Thyroid function and non-alcoholic fatty liver disease in hyperthyroidism patients

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Abstract

Background: Although thyroid function has been demonstrated to be associated with non-alcoholic fatty liver disease (NAFLD) in different population, the prevalence and features of NAFLD in hyperthyroidism have not been reported. The present study aims to investigate the prevalence of NAFLD and association of thyroid function and NAFLD in hyperthyroidism patients.

Methods: This cross-sectional study was performed in Zhongshan Hospital, Fudan University, China. A total 117 patients with hyperthyroidism were consecutively recruited from 2014-2015. Thyroid function and other clinical features were measured, liver fat content was measured by color Doppler ultrasonically, NFALD was defined in patients with liver fat content more than 9.15% . Statistical analyses were performed with SPSS software package version 13.0.

Results: The prevalence of NAFLD was 11.97% in hyperthyroidism. Patient with NAFLD had lower fT3 and fT4 levels than patients without NAFLD ($P < 0.05$). After adjusting for age, gender, metabolic parameters and inflammation factors, higher fT3 were associated with lower liver fat content (β=−0.072, P=0.009) and decreased odds ratio of NAFLD (OR=0.267, 95%CI 0.087-0.817, P=0.021).

Conclusions: The prevalence of NAFLD was 11.97% in hyperthyroidism patients, and FT3 level was negatively associated with the liver fat content in this population.

Background

Obesity and metabolic disease are becoming global issues, and the prevalence of Nonalcoholic fatty liver disease (NAFLD) is up to 20–30%. [1] [2] [3]. NAFLD is a broad spectrum of diseases involves non-alcoholic simple fatty liver (NASFL), nonalcoholic steatohepatitis (NASH), liver cirrhosis, and hepatocellular carcinoma. NAFLD is becoming the main cause of cirrhosis, and NAFLD has been one of the major cause of the hepatocellular carcinoma [4]. Pathogenesis of NAFLD is not yet fully understood, it's widely accepted that NAFLD is caused by the interaction of complex genetic background and environment factors, insulin resistance enhances the lipolysis of adipose tissue, impact a mass of free fatty acids (FFA) into the liver, leading to the deposition of FFA and triglycerides in the liver.

The thyroid hormone plays an important role in glucose metabolism, lipid metabolism, and insulin resistance. Emerging evidences have indicated the relationship between thyroid hormone concentration and NAFLD. Rochon et al firstly reported the association between hypothyroidism and insulin resistance in 2003 [5]. Several other studies demonstrated that morbidity of NAFLD has an inverse association with thyroid hormone levels in the hypothyroid or euthyroid populations[6] [7]. Thyroid hormone analogues[8] and thyroid receptor beta antagonist[9] have been used to reduce liver fat content in animal models. Clinical studies also demonstrated that thyroid hormone analogues may improve NAFLD[10] [11]. However, there are no studies on the prevalence of NAFLD in hyperthyroid patients, and little is known about the association of thyroid hormone and liver fat content under hyperthyroidism condition. It should considered that the insulin resistance and oxidant stress [12] have been reported in patients with hyperthyroidism, both of which were related to the pathology of NAFLD. Therefore, it is necessary to explore liver fat content, NAFLD and possible mechanism in patients with hyperthyroidism.

The aim of the present study is to determine the association between thyroid hormone levels, and liver fat content in patients with hyperthyroidism and investigate the differences of clinical characteristics, including thyroid hormone levels, between patients with or without NAFLD. This study were conducted in 117 patients with hyperthyroidism, and liver fat content was measured by ultrasonography with our previous established methods [13].

Methods

Study population

The present study consecutively enrolled 117 patients with hyperthyroidism from Department of Endocrinology, Zhongshan Hospital, between 2014 to 2015. The Diagnose criteria of hyperthyroidism includes:1) hyper-metabolic syndrome include nervousness, irritability, increased perspiration, heart racing, hand tremors, anxiety, difficulty sleeping, thinning of the skin, fine brittle hair, muscular weakness, and other typical symptoms; 2)Laboratory tests show a low thyroid stimulating hormone (TSH), raised T3 or T4, and positive anti-TSH-receptor antibodies. 3) defuse increased radio-iodine uptake by the thyroid.

