Free Triiodothyronine Concentrations are Inversely Associated with Elevated Carotid Intima-Media Thickness in Middle-Aged and Elderly Chinese Population

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Aim: Increased carotid artery intima media thickness (C-IMT) is an early feature of atherosclerosis. It has been reported to be altered in patients with thyroid dysfunction, and the evidence is still controversial. The present study aimed to explore the relationship between C-IMT and possible variations in thyroid function in Chinese adults aged 40 years and above.

Methods: A community-based cross-sectional study was conducted among 2276 non-diabetic participants. Serum free triiodothyronine (FT₃), free thyroxine (FT₄), and thyroid stimulating hormone (TSH) were determined by chemiluminescent microparticle immunoassay.

Results: The prevalence of elevated C-IMT decreased according to FT₃ quartiles (29.8%, 24.3%, 24.2%, and 22.2%, P for trend = 0.005). In both univariate and multivariate linear regression analyses, FT₃ levels were inversely associated with C-IMT (both P values ≤ 0.002). Multivariate-adjusted logistic regression analysis showed that high FT₃ levels were associated with low prevalent elevated C-IMT. The adjusted odds ratio for elevated C-IMT was 0.71 (95% confidence interval, 0.52-0.99, P = 0.04) when comparing the highest with the lowest quartile of FT₃.

Conclusions: Serum FT₃ levels were inversely associated with elevated C-IMT in middle-aged and elderly Chinese adults without diabetes, independent of traditional risk factors for atherosclerosis.


Key words: FT₃, C-IMT, Cardiovascular disease, Community-based study

Introduction

The impact of thyroid function on cardiovascular morbidity and mortality has received much attention over the past years¹, ². Overt hypothyroidism is associated with abnormal lipid metabolism and impaired endothelial function as well as increased risk of atherosclerosis and ischemic heart disease³, ⁴. Mildly impaired thyroid function has also been shown to be associated with dyslipidemia⁵, ⁶, enhanced low-grade inflammation⁷, and endothelial function⁸, which were intermediary cardiovascular outcome variables. The effect of thyroid hormone variation on markers of early cardiovascular disease has not been adequately evaluated. These markers have become an
important tool in the cardiovascular risk stratification of an asymptomatic individual. Carotid artery intima media thickness (C-IMT) predicts future cardiovascular events, and is an accepted marker of subclinical atherosclerosis. A risk prediction model revealed a positive correlation between C-IMT and the 11.5-year risk of death from circulatory diseases. This can be reliably evaluated in the carotid arteries using the high-resolution ultrasound technique, which is a non-invasive and low-cost method well suited for epidemiological studies.

Some studies have addressed the effect of abnormalities in thyroid function on C-IMT, and the evidence is still controversial. C-IMT is larger in overt hypothyroidism subjects compared with euthyroidism subjects, and it decreases after levothyroxine replacement. In a study by Monzani et al., subjects with subclinical hypothyroidism had significantly higher mean C-IMT than euthyroidism controls. In contrast, another report revealed that C-IMT is smaller in subjects with elevated thyroid stimulating hormone (TSH) levels than in subjects with subclinical hyperthyroidism. It is possible that effects of thyroid function with cardiovascular disease (CVD) may extend to the euthyroidism range, which is important because most subjects at risk for CVD are euthyroid.

In this study, we investigated the associations between thyroid function and C-IMT in a relatively large sample size middle-aged and elderly Chinese population.

