The relationship between thyroid hormone levels, insulin resistance and body mass index, in patients with subclinical hypothyroidism and euthyroid patients

Abstract. Background. Hypothyroidism is a common thyroid disorder with female predominance. In general population its prevalence is 2–5 % while 10 times higher in female than in men. Insulin resistance, one of the most discussed issues recently, is an inadequate response to insulin in peripheral tissues despite the normal secretory function of pancreatic islet cells. In this study, we analyzed relationship between thyroid hormone levels, body mass index and insulin resistance calculated with Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), Quantitative Insulin Sensitivity Check Index (QUICKI) and Atherogenic Index of Plasma (AIP) in SCH and euthyroid patients under levothyroxine treatment. Materials and methods. The clinical and laboratory data of approximately 14 000 patients between the ages of 18–60 were retrospectively evaluated. After these exclusion criteria were applied, 371 eligible individuals were included in the study. All 371 individuals divided into three groups according to TSH levels. Group 1 is euthyroid patients under levothyroxine treatment with TSH levels between 0.27–4.2 μIU/mL. Group 2 is subclinical hypothyroid patients with TSH levels between 4.2–10 μIU/mL. Group 3 is healthy control group with TSH levels between 0.27–4.2 μIU/mL. Results. The euthyroid patient group has the highest (25.66 ± 3.36 kg/m²) mean BMI. On the other hand the mean BMI was higher in SCH (24.0400 ± 3.8436 kg/m²) group than in control group (22.48 ± 2.74 kg/m²) (p < 0.05). Fasting plasma glucose (FPG), serum triglycerid, low density lipoprotein (LDL), anti-thyroid peroxidase (TPO) and insulin levels were significantly higher in euthyroid patient and SCH groups (p < 0.05). Notably, total cholesterol, LDL and TPO levels were higher in euthyroid patient group (p < 0.05). On the other hand, there were no difference between euthyroid patients and SCH group. Conclusions. This study found significantly elevated insulin resistance and cholesterol levels in SCH patients, so we hypothesized that SCH is also a risk factor for insulin resistance disorders such as cardiovascular diseases and metabolic syndrome. As a consequence, lipid metabolism defects and insulin resistance should be screened and treated in SCH patients. Thanks to the strong and significant correlation between HOMA and QUICKI in our study, we suggest the combined use of HOMA and QUICKI in these patients. Further and large-scale studies are needed to evaluate the relationship of HOMA, QUICKI, AIP, and BMI in detecting insulin resistance in SCH patients. Keywords: subclinical hypothyroidism; thyroid hormone levels; insulin resistance; body mass index

Introduction

Hypothyroidism is a common thyroid disorder with female predominance. In general population its prevalence is 2–5 % while 10 times higher in female than in men. The most common cause of primary hypothyroidism characterized with increased thyroid-stimulating hormone (TSH) levels is iodine deficiency worldwide. On the other hand, specifically in regions with adequate iodine intake the main cause of hypothyroidism is chronic autoimmune thyroiditis [1].

Subclinical hypothyroidism (SCH) can be defined as a biochemical condition with normal free thyroxine concentration while serum TSH levels are high [2]. The prevalence of SCH is much more higher than primary hypothyroidism, ranges from 4 to 15 % in general population. When a high serum TSH level is detected with free thyroxine in the normal reference range, tests should be repeated 2 or 3 months later with thyroid peroxidase antibodies to confirm the diagnosis [3].
Insulin resistance, one of the most discussed issues recently, is an inadequate response to insulin in peripheral tissues despite the normal secretory function of pancreatic islet cells [4]. Hyperglycemia is associated with hyperinsulinemia due to disturbances in glucose uptake in tissues, and the combination of these two is the main finding of insulin resistance. Most individuals with insulin resistance may be undiagnosed more than 10 years. This period is detrimental, as insulin resistance is an independent risk factor for obesity, cardiovascular disease, hypertension, and type 2 diabetes [5].