The patients with the history of taking medication that may affect thyroid function, history of hypothalamus or pituitary disease, long-term alcohol consumption, viral hepatitis, autoimmune hepatitis, or Wilson's disease, total parenthetical nutrition, inflammatory bowel disease, or Cushing's syndrome, taking tamoxifen, amiodarone, sodium valproate, methotrexate, or glucocorticoid were excluded. Written, informed consent was obtained from all of the participants, and the study was approved by the ethics committee of Zhongshan Hospital, Fudan University, China.

Clinical And Biochemical Measurements

The clinical data including age, gender, history of drinking and alcohol intake were obtained from the clinical documents of endocrinology clinic. According to the routine protocol, the information of completely physical examination including height, weight, waist circumference (Wc), and blood pressure were recorded after overnight fasting for 12 h, and body mass index (BMI) was calculated by body weight (kg)/height squared (m2). The general laboratory tests (Japan Hitachi 7600 biochemical analyzer) included the levels of fasting blood glucose(FBG), total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C),alanine aminotransferase (ALT), aspartate aminotransferase (AST), uric acid (UA). Free triiodothyronine (FT3), free thyroxine (FT4), thyroid stimulating hormone (TSH), thyrotrophin receptor antibody (TRAb), fasting plasma insulin (f-INS), and hyper-sensitive C-reaction protein (HCRP) were also measured (electrochemiluminescence, Roche Diagnostics, Germany). Insulin resistance index (HOMA-IR) were calculated by fasting blood glucose × fasting insulin / 22.5. All subjects received a ultrasonic examination performed with a GE Vivid7 ultrasound machine as described previously [13]. Briefly, in the sagittal liver/right kidney view of ultrasound images, a region of interest (ROI) in the liver parenchyma and the kidney cortex was selected. In the right liver intercostals view of ultrasound images, a ROI in the liver far-field region was selected. And then all images were analyzed-of by using NIHimage software to estimate the gray scale mean value of the pixels within the two ROIs and calculated the hepatic/renal echo-intensity ratio and hepatic echo-intensity attenuation rate. A 3D abdominal phantom Model was introduced to standardize the measured values of US H/R ratio and hepatic echo- intensity attenuation rate, finally we can compute the liver fat content as the following formula: Liver fat content (%) = 62.592 × US hepatic/renal ratio + 168.076 × US hepatic attenuation rate − 27.863. NFALD was defined in patients with liver fat content more than 9.15% .

Statistical analyses

Normal distribution variables were expressed as the mean ± standard deviation; Comparisons of normal distribution variables between the two groups were performed with the independent sample T test; one-way ANOVA test was used in comparison among the three groups. Non-normally distributed variables were expressed as the median (inter-quartile range), comparisons of non-normally distributed variables between the two groups were performed with the Mann-Whiteny test, while Kruskal-Wallis test was used in comparison of the three groups. The chi-squared test was used to compare the rates. The correlation between liver fat content and thyroid function and other clinical indexes was analyzed by Pearson correlation analysis. Multiple linear regression analysis was used to detect the independent correlation between thyroid function and liver fat content; statistical analyses were performed with SPSS software package version 13.0.

Results

General characteristics of the study population

The general clinical information all patients was showed in Table 1.The present study included 117 patients (34 males, 83 females). The average age was 45.35 ± 12.78 years, BMI was 22.55 ± 3.38 kg/m^2. The prevalence of NAFLD was 11.97% in this hyperthyroidism population. Patients with NAFLD had lower FT3, FT4 levels ($p < 0.05$) and higher BMI, Wc, TG, TC, LDL levels ($p < 0.05$, respectively) than patients without NAFLD. There were no significant differences in age, gender, blood pressure levels, TSH, ALT, AST, UA, FBG, f-INS, IL-6, HCRP and HOMA-IR between the two groups ($p > 0.05$).