## Subjects and Methods

### Study Population and Design

The present cross-sectional study was performed based on a well-characterized cohort study sample. The protocol of study design has been described previously. A flow chart summarizing the study procedure is presented in **Supplementary Fig. 1**. In brief, we enrolled study participants from Songnan Community, Baoshan District, Shanghai, China, in 2 phases. In phase 1 (June-July 2008), all registered permanent residents aged 40 years and above were invited to undergo a screening examination; 10185 persons participated. All participants underwent a fasting blood glucose test. Based on the results of fasting glucose level and history of diabetes, participants were classified into one of the following three groups: normal glucose regulation (fasting plasma glucose level of < 5.6 mmol/L and no history of diabetes); impaired glucose regulation (fasting plasma glucose level of 5.6-<7.0 mmol/L and no history of diabetes); and diabetes (fasting plasma glucose level of ≥ 7.0 mmol/L or a history of diabetes). Because subjects with lower glucose levels were expected to have a lower participation rate than those with higher glucose levels, we randomly selected participants from these groups according to a ratio of 1.44 (normal glucose regulation):1.2 (impaired glucose regulation):1 (diabetes) to conduct a more comprehensive survey including a standard 75-g oral glucose tolerance test (OGTT), blood and urine sampling, an anthropometric measurement, and a detailed questionnaire survey in phase 2 (June-August 2009).

A total of 3455 subjects with their blood and urine samples were included in the second survey. Exclusion criteria were as follows: (i) history of overt hyperthyroidism, hypothyroidism, or thyroiditis and have been taking thyroxine or antithyroid drugs; (ii) taking medications affecting thyroid function such as amiodarone, lithium, antipsychotic drugs, and antiepileptic drugs; (iii) history of thyroidectomy; (iv) participants without data regarding thyroid function or C-IMT; and diabetes patients were also excluded from the study. Finally, a total of 2276 subjects (848 men and 1428 women) were included in the present analysis. The
participants (2276 subjects) and the nonparticipants (7909 subjects) were similar in characteristics, such as age and sex distribution.

The study protocol was approved by the committee on human research at Rui-Jin Hospital, Shanghai Jiao tong University School of Medicine. Informed consent was obtained from all individual participants included in the study.

Clinical and Biochemical Measurements

Sociodemographics, medical history, and lifestyle factors were collected by trained personnel. Current smoking was defined as “yes” if a subject smoked at least one cigarette per day or seven cigarettes per week in the past 6 months. Current alcohol drinking was defined as “yes” if a subject consumed alcohol at least once a week in the past 6 months. Weight, height, and blood pressure were measured by experienced nurses. Three sitting blood pressure values were measured consecutively at 1-min interval after at least 5-min rest using an automated electronic device (OMRON model HEM-752 FUZZY; Omron Co., Dalian, China) and an average of the three was used in the analysis. Hypertension was defined when systolic blood pressure (SBP) was ≥ 140 mmHg, diastolic blood pressure (DBP) was ≥ 90 mmHg, or when taking medication for blood pressure control.

All participants were admitted after an overnight fast of > 10 h and underwent a 75-g OGTT. Blood samples were collected at 0 and 2 h during the OGTT. Sera for the measurement of thyroid function were aliquot and kept frozen at –80°C until use. Plasma glucose; fasting serum creatinine; lipid profile including total cholesterol (TC), triglycerides, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C); and high-sensitivity C-reactive protein (hs-CRP) were measured using an autoanalyzer (ADVIA 1650, Bayer, Leverkusen, Germany). Dyslipidemia was defined according to the National Cholesterol Education Program Adults Treatment Panel III (NCEP ATP III) criteria. The index of homeostasis model assessment of insulin resistance (HOMA-IR) was calculated using the following formula: HOMA-IR = fasting insulin concentrations (mIU/L) × fasting glucose concentrations (mmol/L)/22.5.

Measurement of C-IMT

C-IMT measurements were carried out using a high-resolution B-mode tomographic ultrasound system (Esaote Biomedica SpA, Genoa, Italy) equipped with 7.5-MHz linear transducer. The same experienced investigator measured C-IMT on the far wall of the right and left common carotid arteries, 1.5 cm proximal to the bifurcation. C-IMT was measured online at the end of the diastole as the distance from the leading edge of the first echogenic line (the lumen-intimal interface) to that of the second echogenic line (the collagen-contained upper layer of tunic adventitia). An average of the right and left common C-IMT were used to calculate mean C-IMT. Subjects in the highest 20% of C-IMT (≥ 0.7 mM) were classified as having elevated C-IMT. The reproducibility of the measurements between replicate scans was 0.95, and the intra-observer reliability was 83.6%.