Even though hyperinsulinemic-euglycemic clamp technique is gold standard for demonstrating insulin sensitivity, it is challenging to perform. Therefore, the metabolic syndrome closely associated with insulin resistance, characterized by obesity, increased blood pressure, fasting glucose (FG), triglyceride (TG) levels and low high-density lipoprotein (HDL) is used in clinical decision making [6].

There are many conflicting results regarding correlation between thyroid hormone levels and insulin sensitivity in literature. In an experiment on rats with propylthiouracil-induced hypothyroidism, abnormal insulin secretion was observed as a result of abnormalities of the enzyme activity of pancreatic islet cells [7]. Two recent studies with euthyroid patients suggested that serum free T₄ secretion alone may have an important role in insulin secretion, although not TSH and free T₃ [8, 9]. In addition, some studies have revealed that early atherosclerotic lesions occur in euthyroid autoimmune thyroiditis [10]. The complexity of the effects of thyroid hormones on insulin and glucose metabolism is of great interest [11].

In this study, we analyzed relationship between thyroid hormone levels, body mass index (BMI) and insulin resistance calculated with Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), Quantitative Insulin Sensitivity Check Index (QUICKI) and Atherogenic Index of Plasma (AIP) in SCH and euthyroid patients under levothyroxine treatment.

Materials and methods

The clinical and laboratory data of approximately 14,000 patients between the ages of 18–60 who admitted to the Department of Internal Medicine outpatient clinic in Cumhuriyet University Medical Faculty Hospital between 2012 and 2018 were retrospectively evaluated. Patients with hyperthyroidism or antithyroid treatment, diabetes mellitus, chronic liver disease, chronic kidney disease, malignancy or any infectious disease were excluded from the study. On the other hand, patients with a BMI above 30 kg/m², those using drugs that may affect insulin and glucose metabolism, and those with a diagnosis of impaired glucose tolerance or impaired fasting glucose were also excluded from the study.

After these exclusion criteria were applied, 371 eligible individuals were included in the study. All 371 individuals divided into three groups according to TSH levels. Group 1 is euthyroid patients under levothyroxine treatment with TSH levels between 0.27–4.2 μIU/mL. Group 2 is subclinical hypothyroid patients with TSH levels between 4.2–10 μIU/mL. Group 3 is healthy control group with TSH levels between 0.27–4.2 μIU/mL.

Glucose, TG, total cholesterol (TC), low density lipoprotein (LDL-C) and HDL-C levels were measured by spectrophotometric method (Beckman Coulter AU 5800, USA). Insulin, TSH, antiTPO and FT4 levels were determined immunometric methods (Beckman Coulter, Dxl 800, USA).

Three different tools were used to determine insulin resistance; Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), Quantitative Insulin Sensitivity Check Index (QUICKI) [12] and Atherogenic Index of Plasma (AIP) [13].

Statistical analysis

The data obtained from our study were analysed with on SPSS (ver: 22.0) packet program. Normality was checked with Kolmogorof — Simirnov test. For significance analyses, Tukey test was used to determine differed group or groups. For non-parametric data, Kruskal — Wallis test, Mann — Whitney U test were used. Pearson correlation analysis was used to determine the relationships between variables and the error level was 0.05.

Results

The patients included in the study were divided into 3 groups, patients with SCH (n = 154), euthyroid patients (n = 94) and healthy control group (n = 123). The percentage of female patients was higher in all groups; 85.1, 93.6 and 72.4 % respectively. The mean ages of control, euthyroid and SCH groups were 25.79 ± 8.28; 38.17 ± 11.27; 30.29 ± 11.61 respectively. The euthyroid patient group has the highest (25.66 ± 3.36 kg/m²) mean BMI. On the other hand the mean BMI was higher in SCH (24.04 ± 3.8436 kg/m²) group than in control group (22.48 ± 2.74 kg/m²) (p < 0.05).