Table 1
Clinical characteristics of 117 cases with hyperthyroidism

Characteristics	Total (n = 117)	Without NAFLD (n = 103)	With NAFLD (n = 14)	P-value
Age (years)	45.35 ± 12.78	44.72 ± 13.04	50.00 ± 9.88	0.148
Gender(M/F)	34/83	29/74	5/9	0.559
BMI(kg/m^2)	22.55 ± 3.38	22.19 ± 3.31	25.23 ± 2.72	0.001
Waist circumference(cm)	80.82 ± 9.52	79.93 ± 9.19	90.29 ± 8.06	0.005
SBP(mmHg)	122.52 ± 13.79	121.82 ± 13.77	127.71 ± 13.33	0.115
DBP(mmHg)	74.32 ± 9.35	73.73 ± 9.34	78.71 ± 8.50	0.115
FBG(mmol□L)	5.09 ± 1.08	5.04 ± 0.91	5.48 ± 1.92	0.159
FINS(mU/L)	8.70(6.50,10.60)	8.70(6.20,10.55)	8.90(7.35,11.63)	0.690
TG (mmol□L)	0.99 ± 0.49	0.94 ± 0.43	1.36 ± 0.71	0.048
TC (mmol□L)	3.45 ± 0.81	3.37 ± 0.76	4.00 ± 0.95	0.006
LDL (mmol□L)	1.79 ± 0.66	1.72 ± 0.62	2.26 ± 0.76	0.004
IL6(pg/ml)	2.30(2.00,3.00)	2.30(2.00,3.00)	2.10(2.00,3.00)	0.564
HCRP(mg/L)	0.80(0.40,1.98)	0.80(0.40,2.05)	0.90(0.70,1.70)	0.594
UA(umol/L)	292.89 ± 69.51	293.14 ± 66.50	291.07 ± 91.53	0.917
ALT(U/L)	36.80 ± 33.06	38.32 ± 34.45	25.64 ± 16.96	0.179
AST(U/L)	27.15 ± 16.61	27.86 ± 17.10	21.86 ± 11.50	0.206
FT3(pmol/L)	20.42 ± 12.73	21.69 ± 12.57	11.09 ± 10.01	0.002
FT4(pmol/L)	54.15 ± 29.87	57.11 ± 29.58	32.41 ± 22.73	0.002
TSH(uIU/ml)	0.005(0.005,0.010)	0.005(0.005,0.010)	0.005(0.005,0.508)	0.824
HOMA-IR	1.90(1.38,2.54)	1.86(1.37,2.52)	2.26(1.56,3.22)	0.956

BMI = body-mass-index; SBP = Systolic Blood Pressure; DBP = diastolic blood pressure; FBG = fasting blood glucose; FINS = fasting insulin; TG = triglyceride; TC = Serum total cholesterol; LDL = low density lipoprotein; IL-6 = interleukin-6; HCRBP = hypersensitive C-reactive protein; UA = uric acid; ALT = alanine aminotransferase; AST = aspartate aminotransferase; FT3 = free triiodothyronine; FT4 = free thyroxine; TSH = thyroid-stimulating hormone; HOMA-IR = homeostasis model assessment for insulin resistance

All subjects were further divided into three groups according to tertiles of FT3 level (Table2). The liver fat content (p for trend < 0.05) and the prevalence of NAFLD (p for trend < 0.05) gradually decreased with the increasing of fT3 (Fig. 1a-b). In addition, the levels of BMI, TG, TC, and LDL-c gradually decreased, and the levels of ALT and AST gradually increased with the increasing of fT3 (p for trend < 0.01). There were no significant differences in gender, waist circumference, blood pressure level, fasting blood glucose, fasting insulin, uric acid, IL-6, HCRP and HOMA-IR among the three groups (p > 0.05). After adjustment for age, gender, and BMI, the association of liver fat content still reached the statistical significance (p < 0.01).