Measurements of Thyroid Function

We measured serum TSH, free triiodothyronine (FT3), free thyroxine (FT4), thyroid peroxidase antibody (TPOAb), and thyroglobulin antibody (TgAb) levels. Thyroid function tests were analyzed at the Clinical Laboratory for Endocrinology, Shanghai Institution of Endocrine and Metabolic Diseases, which was certified by the College of American Pathologists. FT3, FT4, and TSH were determined using the chemiluminescent microparticle immunoassay method (Architect system; Abbott Laboratories, Abbott Park, IL). TPOAb and TgAb were measured using chemiluminescent microparticle immunoassay using Architect Anti-TPO and Anti-TG on the Architect i System (Abbott Laboratories). The total coefficient of variation (CV%) were as follows: FT3: 4.7%-8.0%; FT4: 2.6%-5.3%; TSH: 3.1%-3.4%; TPOAb: 4.3%-6.8%; and TgAb: 3.2%-5.2%. Reference ranges were as follows: FT3: 2.62-6.49 pmol/L; FT4: 0.81-1.94 pmol/L; TSH: 0.35-4.94 mIU/mL; TPOAb: below 5.61 IU/mL; and TgAb: below 4.11 IU/mL.

Statistics Analysis

Statistical analysis was performed using SAS 9.3 (SAS Institute, Cary, NC), and a P value < 0.05 (two-sided) was considered to be statistically significant. Continuous variables were presented as means ± SD or medians (interquartile ranges) for skewed variables. All categorical variables were summarized as proportions. Triglycerides, fasting plasma glucose (FPG), OGTT 2-hour plasma glucose (OGTT-2 h PG), hs-CRP, FT3, FT4, TSH, TPOAb, and TgAb were normalized by logarithmic transformation before analyses because of non-normal distribution.

The study participants were divided into four groups according to the quartiles of FT3. Demographic and metabolic features in each quartile were described, and P for trend was measured using linear regression analysis across FT3 quartiles.

We used multiple linear regression models to
evaluate the association of C-IMT with FT3, FT4, TSH, hs-CRP, TPOAb, and TgAb. We applied the following two kinds of models in the linear regression analyses: univariate and multivariate models, which were additionally adjusted for age, sex, body mass index (BMI), smoking and drinking status, SBP, TC, log triglycerides, FPG, HOMA-IR, log TPOAb and log TgAb (except for TPOAb and TgAb), log hs-CRP, and antihypertension medication use.

We also implemented three logistic regression models to assess the relationship between FT3 categories and elevated C-IMT, which were performed with elevated C-IMT as a dependent variable, FT3 as an independent variable, and the same multivariate adjustments as above. Odds ratios (OR) with the lowest quartile were computed as the reference group.

**Results**

**Characteristics of the Study Population**
Among the 2276 participants, the prevalence of hypertension, dyslipidemia, and cardiovascular disease (self-reported) is 49.2%, 50.4% and 9.5% respectively. FT3 concentrations in males were significantly higher than those in females ($P<0.0001$). The characteristics are given in Table 1 according to quartiles of FT3 ($≤4.31, 4.32-4.62, 4.63-4.94,$ and $>4.95$ pmol/L). Metabolic risk factors including sex distribution, current smoking status, current drinking status, BMI, DBP, FPG, HOMA-IR, triglycerides, TC, LDL-C, and FT4 increased significantly with the increment of FT3, whereas age, HDL-C, and TSH decreased (all $P$ for trend $<0.05$). Compared with the participants in the lowest quartile of FT3, those in the second, third, and highest quartiles have significantly lower levels of C-IMT as follows: $0.64±0.16$ mm vs. $0.60±0.12$, $0.61±0.13$, and $0.61±0.13$ mm ($P$ for trend $=0.03$, Table 1). Nevertheless, no statistical difference was found for SBP, OGTT-2h PG, antihypertension medication use, TgAb, TPOAb, and hs-CRP among the four groups.