Fasting plasma glucose (FPG), serum triglycerid, low density lipoprotein (LDL), anti-thyroid peroxidase (TPO) and insulin levels were significantly higher in euthyroid patient and SCH groups (p < 0.05). Notably, total cholesterol, LDL and TPO levels were higher in euthyroid patient group (p < 0.05). All laboratory data are summarized in Table 1.

When analyzed HOMA, QUICKI and AIP results to evaluate insulin resistance, these values were significantly higher in SCH group (p < 0.05). On the other hand, there were no difference between euthyroid patients and SCH group (Table 2).

Body mass index (BMI) was positively correlated with HOMA and AIP while negatively correlated with QUICKI.

The correlation coefficients between the variables in the subclinical hypothyroidism, euthyroid and control groups are summarized in Tables 3–5.

Discussion

In our retrospective study, HOMA, QUICKI and AIP values were significantly higher in SCH group according to controls. Also FPG, triglyceride, LDL and fasting insulin levels were significantly higher in euthyroid and SCH patients. Euthyroid group has highest mean BMI in all groups. Homeostatic Model Assessment for Insulin Resistance levels were significantly different between controls and SCH, and between controls and euthyroid patients. Body mass index was positively correlated with HOMA and AIP but negatively with...
QUICKI. On the other hand, AIP has positive correlation with HOMA but weak negative correlation with QUICKI. High density lipoprotein levels positively correlated with QUICKI but negatively with HOMA. In SCH group, TSH and T4 levels showed statistically insignificant correlation with other variables, but FPG was positively correlated with triglyceride levels, AIP, BMI and HOMA levels meanwhile it is negatively correlated with HDL and QUICKI. Triglyceride levels were positively correlated with HOMA and BMI.

As is well known, one of the most common causes of hypothyroidism is autoimmunity. In accordance, 55.2% (79/143) of patients with SCH and 80.2% (73/91) of euthyroid patients under treatment had chronic autoimmune thyroiditis in our study.

M. Owecki et al. [15] examined 15 patients with hypothyroidism due to total thyroidectomy and did not find any correlation with insulin resistance by using HOMA index. A. Tuzcu et al. [16] showed that 77 SCH patients without insulin resistance had higher fasting insulin, total and LDL cholesterol levels according to control group. However, there was no significant difference between HOMA levels. In another study by S. Sengupta et al. [17] HOMA index, BMI, LDL and insulin levels were found to be significantly higher in patients with SCH than healthy controls.

In our study, difference of HOMA levels between control and SCH, and control and euthyroid group were significant. On the other hand, HOMA, QUICKI and AIP values were significantly higher in SCH group than in controls; FPG, TG, LDL cholesterol, TPO and insulin levels were significantly higher in euthyroid patients and SCH groups than controls.

A. Sayed et al. [18] suggested that lipid metabolism defects should be screened and treated in SCH patients due to their study which showed higher insulin, total cholesterol and LDL levels in SCH groups than healthy controls.

In recent study, BMI was positively correlated with HOMA and AIP, while negatively correlated with QUICKI. N. Aksoy et al. [19] found no difference of BMI and HOMA in SCH and control groups. H.O. Doğan et al. [20] stated that AIP alone was not reliable to detect insulin resistance but could be use together with HOMA and QUICKI to exclude insulin resistance. Another recent study showed a positive correlation between AIP and serum TSH levels in SCH group [21]. In a study published in 2021, no significant association was found between TSH and HOMA levels [22].