Table 2
clinical characteristics of all cases by tertiles of free triiodothyronine

FT3	T1(≦12.70 pmol/L)	T2(12.71 ~ 25.80 pmol/L)	T3(≧25.80 pmol/L)	P for trend
Age(years)	49.9 ± 11.9	46.1 ± 13.8	40.1 ± 10.8※▯	0.002
Gender(M/F)	14/25	11/28	9/30	0.455
FT4(pmol/L)	25.28 ± 10.26	48.41 ± 14.11※	88.78 ± 17.28※▯	< 0.001
TSH(uIU/ml)	0.01(0.005,1.470)	0.005(0.005,0.010)※	0.005(0.005,0.010)※	< 0.001
BMI(kg/m^2)	23.41 ± 3.30	23.40 ± 3.41	20.85 ± 2.82※▯	< 0.001
Waist circumference(cm)	83.17 ± 8.82	81.43 ± 10.19	77.79 ± 8.95※	0.113
SBP(mmHg)	121.46 ± 13.26	124.72 ± 10.94	121.38 ± 16.68	0.480
DBP(mmHg)	74.92 ± 9.10	75.79 ± 8.54	72.26 ± 10.21	0.221
FBG(mmol▯L)	5.01 ± 1.30	5.01 ± 0.79	5.25 ± 1.09	0.541
FINS(mU/L)	8.30(5.50,9.70)	7.90(5.80,11.1)	9.20(7.00,11.00)	0.367
TG(mmol▯L)	1.03 ± 0.48	1.14 ± 0.58	0.79 ± 0.28※▯	0.006
TC(mmol▯L)	3.91 ± 0.85	3.47 ± 0.77※	2.94 ± 0.43※▯	< 0.001
LDL(mmol▯L)	2.23 ± 0.63	1.76 ± 0.62※	1.36 ± 0.38※▯	< 0.001
IL6(pg/ml)	2.20(2.00,3.00)	2.10(2.00,2.58)	2.60(2.10,3.38)	0.352
HCRP(mg/L)	0.80(0.40,1.98)	0.70(0.30,2.20)	1.00(0.45,2.15)	0.389
UA(umol/L)	295.90 ± 77.90	282.28 ± 56.85	300.68 ± 72.63	0.486
ALT(U/L)	24.92 ± 19.76	36.79 ± 26.95※	48.69 ± 43.93※	0.006
AST(U/L)	21.46 ± 10.29	26.36 ± 13.41	33.62 ± 21.91※	0.004
Liver fat content(%)	6.75 ± 3.45	6.14 ± 4.34	4.01 ± 2.43※▯	0.002
With NAFLD/without NAFLD	10/29	3/36	1/38※	0.004
HOMA-IR	1.70(1.11,2.64)	1.76(1.19,2.55)	2.04(1.63,2.54)	0.289
※ P▯0.05 versus T1 group,; P▯0.05 versus T2 group				

Significant correlation was found between fT3 and liver fat content, the correlation was significant after adjusting for age, gender and BMI (Fig. 1c, Table 3). Pearson correlation analysis showed that FT3 was negatively correlated with BMI, waist circumference, TG, TC and LDL, and positively correlated with ALT and AST (Table3). The association of FT3 with TC, LDL, ALT and AST were still significant after adjusting for age, gender and BMI ($P < 0.01$).

Table 3
Pearson correlation analysis of factors associated with FT3 and liver fat content

