Original Article

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.

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

Introduction

The impact of thyroid function on cardiovascular morbidity and mortality has received much atten-

tion over the past years^{1, 2}. Overt hypothyroidism is associated with abnormal lipid metabolism and impaired endothelial function as well as increased risk of atherosclerosis and ischemic heart disease^{3, 4}. Mildly impaired thyroid function has also been shown to be associated with dyslipidemia^{5, 6}, enhanced low-grade inflammation⁶, and endothelial function⁷, 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

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important tool in the cardiovascular risk stratification of an asymptomatic individual⁸⁻¹⁰). Carotid artery intima media thickness (C-IMT) predicts future cardiovascular events^{9, 11}), and is an accepted marker of subclinical atherosclerosis¹²). A risk prediction model revealed a positive correlation between C-IMT and the 11.5-year risk of death from circulatory diseases¹³). 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^{14, 15}). In a study by Monzani *et al.*¹⁶), 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 hyperthyroidism¹⁷). 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 previously¹⁸). 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 diabe-

Fig. 1.

Prevalence of elevated C-IMT in different FT3 quartiles: quartile 1 (Q1, $n=573$), ≤ 4.31 pmol/L; quartile 2 (Q2, $n=569$), 4.32-4.62 pmol/L; quartile 3 (Q3, $n=571$), 4.63-4.94 pmol/L; quartile 4 (Q4, $n=563$), > 4.95 pmol/L.

tes (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 ($n=12$); (ii) taking medications affecting thyroid function such as amiodarone, lithium, antipsychotic drugs, and antiepileptic drugs ($n=5$); (iii) history of thyroidectomy ($n=2$); (iv) participants without data regarding thyroid function or C-IMT ($n=104$). Because diabetes is an important confounder in the associations with surrogates of endothelial function, diabetes patients were also excluded from the study ($n=1056$). 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 ATPIII) criteria¹⁹. The index of homeostasis model assessment of insulin resistance (HOMA-IR) was calculated using the following formula: $\text{HOMA-IR} = \text{fasting insulin concentrations (mIU/L)} \times \text{fasting glucose concentrations (mmol/L)} / 22.5$.

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 on-line 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 Pathologists²⁰. FT3, FT4, and TSH were determined using the chemiluminescent microparticle immunoassay method (Architect system; Abbott Laboratories, Abbott Park, IL). TPOAb and TgAb were measured by 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: 9.01-19.04 pmol/L; TSH: 0.35-4.94 $\mu\text{IU/mL}$; 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 $\pm$ 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^{12, 21}, 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^{14, 22}. In accordance with this, Monzani *et al.*¹⁶ 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.*¹⁴, C-IMT is larger in subjects with overt hypothyroidism compared to euthyroid subjects. Furthermore, Dullaart *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-

Table 1. General characteristics of the study population

	FT3 quartiles (pmol/l)				<i>P</i> for trend
	Quartile 1 (<i>n</i> = 573)	Quartile 2 (<i>n</i> = 569)	Quartile 3 (<i>n</i> = 571)	Quartile 4 (<i>n</i> = 563)	
Male, <i>n</i> (%)	167 (29.1)	177 (31.1)	214 (37.5)	290 (51.5)	<0.0001
Age (years)	62.0 ± 11.5	59.0 ± 9.6	59.3 ± 9.1	58.0 ± 8.0	<0.0001
Current smoker, <i>n</i> (%)	84 (14.7)	105 (18.5)	120 (21.0)	168 (29.8)	<0.0001
Current drinkers, <i>n</i> (%)	73 (12.7)	86 (15.1)	95 (16.6)	105 (18.7)	0.005
BMI (kg/m ²)	24.4 ± 3.6	24.8 ± 3.4	24.9 ± 3.5	25.4 ± 3.4	<0.0001
SBP (mmHg)	135 ± 22	133.3 ± 21.8	135.6 ± 20.6	136.6 ± 20.0	0.07
DBP (mmHg)	76 ± 10	77.6 ± 10.0	77.8 ± 9.4	80.1 ± 10.4	<0.0001
FPG (mmol/L)	4.9 (4.6-5.3)	5.0 (4.7-5.3)	5.0 (4.7-5.4)	5.0 (4.7-5.4)	0.0004
OGTT-2 h PG (mmol/L)	6.8 (5.6-8.2)	6.7 (5.6-8.0)	6.9 (5.7-8.0)	6.9 (5.9-8.2)	0.07
HOMA-IR	1.33 (0.81-1.97)	1.40 (0.90-2.07)	1.46 (0.96-2.22)	1.63 (1.06-2.42)	<0.0001
Triglycerides (mmol/L)	1.16 (0.86-1.71)	1.34 (0.96-1.85)	1.32 (0.94-1.90)	1.53 (1.05-2.14)	<0.0001
TC (mmol/L)	5.02 ± 0.98	5.17 ± 0.95	5.16 ± 0.92	5.15 ± 0.93	0.03
HDL-C (mmol/L)	1.40 ± 0.33	1.40 ± 0.30	1.39 ± 0.34	1.34 ± 0.28	0.005
LDL-C (mmol/L)	2.30 ± 0.69	2.42 ± 0.67	2.38 ± 0.62	2.41 ± 0.68	0.03
Antihypertension medication use, <i>n</i> (%)	125 (5.49)	125 (5.49)	137 (6.02)	116 (5.10)	0.58
FT3 (pmol/L)	4.07 (3.87-4.21)	4.47 (4.39-4.55)	4.77 (4.70-4.85)	5.19 (5.05-5.40)	-
FT4 (pmol/L)	13.7 (12.8-14.8)	14.0 (13.1-14.9)	14.1 (13.3-15.2)	14.7 (13.8-15.6)	<0.0001
TSH (μIU/mL)	1.66 (1.11-2.45)	1.56 (1.11-2.21)	1.48 (1.03-2.17)	1.37 (0.94-2.03)	<0.0001
TPOAb (IU/mL)	0.30 (0.17-0.68)	0.31 (0.16-0.70)	0.31 (0.17-0.72)	0.36 (0.18-0.86)	0.31
TgAb (IU/mL)	1.16 (0.76-3.60)	1.11 (0.70-3.03)	1.06 (0.74-2.48)	1.08 (0.73-2.54)	0.08
Hs-CRP (mg/L)	0.14 (0.04-0.73)	0.15 (0.05-0.47)	0.15 (0.06-0.42)	0.20 (0.07-0.66)	0.24
C-IMT* (mm)	0.64 ± 0.16	0.60 ± 0.12	0.61 ± 0.13	0.61 ± 0.13	0.03