Table 1. Laboratory data of patient subgroups

| Condition                  | Control (n = 123)          | Euthyroid (n = 94)           | Subclinical hypothyroidism (n = 154) | Result |
|----------------------------|-----------------------------|-----------------------------|-------------------------------------|--------|
| FPG (mg/dL)                | 80.42 ± 6.38 (65–100)      | 85.76 ± 7.94 (70–125)       | 84.20 ± 7.57 (64–110)              | F = 16.07, P = 0.001 |
| TG (mg/dL)                 | 76.12 ± 34.16 (26–200)     | 111.63 ± 86.32 (34–537)    | 109.87 ± 71.54 (32–495)            | F = 9.98, P = 0.001 |
| CHOL (mg/dL)               | 157.59 ± 28.18 (96–243)    | 186.55 ± 38.72 (67–285)    | 170.70 ± 37.50 (96–296)            | F = 14.10, P = 0.001 |
| LDL (mg/dL)                | 91.34 ± 27.44 (34–191)     | 112.41 ± 30.73 (52–192)    | 100.85 ± 31.12 (38–204)            | F = 12.36, P = 0.001 |
| HDL (mg/dL)                | 54.01 ± 11.37 (32–92)      | 54.39 ± 14.98 (30–113)     | 50.72 ± 11.94 (26–81)              | F = 2.14, P = 0.001 |
| TSH (µIU/mL)               | 2.94 ± 11.30 (0.38–127)    | 2.53 ± 1.86 (0.31–16.9)    | 5.82 ± 1.73 (4.25–13.9)            | F = 9.56, P = 0.001 |
| T4 (ng/dL)                 | 1.28 ± 0.15 (0.93–1.74)    | 1.28 ± 0.22 (0.61–1.76)    | 1.23 ± 0.63 (0.87–8.6)             | F = 0.63, P = 0.001 |
| antiTPO (IU/mL)            | 13.51 ± 4.42 (2.1–28)      | 143.30 ± 193.67 (0.24–86)  | 85.03 ± 142.84 (0.1–60)            | KW = 33.36, P = 0.001 |
| Insulin (µIU/mL)           | 7.52 ± 2.50 (1.71–12.75)   | 9.56 ± 4.73 (2.6–35.71)    | 10.16 ± 4.77 (3.47–30)             | KW = 23.04, P = 0.001 |

Notes: FPG — fasting plasma glucose; TG — triglyceride; CHOL — cholesterol; LDL — low density lipoprotein; HDL — high density lipoprotein; TSH — thyroid-stimulating hormone; T4 — thyroxine; antiTPO — anti-thyroid peroxidase.

Table 2. HOMA, QUICKI, AIP results of subgroups

| Condition      | Control (n = 123)          | Euthyroid (n = 94)           | Subclinical hypothyroidism (n = 154) | Result |
|----------------|-----------------------------|-----------------------------|-------------------------------------|--------|
| HOMA           | 1.49 ± 0.51 (0.324–2.50)   | 2.04 ± 1.05 (0.449–7.32)    | 2.13 ± 1.11 (0.69–7.56)             | F = 17.42, P = 0.001 |
| QUICKI         | 0.11 ± 0.03 (0.068–0.27)    | 0.09 ± 0.03 (0.027–0.22)    | 0.09 ± 0.03 (0.0312–0.18)           | F = 11.81, P = 0.001 |
| AIP            | 0.03 ± 0.00 (0.019–0.06)    | 0.03 ± 0.01 (0.014–0.07)    | 0.04 ± 0.01 (0.0216–0.09)           | F = 5.31, P = 0.006 |

Notes: HOMA — Homeostasis Model Assessment; QUICKI — The quantitative insulin sensitivity check index; AIP — Atherogenic Index of Plasma.
Table 3. The correlation coefficients between the variables in the control group