index	Pearson correlation analysis (P-value)				Adjusted for age, gender (P-value)				Adjusted for age, gender, BMI (P-value)			
	Liver fat content		FT3		Liver fat content		FT3		Liver fat content		FT3	
	R	P-value	R	P-value	R	P-value	R	P-value	R	P-value	R	P-value
Age(years)	NS		-0.315	0.001	-	-	-	-	-	-	-	-
BMI(kg/m^2)	0.337	< 0.001	-0.347	< 0.001	0.321	< 0.001	-0.292	0.002	-	-	-	-
Waist circumference(cm)	0.300	0.006	-0.219	0.049	0.293	0.009	NS		NS		NS	
SBP(mmHg)	NS		NS		NS		NS		NS		NS	
DBP(mmHg)	NS		NS		NS		NS		NS		NS	
FT3(pmol/L)	-0.328	< 0.001	-	-	-0.316	0.001	-	-	-0.245	0.009	-	-
FT4(pmol/L)	-0.305	0.001	0.937	< 0.001	-0.291	0.002	0.930	< 0.001	-0.216	0.021	0.923	< 0.001
TSH(uIU/ml)	NS		-0.341	< 0.001	NS		-0.325	< 0.001	NS		-0.275	0.003
TG(mmol/L)	0.284	0.002	-0.239	0.011	0.274	0.004	-0.191	0.046	0.209	0.029	NS	
TC(mmol/L)	0.331	< 0.001	-0.547	< 0.001	0.323	0.001	-0.519	< 0.001	0.286	0.003	-0.495	< 0.001
LDL(mmol/L)	0.346	< 0.001	-0.543	< 0.001	0.333	< 0.001	-0.513	< 0.001	0.301	0.001	-0.492	< 0.001
IL6(pg/ml)	NS		NS		-0.194	0.048	NS		NS		NS	
HCRP(mg/L)	NS		NS		-0.240	0.012	NS		-0.215	0.026	NS	
UA(umol/L)	NS		NS	NS	NS		NS	NS				
ALT(U/L)	NS		0.310	0.001	NS		0.338	< 0.001	NS		0.336	< 0.001
AST(U/L)	NS		0.342	< 0.001	NS		0.374	< 0.001	NS		0.375	< 0.001
HOMA	NS		NS		NS		NS		NS		NS	

As shown in Table 4, multiple linear regression analysis was used to analyze the independent risk factors associated with liver fat content in hyperthyroidism patients. Model 1 included FT3, FT4, TSH, and BMI, and adjusted for age and gender. The results showed that FT3 ($p < 0.01$) and BMI ($p < 0.01$) were independently correlated with the liver fat content. The full model 2 further included the FT3, FT4, TSH, TG, CHOL, LDL, systolic blood pressure, diastolic blood pressure, UA, IL − 6, HCRP as the independent variables, and adjusted for age, gender and BMI. The results showed that FT3 ($p < 0.05$) and TG ($p < 0.05$) were independently correlated with liver fat content.

Table 4
Multiple linear regression analysis of independent factors associated with liver fat content

Dependent variable	Model 1※			Model 2※		
	Independent variable	β	P-value	Independent variable	β	P-value
Liver fat content	FT3	-0.072	0.009	FT3	-0.059	0.016
	BMI	0.281	0.007	TG	1.461	0.013

※Model 1 FT3, FT4, TSH, and BMI were included as the independent variables, adjusted with age and gender;※ Model 2 FT3, FT4, TSH, TG, CHOL, LDL, systolic blood pressure, diastolic blood pressure, UA, IL-6, and HCRP were included as the independent variables, adjusted with age, gender and BMI.

In the binary logistic regression analysis (Table 5), after adjustment with age and gender, FT3, FT4, TSH, and BMI tertiles were used and independent variables, and the results showed FT3 (OR 0.297, 95% CI.0.106※0.832), and BMI (OR 4.585, 95% CI.1.488※14.128) was independently associated with NAFLD. In full Model 2, FT4, TSH, TG, CHOL, LDL, Systolic blood pressure, diastolic blood pressure, UA, IL6, and HCRP tertiles were included, adjusted variable of age, gender and BMI. The results showed FT3 (OR 0.267, 95% CI.0.087 ~ 0.817) were still independently associated with NAFLD.

Table 5
Binary logistic regression analysis of risk factors for NAFLD

Binary logistic regression analysis	Independent variable	P-value	OR	95% C.I.
Model1※	FT3	0.021	0.297	0.106–0.832
	BMI	0.008	4.585	1.488–14.128
Model2※	FT3	0.021	0.267	0.087–0.817

※ Model 1 tertiles of FT3, FT4, TSH, and BMI were included as the independent variables, adjusted with age and gender;※ Model 2 tertiles of FT3, FT4, TSH, TG, CHOL, LDL, systolic blood pressure, diastolic blood pressure, UA, IL-6, and HCRP were included as the independent variables, adjusted with age, gender and BMI.