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

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose; OGTT-2 h PG, OGTT 2-hour plasma glucose; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein; C-IMT, carotid intima-media thickness; FT3, free triiodothyronine; FT4, free thyroxine; TSH, thyroid stimulating hormone; TPOAb, thyroid peroxidase antibody; and TgAb, thyroglobulin antibody.

FT3 quartiles were as follows: quartile 1, ≤ 4.31 pmol/L; quartile 2, 4.32-4.62 pmol/L; quartile 3, 4.63-4.94 pmol/L; quartile 4, ≥ 4.95 pmol/L.

*: adjusted for age and gender.

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

	Univariate		Multivariate *	
	$\beta \pm SE$	<i>P</i> value	$\beta \pm SE$	<i>P</i> value
Log FT3 (pmol/L)	-0.17 ± 0.054	0.002	-0.16 ± 0.049	0.0006
Log FT4 (pmol/L)	0.03 ± 0.05	0.52	-0.02 ± 0.05	0.59
Log TSH (μIU/mL)	-0.02 ± 0.008	0.03	0.002 ± 0.007	0.77
Log TPOAb (IU/mL)	0.005 ± 0.003	0.06	-0.002 ± 0.003	0.57
Log TgAb (IU/mL)	-0.001 ± 0.004	0.71	0.006 ± 0.004	0.13

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.

pendently related to FT4, but not to TSH and thyroid antibodies²³). Moreover, previous data do not confirm an association of C-IMT with TSH, in accordance with our results²⁴).

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 3. The risk of elevated C-IMT according to quartiles of FT3

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

Data are presented as odds ratios (ORs, 95% confidential 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.

diate cardiovascular outcome variables and systemic hemodynamic factors may also be involved in the relationship between thyroid hormone status and C-IMT. Nevertheless, the exact mechanisms for these associations remain unclear. Variations in the thyroid hormone status could affect lipoprotein quality and oxidation²⁵, vascular remodeling via an effect on local angiotensin signaling²⁶, and endothelial function²⁷. In experimental models, T3 has important effects on the vascular system, by inducing relaxation of vascular smooth muscle cells through a direct or indirect effect via activation of nitric oxide synthase and inducing adrenomedullin expression in endothelial cells²⁸. Several studies have suggested anti-atherosclerotic effects of FT3 on the vascular bed via blood vessel dilation, production of vasodilator molecules, and inhibition of angiotensin II receptor expression and downstream signal transduction not necessarily involving the inflammatory cascade²⁶.

Autoimmune diseases have been associated with accelerated atherosclerosis. This is attributed primarily to a status of low grade inflammation²⁹. In our study, multiple linear regression analysis did not reveal an independent relation of this low-grade inflammatory marker as assessed by CRP levels with C-IMT, which agrees with several but not all previous reports^{30, 31}. Furthermore, adjustment for hs-CRP minimally affected the link between FT3 and C-IMT. Thyroid autoimmunity may have an impact on the cardiovascular system independent of the thyroid function. It has been found that endothelial function is diminished in euthyroid subjects with positive anti-TPO antibodies, which possibly reflects an effect of a pathological immune response on early atherosclerotic changes²⁷. However, our data showed that the link with C-IMT was roughly similar for FT3 with and without TPOAb and TGAb. This demonstrates that

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 disorders³² 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.

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Competing interests

The authors declare that they have no competing interests.

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Supplementary Fig. 1.