**Prevalence of Elevated C-IMT in Different FT3 Levels**
The prevalence of elevated C-IMT differed in the four groups with different FT3 quartiles. From the lowest quartile to the highest one of FT3 quartiles, the prevalence of elevated C-IMT was 29.8%, 24.3%, 24.2%, and 22.2%, respectively ($P$ for trend $=0.005$, Fig. 1). Compared with the lowest FT3 quartile, the second, third, and highest quartiles showed a significant decrease in the prevalence of elevated C-IMT ($P=0.02, 0.03$, and $0.003$, respectively).

**Association between FT3 and Elevated C-IMT**
We conducted linear regression analyses for FT3 and C-IMT. In both univariate and multivariate linear regression analyses, FT3 levels were inversely associated with C-IMT (Table 2, both $P$ values $≤0.002$).

In the univariate logistic regression model (model 1), the risk for elevated C-IMT decreased across FT3 quartiles. OR for the highest FT3 quartile compared with the lowest quartile was as follows: 0.67, 95% confidence intervals (95% CI) 0.51-0.88, $P=0.003$, and those in the second and third quartile were also less likely to have elevated C-IMT (OR: 0.75, 95% CI 0.58-0.98; $P=0.03$ and OR: 0.75, 95% CI 0.58-0.97; $P=0.03$, respectively). The test for the trend was significant ($P$ for trend $=0.005$). After adjustment for age, sex, BMI, smoking and drinking status, SBP, TC, log triglycerides, FPG, HOMA-IR, and antihypertension medication use (model 2), the adjusted logistic regression (Table 3) showed similar associations for the highest quartile but not for the second and third quartile. After further adjustments for log TPOAb, log TgAb, and log hs-CRP, the results did not show significant changes ($P$ for trend $=0.03$, Table 3). As compared with quartile 1, the ORs and 95% CI for quartile 2, 3, and 4 were 0.96 (0.70-1.31), 0.87 (0.64-1.18), and 0.71 (0.52-0.99), respectively.

**Discussion**
In this population-based study, we found that C-IMT is negatively correlated with FT3 in non-diabetic individuals. Moreover, the association was independent of other traditional vascular risk factors such as blood pressure, TC, triglycerides, and FPG, which suggested that FT3 may be associated with C-IMT, independent of circulation dynamics, lipid metabolism, and glucose metabolism. Thus, in view of the contention that C-IMT predicts cardiovascular disease, our data support the possibility that relatively low thyroid function could contribute to an increased cardiovascular risk.

The presence of both overt hypothyroidism and subclinical hypothyroidism is related to accelerated atherosclerosis. In accordance with this, Monzani et al. reported significantly higher C-IMT in 45 subjects with subclinical hypothyroidism when compared with 32 euthyroid controls (0.75 versus 0.63 mm). Similarly, in a study by Nagasaki et al., C-IMT is larger in subjects with overt hypothyroidism compared to euthyroid subjects. Furthermore, Dulaart et al. performed a cross-sectional study of non-smoking, predominantly middle-aged, euthyroid subjects and showed that C-IMT was found to be inde-
Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose; OGTT-2 h PG, oral glucose tolerance test-2 hour plasma glucose; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; C-IMT, carotid intima-media thickness; FT3, free triiodothyronine; FT4, free thyroxine; TSH, thyroid stimulating hormone; TPOAb, thyroid peroxidase antibody; Hs-CRP, high-sensitivity C-reactive protein; TgAb, thyroglobulin antibody.

Our study showed that FT3 was significantly correlated with C-IMT after adjustment for age, sex, SBP, TC, triglycerides, FPG, HOMA-IR, and hs-CRP, suggesting that mechanisms other than these interme-