Discussion

The present study reported that the prevalence of NAFLD was 11.97% in 117 clinical hyperthyroidism patients. Liver fat content was closely related to the fT3 levels in this population, and this association was independent of metabolic components and inflammatory factors.

The prevalence of NAFLD is 27.4–33.1% in euthyroidism population, and 35.7–36.3% in hypothyroidism population [1 2,3]. However, there are extremely limited reports on the prevalence of NAFLD in hyperthyroid population. From Rotterdam Study, the prevalence of NAFLD was 21.5% in hyperthyroidism subjects, and a decreasing trend of NAFLD prevalence was found in different thyroid status from hypothyroidism, euthyroidism to hyperthyroidism [14]. NAFLD risk decreased gradually from hypothyroidism to hyperthyroidism. However, 114 subjects were in subclinical status, there were only 7 clinical hyperthyroidism cases were included in Rotterdam Study. Our data showed that the prevalence of NAFLD 11.95% in clinical hyperthyroidism subjects, which was lower than subclinical hyperthyroidism and other thyroid status population. To be consistent of our findings, a case also reported that hyperthyroidism improved the pathological condition of nonalcoholic steatohepatitis [15].

The results of the present study indicated a negative linear association between FT3 levels and NAFLD in this specific hyperthyroidism population. Several study demonstrated the association of thyroid hormone and NAFLD in different thyroid status population. The serum thyroxin (TT4) concentration in subjects with hepatic steatosis was reduced in subclinical and clinical hypothyroidism subjects. [7] Subclinical hypothyroidism and low-normal thyroid function are associated with nonalcoholic steatohepatitis and fibrosis according to the TSH levels. [16] From lifeline cohort study, higher fT3 is associated with NAFLD in euthyroid subjects. [17] Higher fT4 levels were associated with a decreased risk of NAFLD, and higher thyroid-stimulating hormone levels were associated with inn increased risk of having clinically relevant fibrosis in NAFLD in Rotterdam study. [14] Our study demonstrated that FT3 level was independently associated

with decreased liver fat content in the hyperthyroidism population. TSH levels were significantly suppressed in hyperthyroidism subjects, which can not accurately reflect the thyroid function. In addition, FT3 activity is much higher than FT4 [18 19], so it is more authentic to regard FT3 level as an indicator of thyroid function in patients with hyperthyroidism. Therefore, in hyper-metabolic hyperthyroid population, FT3 is independently associated with liver fat content, while in hypothyroid or euthyroid population, TSH or FT4 and NAFLD are closely related.

The mechanisms about the effect of thyroid hormone levels on liver fat content and NAFLD remain unclear. Study of rodent models have demonstrated that thyroid receptor β agonist MB07811 can reduce hepatic steatosis [9]. Thyroid hormone induces intrahepatic lipolysis via activation of autophagy [20]. Previous studies on the hypothyroidism patients indicated that lower thyroid hormone caused insulin resistance, metabolic disorders, and NAFLD [21 22]. Our results indicated that thyroid hormone further reduced liver fat content in the condition of hyperthyroidism. Thyroid hormone may promote body fat consumption, and reduce body weight, it may also directly impact on the liver, accelerating intrahepatic fat clearance, this process was independent from metabolic factors and inflammatory factors.

There are still some limitations in this study, this is a cross-sectional study without follow-up, liver biopsy or liver magnetic resonance spectroscopy (MRS) were not used to accurately detect liver fat content. Further prospective study should be conducted to confirm our results.

Conclusion

In conclusion, The present study reported that the prevalence of NAFLD was 11.97% in 117 clinical hyperthyroidism patients. In addition, the prevalence and liver fat content significantly decrease with the elevation of fT3 levels in this population. These results may provide new evidence in the role of thyroid hormone on the regulation of liver fat content and NAFLD.