| Variable | FPG (mg/dL) | TG (mg/dL) | CHOL (mg/dL) | LDL (mg/dL) | HDL (mg/dL) | TSH (µIU/mL) | T4 (ng/dL) | TPO (IU/mL) | AIP | HOMA | QUICKI | BMI (kg/m²) |
|----------|-------------|-------------|--------------|-------------|-------------|--------------|-------------|-------------|-----|------|--------|-------------|
| FPG (mg/dL) | R 1 0.192 | 0.011 | −0.032 | −0.008 | 0.024 | −0.096 | 0.081 | 0.253 | −0.092 | 0.020 |
| p | 0.043 | 0.910 | 0.903 | 0.780 | 0.929 | 0.791 | 0.296 | 0.497 | 0.005 | 0.311 | 0.824 |
| TG (mg/dL) | R 1 0.285 | 0.378 | −0.388 | −0.034 | −0.198 | −0.011 | 0.686 | 0.193 | −0.184 | 0.340 |
| p | 0.004 | 0.000 | 0.001 | 0.720 | 0.038 | 0.910 | 0.000 | 0.043 | 0.053 | 0.000 |
| CHOL (mg/dL) | R 1 0.897 | 0.236 | 0.083 | −0.088 | −0.006 | −0.076 | −0.203 | 0.155 | 0.175 |
| p | 0.000 | 0.038 | 0.395 | 0.371 | 0.953 | 0.525 | 0.037 | 0.114 | 0.073 |
| LDL (mg/dL) | R 1 −0.141 | 0.119 | −0.068 | −0.031 | 0.243 | −0.114 | 0.092 | 0.249 |
| p | 0.223 | 0.207 | 0.469 | 0.744 | 0.042 | 0.225 | 0.330 | 0.007 |
| HDL (mg/dL) | R 1 0.300 | 0.336 | 0.581 | 0.000 | 0.162 | 0.104 | 0.205 |
| p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| TSH (µIU/mL) | R 1 0.260 | 0.041 | 0.087 | −0.091 | 0.075 | −0.057 |
| p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| T4 (ng/dL) | R 1 0.004 | 0.657 | 0.466 | 0.319 | 0.408 | 0.528 |
| p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| TPO (IU/mL) | R 1 0.058 | 0.818 | 0.708 | 0.546 | 0.070 |
| p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AIP | R 1 0.683 | 0.898 | 0.814 | 0.000 |
| p | 0.000 | 0.000 | 0.000 | 0.000 |
| HOMA | R 1 0.111 | 0.189 | −0.217 | 0.243 |
| p | 0.000 | 0.000 | 0.000 | 0.000 |
| QUICKI | R 1 −0.090 | 0.142 |
| p | 0.000 | 0.000 |
| BMI (kg/m²) | R 1 0.085 |
| p | 0.000 |

Notes: FPG — Fasting plasma glucose; TG — Triglyceride; CHOL — Cholesterol; LDL — Low density lipoprotein; HDL — High density lipoprotein; TSH — thyroid-stimulating hormone; T4 — thyroxine; TPO — anti-thyroid peroxidase; HOMA-IR — Homeostasis Model Assessment — Insulin Resistance; QUICKI — The quantitative insulin sensitivity check index; AIP — Atherogenic Index of Plasma; BMI — Body Mass Index.
### Table 4. The correlation coefficients between the variables in the subclinical hypothyroidism group