Table 1. General characteristics of the study population

<table>
<thead>
<tr>
<th>FT3 quartiles (pmol/L)</th>
<th>Quartile 1 (n = 573)</th>
<th>Quartile 2 (n = 569)</th>
<th>Quartile 3 (n = 571)</th>
<th>Quartile 4 (n = 563)</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, n (%)</td>
<td>167 (29.1)</td>
<td>177 (31.1)</td>
<td>214 (37.5)</td>
<td>290 (51.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age (years)</td>
<td>62.0 ± 11.5</td>
<td>62.0 ± 11.5</td>
<td>65.0 ± 11.5</td>
<td>68.0 ± 11.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current smoker, n (%)</td>
<td>84 (14.7)</td>
<td>105 (18.5)</td>
<td>120 (21.0)</td>
<td>168 (29.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current drinkers, n (%)</td>
<td>73 (12.7)</td>
<td>86 (15.1)</td>
<td>95 (16.6)</td>
<td>105 (18.7)</td>
<td>0.005</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.4 ± 3.6</td>
<td>24.8 ± 3.4</td>
<td>24.9 ± 3.5</td>
<td>25.4 ± 3.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>135 ± 22</td>
<td>133.3 ± 21.8</td>
<td>135.6 ± 20.6</td>
<td>136.6 ± 20.0</td>
<td>0.07</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>76 ± 10</td>
<td>77.6 ± 10.0</td>
<td>77.8 ± 9.4</td>
<td>80.1 ± 10.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>FPG (mmol/L)</td>
<td>4.9 (4.6-5.3)</td>
<td>5.0 (4.7-5.3)</td>
<td>5.0 (4.7-5.4)</td>
<td>5.0 (4.7-5.4)</td>
<td>0.0004</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>1.16 (0.86-1.71)</td>
<td>1.34 (0.96-1.85)</td>
<td>1.32 (0.94-1.90)</td>
<td>1.53 (1.05-2.14)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>5.02 ± 0.98</td>
<td>5.17 ± 0.95</td>
<td>5.16 ± 0.92</td>
<td>5.15 ± 0.93</td>
<td>0.03</td>
</tr>
<tr>
<td>HDL-C (mmol/L)</td>
<td>1.40 ± 0.33</td>
<td>1.40 ± 0.30</td>
<td>1.39 ± 0.34</td>
<td>1.34 ± 0.28</td>
<td>0.005</td>
</tr>
<tr>
<td>LDL-C (mmol/L)</td>
<td>2.30 ± 0.69</td>
<td>2.42 ± 0.67</td>
<td>2.38 ± 0.62</td>
<td>2.41 ± 0.68</td>
<td>0.03</td>
</tr>
<tr>
<td>Antihypertension medication use, n (%)</td>
<td>125 (5.49)</td>
<td>125 (5.49)</td>
<td>137 (6.02)</td>
<td>116 (5.10)</td>
<td>0.58</td>
</tr>
<tr>
<td>FT3 (pmol/L)</td>
<td>4.07 (3.87-4.21)</td>
<td>4.47 (4.39-4.55)</td>
<td>4.77 (4.70-4.85)</td>
<td>5.19 (5.05-5.40)</td>
<td>-</td>
</tr>
<tr>
<td>FT4 (pmol/L)</td>
<td>13.7 (12.8-14.8)</td>
<td>14.0 (13.1-14.9)</td>
<td>14.1 (13.3-15.2)</td>
<td>14.7 (13.8-15.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>TSH (μIU/mL)</td>
<td>1.66 (1.11-2.45)</td>
<td>1.56 (1.11-2.21)</td>
<td>1.48 (1.03-2.17)</td>
<td>1.37 (0.94-2.03)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>TPOAb (IU/mL)</td>
<td>0.30 (0.17-0.68)</td>
<td>0.31 (0.16-0.70)</td>
<td>0.31 (0.17-0.72)</td>
<td>0.36 (0.18-0.86)</td>
<td>0.31</td>
</tr>
<tr>
<td>TgAb (IU/mL)</td>
<td>1.16 (0.76-3.60)</td>
<td>1.11 (0.70-3.03)</td>
<td>1.06 (0.74-2.48)</td>
<td>1.08 (0.73-2.54)</td>
<td>0.08</td>
</tr>
<tr>
<td>Hs-CRP (mg/L)</td>
<td>0.14 (0.04-0.73)</td>
<td>0.15 (0.05-0.47)</td>
<td>0.15 (0.06-0.42)</td>
<td>0.20 (0.07-0.66)</td>
<td>0.24</td>
</tr>
<tr>
<td>C-IMT (mm)</td>
<td>0.64 ± 0.16</td>
<td>0.60 ± 0.12</td>
<td>0.61 ± 0.13</td>
<td>0.61 ± 0.13</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Data were presented as means ± SD or medians (interquartile ranges) or numbers (proportions).