List Of Abbreviations

NAFLD non-alcoholic fatty liver disease

FT3 free triiodothyronine

FT4 free thyroxine

NASFL non-alcoholic simple fatty liver

NASH nonalcoholic steatohepatitis

FFA free fatty acids

TSH thyroid stimulating hormone

Wc waist circumference

BMI body mass index

FBG fasting blood glucose

TC total cholesterol

TG triglyceride

HDL-C high-density lipoprotein cholesterol

LDL-C low-density lipoprotein cholesterol

ALT alanine aminotransferase

AST aspartate aminotransferase

UA uric acid

TRAb thyrotrophin receptor antibody

f-INS fasting plasma insulin

HCRP hyper-sensitive C-reaction protein

HOMA-IR insulin resistance index

ROI region of interest

Declarations

Ethics approval and consent to participate

Written, informed consent was obtained from all of the participants, and the study was approved by the ethics committee of Zhongshan Hospital, Fudan University, China.

Consent for publication

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

Availability of data and material

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

I certify that neither I nor my co-authors have a conflict of interest as described above that is relevant to the subject matter or materials included in this work

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Authors' contributions

BW and XL participated in the design of the study, performed the statistical analysis and drafted the manuscript. XG and XL participated in the design of the study. BX, MH and JX participated in the data collection. XL and XG conceived of the study. All authors read and approved the final manuscript.

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Figures

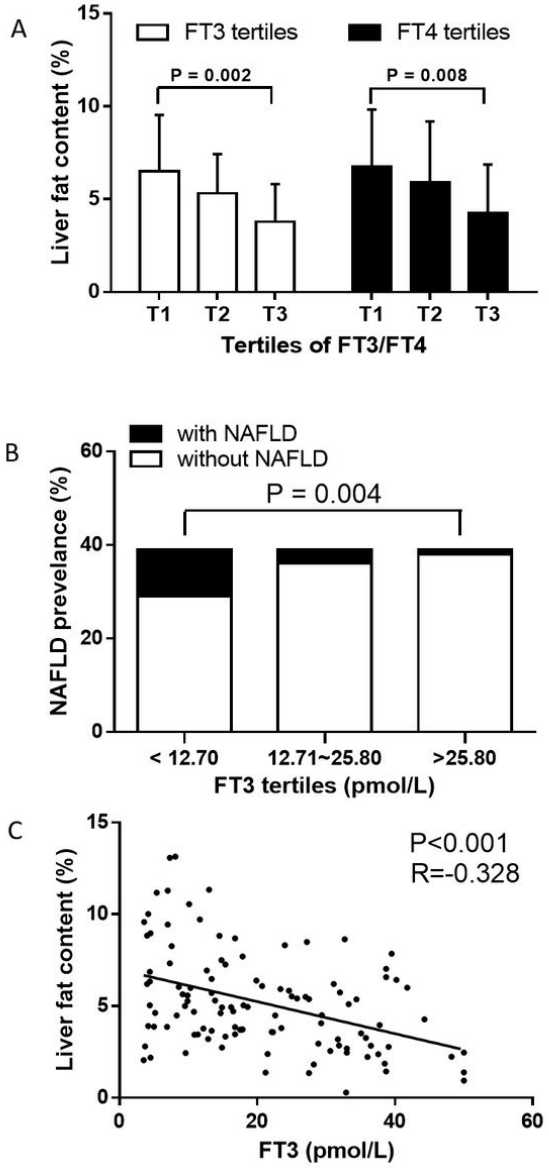

Figure 1

Correlation of liver fat content and prevalence of NAFLD with thyroid hormoe levels in hyperthyroidism patients. a. The fT3/fT4 levels in respective tertiles was plotted against liver fat content, the liver fat content showed a decreased trend with increasing of fT3/fT4 levels; b. The fT3 levels in respective tertiles was plotted against prevalence of NAFLD, the prevalence of NAFLD showed a decreased trend with increasing of fT3 levels; c. the fT3 concentration was plotted against liver fat content, and a negative significant correlation was found between fT3 and liver fat content.