|                | FPG (mg/dL) | TG (mg/dL) | CHOL (mg/dL) | LDL (mg/dL) | HDL (mg/dL) | TSH (µIU/mL) | T4 (ng/dL) | TPO (IU/mL) | AIP | HOMA | QUICKI | BMI  |
|----------------|-------------|------------|--------------|-------------|-------------|--------------|------------|-------------|-----|------|--------|------|
| FPG (mg/dL)   | R 1         | 0.239      | 0.095        | -0.272      | -0.045      | -0.065       | -0.036     | 0.225       | 0.464| -0.261| 0.242  |
| P              | 0.005       | 0.997      | 0.270        | 0.007       | 0.579       | 0.425        | 0.672      | 0.027       | 0.000| 0.001| 0.003  |
| TG (mg/dL)    | R 1         | 0.365      | 0.298        | -0.549      | 0.028       | -0.015       | -0.004     | 0.812       | 0.313| -0.235| 0.309  |
| P              | 0.000       | 0.000      | 0.000        | 0.749       | 0.860       | 0.964        | 0.000      | 0.000       | 0.000| 0.006| 0.000  |
| CHOL (mg/dL)  | R 1         | 0.936      | 0.083        | -0.171      | -0.075      | 0.076        | 0.108      | 0.059       | -0.020| 0.279 |
| P              | 0.000       | 0.466      | 0.089        | 0.458       | 0.459       | 0.325        | 0.560      | 0.842       | 0.005|      |
| LDL (mg/dL)   | R 1         | -0.009     | -0.101       | -0.068      | -0.005      | 0.097        | 0.023      | 0.043       | 0.252 |
| P              | 0.926       | 0.240      | 0.431        | 0.958       | 0.346       | 0.793        | 0.620      | 0.003       |      |
| HDL (mg/dL)   | R 1         | -0.048     | -0.035       | -0.897      | -0.253      | 0.249        | -0.337     |            |      |
| P              | 0.624       | 0.240      | 0.431        | 0.958       | 0.346       | 0.793        | 0.620      | 0.003       |      |
| TSH (µIU/mL)  | R 1         | -0.063     | 0.170        | -0.039      | -0.083      | -0.016       | -0.011     |            |      |
| P              | 0.441       | 0.052      | 0.702        | 0.304       | 0.848       | 0.897        |            |            |      |
| T4 (ng/dL)    | R 1         | -0.046     | 0.049        | 0.057       | -0.093      | -0.053       |            |            |      |
| P              | 0.588       | 0.630      | 0.481        | 0.250       | 0.510       |            |            |            |      |
| TPO (IU/mL)   | R 1         | 0.018      | -0.066       | 0.022       | -0.045      |            |            |            |      |
| P              | 0.865       | 0.434      | 0.792        | 0.592       |            |            |            |            |      |
| AIP           | R 1         | 0.274      | -0.251       | 0.322       |            |            |            |            |      |
| P              | 0.007       | 0.013      | 0.001        |            |            |            |            |            |      |
| HOMA          | R 1         | -0.855     | 0.184        |            |            |            |            |            |      |
| P              | 0.000       | 0.022      |            |            |            |            |            |            |      |
| QUICKI        | R 1         |            | -0.198       |            |            |            |            |            |      |
| P              |            |            | 0.014        |            |            |            |            |            |      |
| BMI (kg/m²)   | R 1         |            |            |            |            |            |            |            |      |
| P              |            |            |            |            |            |            |            |            |      |

**Notes:** FPG — Fasting plasma glucose; TG — Triglyceride; CHOL — Cholesterol; LDL — Low density lipoprotein; HDL — High density lipoprotein; TSH — thyroid-stimulating hormone; T4 — thyroxine; TPO — anti-thyroid peroxidase, HOMA-IR — Homeostasis Model Assessment — Insulin Resistance; QUICKI — The quantitative insulin sensitivity check index; AIP — Atherogen Index of Plasma; BMI — Body Mass Index.
Table 5. The correlation coefficients between the variables in the euthyroid group

