.73 for DM cases with and without TD respectively, with no significant difference (p=0.755). In our study, there was no association between age and thyroid disorders, which agrees with the results of other studies [15, 18]. However some studies revealed that TD prevalence is increased with age [16, 28].

The percent of smoking habits among T2DM cases with and without TD in this study did not show any significant difference (p=0.328) similar to **Al-Geffari *et al.*** [20] findings. It is noteworthy that smoking has been reported as a risk factor for TD in general population, particularly when smoking is significantly prevalent, where elevated T4 values and reduced TSH values were reported in smokers but not in non-smokers or ex-smokers [20].

The high prevalence of diabetes microvascular complications in this study can be related to diabetes duration, poor glycemic control (high mean HbA1c = 8.53 ± 2.11), hypertension (39.6%) and smoking (11.3%). However, in our current study, there were no associations between the development of diabetic complications and thyroid disorders, which is in agreement with the results of other studies [16-18]. In a study in north India, diabetic retinopathy and nephropathy did not predict TD [29]. On the other hand, subclinical hypothyroidism among T2DM cases has been associated with diabetic nephropathy [30].

The higher prevalence of TD in T2DM females can be because of the direct effect of oestrogen on thyroid follicular cells, and on thyroxin-binding globulin (TBG) [31]**.** This study is consistent with such a concept since TD prevalence was statistically significantly greater among female patients (p=0.04) where 12.3% of female cases had thyroid dysfunction, 8.8% had subclinical hypothyroidism, and 3.5% had overt hyperthyroidism while none of the studied males had abnormal thyroid function. Such findings are in agreement with previous reports of greater prevalence of TD among female patients [10, 32]. As regarding anthropometric measurements, the mean BMI of the total sample was 25.98 ± 1.61, but 26.28 ± 2.11 and 25.96 ± 1.58 for diabetics with and without TD, respectively, without a significant difference (p=0.610), which is consistent with other studies [16, 18, 20]. On the other side, TD was found to be more common in obese diabetics in comparison with non-obese [10, 29]**.**

In our study, T2DM patients showed a high mean HbA1c (8.53 ± 2.10) reflecting poor glycemic control. Inappropriate drug adherence and financial constraints might be the main contributors [16]**.** This study showed that TD was associated with poorly controlled diabetic state in T2DM cases without a statistically significant difference (p=0.859). This comes in concordance with **Al-Geffari *et al.*** [20] and **Diez *et al.*** [18] findings where there was no significant difference in those with or without TD as regarding the mean HbA1c and FBS. When we analysed the association between TD and glycaemic control among diabetic cases, we detected that TD was linked to increased mean HbA1c values. Also, TD prevalence increased significantly at a HbA1c level of ≥ 7%, whereas better glycaemic control (HbA1c <7%) was associated with more cases without TD. This suggests poor glycaemic control that might be a contributor factor for TD among T2DM cases, as mentioned in **Elgazar *et al.*** [10].

This comes in agreement with **Sreelatha *et al.*** [33] who found that TD prevalence was higher when HbA1c was ≥7% (78.57%) as compared to HbA1c <7% (21.4%)**.** Our result is also in concordance with the finding of **Jain *et al.*** [34]**,** who showed that the majority of diabetics who had TD (81.25%) had HbA1c ≥7 as compared to (18.75%) had HbA1c <7.

As regarding the thyroid function tests, our study didn't reveal any association between serum TSH and HbA1c which is concordant with results of **Khassawneh *et al.*** [16] and **Uppal *et al.*** [35], which showed that serum TSH value was not significantly different in T2DM cases and non-diabetic individuals.

The overall prevalence of thyroid nodules was 46.7% in the cases that underwent thyroid US, compared to 28.6% in patients with thyroid dysfunction and 71.4% in cases without TD. Our results indicate that T2DM cases are at high risk of thyroid nodules. This is in accordance with **Hmood *et al.*** [25]. Goiter was not found to be a significant risk factor for TD in our study similar to that reports by **Díez *et al.*** [18] and **Al-Geffari *et al.*** [20].

## CONCLUSION

Thyroid dysfunction was commonly developed in recently diagnosed patients with T2DM, with hypothyroidism more frequent than hyperthyroidism and subclinical hypothyroidism being the commonest type. The female gender could be considered a predictor and risk factor for thyroid dysfunction. Poorly controlled diabetes was observed among T2DM subjects with thyroid dysfunction. Thus, proper treatment and control of DM can reduce the frequency of thyroid dysfunction, and vice versa. Future studies with a larger sample size from different centers are recommended to validate such results, and to recognize the potential mechanisms.

## RECOMMENDATIONS

Regular screening of TD in T2DM subjects, particularly those who have greater HbA1c, can help early detection and treatment of TD permitting for good glycaemic control and reducing complications of DM. More large-scale studies are needed in the future. Future studies are needed for determination of the cost-effectiveness of TD screening in T2DM patients.


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