Table 2. Univariate and multivariate linear regression analysis for association of C-IMT with thyroid functions

<table>
<thead>
<tr>
<th>FT3 quartiles (pmol/L)</th>
<th>Univariate</th>
<th>Multivariate *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β ± SE</td>
<td>P value</td>
</tr>
<tr>
<td>Log FT3 (pmol/L)</td>
<td>-0.17 ± 0.054</td>
<td>0.002</td>
</tr>
<tr>
<td>Log FT4 (pmol/L)</td>
<td>0.03 ± 0.05</td>
<td>0.52</td>
</tr>
<tr>
<td>Log TSH (μIU/mL)</td>
<td>-0.02 ± 0.008</td>
<td>0.03</td>
</tr>
<tr>
<td>Log TPOAb (IU/mL)</td>
<td>0.005 ± 0.003</td>
<td>0.06</td>
</tr>
<tr>
<td>Log TgAb (IU/mL)</td>
<td>-0.001 ± 0.004</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Data are presented as regression coefficient ± standard error.

*Adjusted for age, sex, BMI, smoking and drinking status, SBP, TC, log triglycerides, FPG, HOMA-IR, log TPOAb and log TgAb (except for TPOAb and TgAb, respectively), log hs-CRP, and antihypertension medication use.

Univarately related to FT4, but not to TSH and thyroid antibodies. Moreover, previous data do not confirm an association of C-IMT with TSH, in accordance with our results.
The effect of FT3 on C-IMT may be independent of thyroid autoimmunity. A previous study reporting that the presence of atheromatosis is independent of chronic inflammatory disorders is in agreement with our conclusions.

Our results show that FT3 level is associated with the degree of carotid atherosclerosis in nondiabetic subjects. Our study provided confirmatory evidence for the association between FT3 and C-IMT. However, a limitation of the present study is its cross-sectional design. Further longitudinal research is required to clarify the cause and effect relationships. Another limitation is that our study included only middle-aged and elderly subjects, and the results may not be applicable to a general population with different age composition.

Conclusions

The present cross-sectional study has shown that C-IMT is negatively related to the serum FT3 concentration in middle-aged and elderly Chinese subjects. Furthermore, this relationship was present after adjustment for clinical factors. These results add to the growing body of evidence involving thyroid alterations in the cardiovascular risk patients. Specific mechanistic and intervention studies are warranted to clarify the nature of these cross-sectional associations.

Acknowledgments

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<table>
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<th>FT3 quartiles (pmol/l)</th>
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<th>Quartile 3</th>
<th>Quartile 4</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases/participants</td>
<td>171 (573)</td>
<td>138 (569)</td>
<td>138 (571)</td>
<td>125 (563)</td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1.00</td>
<td>0.75 (0.58-0.98)</td>
<td>0.75 (0.58-0.97)</td>
<td>0.67 (0.51-0.88)</td>
<td>0.005</td>
</tr>
<tr>
<td>Model 2</td>
<td>1.00</td>
<td>0.94 (0.69-1.29)</td>
<td>0.85 (0.62-1.15)</td>
<td>0.71 (0.52-0.98)</td>
<td>0.03</td>
</tr>
<tr>
<td>Model 3</td>
<td>1.00</td>
<td>0.96 (0.70-1.31)</td>
<td>0.87 (0.64-1.18)</td>
<td>0.71 (0.52-0.99)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Data are presented as odds ratios (ORs, 95% confidence interval).
Model 1 is unadjusted.
Model 2 is adjusted for age, sex, BMI, smoking and drinking status, SBP, TC, log triglycerides, FPG, HOMA-IR, and antihypertension medication use.
Model 3 is adjusted for age, sex, BMI, smoking and drinking status, SBP, TC, log triglycerides, FPG, HOMA-IR, log TPOAb and log TgAb, log hs-CRP, and antihypertension medication use.
See Table 1 for the FT3 quartiles definition.
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Competing interests

The authors declare that they have no competing interests.

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Supplementary Fig. 1.