|                   | FPG (mg/dL) | TG (mg/dL) | CHOL (mg/dL) | LDL (mg/dL) | HDL (mg/dL) | TSH (µIU/mL) | T4 (ng/dL) | TPO (IU/mL) | AIP | HOMA | QUICKI | BMI (kg/m²) |
|-------------------|-------------|------------|--------------|-------------|-------------|--------------|------------|-------------|-----|------|--------|-------------|
| FPG (mg/dL)       | R           | -0.002     | 0.262        | 0.162       | 0.107       | -0.087       | 0.005      | -0.126      | -0.046 | 0.410 | -0.303 | 0.066       |
|                   | p           | 0.987      | 0.038        | 0.134       | 0.444       | 0.407        | 0.962      | 0.233        | 0.745  | 0.000 | 0.003  | 0.525       |
| TG (mg/dL)        | R           | 1          | 0.394        | 0.299       | -0.288      | -0.016       | -0.143     | 0.197        | 0.634  | 0.409 | -0.341 | 0.211       |
|                   | p           | 0.001      | 0.005        | 0.036       | 0.886       | 0.182        | 0.070      | 0.000        | 0.000  | 0.001 | 0.049  |             |
| CHOL (mg/dL)      | R           | 1          | 0.833        | 0.173       | 0.000       | -0.220       | -0.008     | 0.056        | 0.226  | -0.202 | 0.133  |             |
|                   | p           | 0.000      | 0.233        | 0.999       | 0.083       | 0.950        | 0.703      | 0.075        | 0.113  | 0.298 |        |             |
| LDL (mg/dL)       | R           | 1          | -0.188       | -0.093      | -0.216      | 0.037        | 0.271      | 0.235        | -0.166 | 0.207 |        |             |
|                   | p           | 0.182      | 0.394        | 0.044       | 0.738       | 0.052        | 0.029      | 0.125        | 0.054  |        |        |             |
| HDL (mg/dL)       | R           | 1          | 0.192        | -0.153      | -0.102      | -0.857       | -0.256     | 0.329        | -0.351 |        |        |             |
|                   | p           | 0.168      | 0.275        | 0.471       | 0.000       | 0.065        | 0.016      | 0.010        |        |        |        |             |
| TSH (µIU/mL)      | R           | 1          | -0.291       | -0.099      | -0.186      | 0.153        | -0.028     | -0.134       |        |        |        |             |
|                   | p           | 0.004      | 0.353        | 0.182       | 0.141       | 0.789        | 0.199      |        |        |        |             |
| T4 (ng/dL)        | R           | 1          | 0.079        | 0.058       | -0.048      | -0.053       | 0.115      |        |        |        |             |
|                   | p           | 0.455      | 0.682        | 0.645       | 0.613       | 0.269        |        |        |        |             |
| TPO (IU/mL)       | R           | 1          | 0.113        | 0.301       | -0.269      | 0.154        |        |        |        |             |
|                   | p           | 0.427      | 0.004        | 0.000       | 0.010       | 0.145        |        |        |        |             |
| AIP               | R           | 1          | 0.387        | -0.465      | 0.404       |        |        |        |        |        |             |
|                   | p           | 0.004      | 0.000        | 0.000       | 0.003       |        |        |        |        |        |             |
| HOMA              | R           | 1          | -0.846       | 0.254       |        |        |        |        |        |        |             |
|                   | p           | 0.000      | 0.013        |        |        |        |        |        |        |        |             |
| QUICKI            | R           | 1          | -0.208       |        |        |        |        |        |        |        |             |
|                   | p           | 0.044      |        |        |        |        |        |        |        |        |             |
| BMI (kg/m²)       | R           | 1          |        |        |        |        |        |        |        |        |             |
|                   | p           |        |        |        |        |        |        |        |        |        |             |

Notes: FPG — Fasting plasma glucose; TG — Triglyceride; CHOL — Cholesterol; LDL — Low density lipoprotein; HDL — High density lipoprotein; TSH — thyroid-stimulating hormone; T4 — thyroxine; TPO — anti-thyroid peroxidase; HOMA-IR — Homeostasis Model Assessment — Insulin Resistance; QUICKI — The quantitative insulin sensitivity check index; AIP — Atherogenic Index of Plasma; BMI — Body Mass Index.
B. Upadhya et al. [23] studied with 20 hypothyroid and 20 SCH patients and concluded that TSH and cholesterol levels were correlated in SCH group while TSH and HOMA was not. Also in both groups HOMA and cholesterol, LDL, VLDL, triglyceride levels were correlated but HDL not. In contrast to this study we found negative correlation between HDL, AIP and HOMA, besides positive correlation between LDL and QUICKI in both groups.

J. Liu et al. [24], based on their study with 1402 non-obese euthyroid autoimmunity thyroiditis patients, concluded that anti-TPO levels are associated with HOMA and levothyroxine treatment can reduce the risk of atherosclerosis, especially in patients with high anti-TPO titers. Another study with 164 non-diabetic euthyroid patients showed similar results [25]. In a study conducted in Turkey; FPG, serum cholesterol and HOMA levels were found significantly higher in euthyroid patients with thyroid antibodies than autobody negative healthy controls [26]. Similar to this studies, we found a positive correlation between TPO, AIP and HOMA in euthyroid patients, in addition to negative correlation between TPO and QUICKI.

G. Brenta et al. [27] suggested that increase in atherogenic LDL may be due to decrease in hepatic lipase activity because of high TSH level. Although levothyroxine treatment has not alter the plasma lipid levels in general group, there was a remarkable decrease in patients with TSH > 12 μIU/mL. As can be interpreted similar, we found negative correlation between fT4 and LDL levels in euthyroid group.

Conclusion

This study found significantly elevated insulin resistance and cholesterol levels in SCH patients, so we hypothesized that SCH is also a risk factor for insulin resistance disorders such as cardiovascular diseases and metabolic syndrome. As a consequence, lipid metabolism defects and insulin resistance should be screened and treated in SCH patients. Thanks to the strong and significant correlation between HOMA and QUICKI in our study, we suggest the combined use of HOMA and QUICKI in these patients. Further and large-scale studies are needed to evaluate the relationship of HOMA, QUICKI, AIP, and BMI in detecting insulin resistance in SCH patients.

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Зв’язок між рівнями гормонів щитоподібної залози, інсулинорезистентності та індексом маси тіла в пацієнтів із субклінічним гіпотиреозом

Резюме. Актуальність і мета дослідження. Гіпотиреоз — поширене захворювання щитоподібної залози, із діагностуванням серед жінок. У загальній популяції його поширеність становить 2–5%, тоді як у жінок цей показник у 10 разів вищий, ніж у чоловіків. Інсулинорезистентність, одна з найбільш обговорюваних проблем, розглядається як неадекватна відповідь на дію інсуліну в периферичних тканинах, незважаючи на нормальну секреторну функцію клітин острівців підшлуноку. З іншого боку, інсулінорезистентність є фактором ризику розвитку інсулинорезистентності, серцево-судинних захворювань та метаболічного синдрому. Тому ми припустили, що субклінічний гіпотиреоз також є фактором ризику розвитку інсулинорезистентності, серцево-судинних захворювань та метаболічного синдрому.

Матеріали та методи. Клінічні та лабораторні дані приблизно 14 000 пацієнтів віком від 18 до 60 років були ретроспективно оцінені. Після застосування критеріїв виключення до дослідження було включено 371 відповідну особу. Усі відповідно розділені на три групи за рівнем тиреотропного гормону (ТТГ). Група 1 — це еутиреоїдні пацієнти із рівнем ТТГ 0,27–2,34 ммоль/л (p < 0,05). Рівні глюкози плазми натрію, тригілерідерія, ліпопротеїнів низької щільності (ЛПНП) зменшені порівняно з контрольною групою (p < 0,05). Рівні індексу компенсації глікози (HOMA-IR), кількості індексу перевірки чутливості до інсуліну у групах пацієнтів у стані еутиреозу та з субклінічним гіпотиреозом були значно вищими у групах пацієнтів у стані еутиреозу та з субклінічним гіпотиреозом (p < 0,05). У дослідженні встановлено вірогідно підвищений рівень інсулинорезистентності до інсулу і рівень холестерину в пацієнтів із субклінічним гіпотиреозом. Тому ми припустили, що субклінічний гіпотиреоз також є фактором ризику розвитку інсулинорезистентності, серцево-судинних захворювань та метаболічного синдрому. Тому показники лінійних і інсулинорезистентності слід враховувати при лікуванні осіб із субклінічним гіпотиреозом.

Ключові слова: субклінічний гіпотиреоз; інсулинорезистентність; індекс маси тіла