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Conscientiousness personality is associated with increased thyroid nodule risk and sleep quality plays a masking role in this association

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This study aimed to investigate the correlation between the Big Five Personality Traits and the occurrence of thyroid nodules (TNs), so as to provide evidence for individualized treatment from the perspective of personality and raise public awareness about thyroid health. A total of 331 participants who underwent physical examinations and thyroid ultrasound at the Health Management Center of the First Affiliated Hospital of Jinzhou Medical University were included in this survey and completed a panel of questionnaires including a general demographic questionnaire, the NEO Five-Factor Inventory (NEO-FFI), and the Pittsburgh Sleep Quality Index (PSQI). Among the 331 subjects, 42.9% (142/331) had TNs, 72.51% (240/331) were female, and 70.69% (234/331) were younger than 45 years old. There were statistically significant differences between the TNs group and the non-TNs group in terms of gender, age, age group, education, occupation, conscientiousness, smoking status, sleep disturbances, daytime dysfunction, total PSQI score, hyperlipidemia, hypertension and blood glucose (all *Ps* < 0.05). Logistic regression showed that conscientiousness was positively correlated with the occurrence of TNs in people under 45 years old (*P* < 0.05). Mediating effect analysis indicated that sleep quality had a masking effect between conscientiousness and the occurrence of TNs. Conscientiousness increases the risk of TNs, and sleep quality plays a masking role in the influence of conscientiousness on the occurrence of TNs among adults aged < 45 years old.

Keywords Thyroid nodules, The big five personality, Sleep quality, Masking effect

Thyroid nodules (TNs) are localized lesions that occur within thyroid tissue and can be clearly identified through ultrasound images[1]. In recent years, this condition has gradually been increasing worldwide[2], and according to a recent study, TNs present a 54.1% presence among 14,973 adults from North China and have become a major public health concern in China[3]. Severe cases of TNs would bring about strong sensation of foreign body and compression and mental disorders, taking a toll on the somatic and psychological health of affected individuals and their families[4,5]. In addition, approximately 10–15% cases of TNs have a tendency to demonstrate malignancy[1]. Hence, it is particularly urgent to determine and manage risk factors related to TNs.

The Big Five personality dimensions consist of Neuroticism, Extroversion, Openness, Agreeableness and Conscientiousness, and have been widely confirmed to effectively predict an person's health-related behaviors and results[6]. For instance, high neuroticism, high extroversion and low conscientiousness were found to be associated with a higher likelihood to develop chronic bronchitis[7]. Previous research suggested that personality traits affected the health outcomes via multiple and diverse processes, like via affecting exercise behaviors[8]. To our knowledge, there are few studies regarding the influence and mechanisms of the Big Five personality traits on the occurrence of TNs, despite only one study showing that type B behavioral patterns (characterized by low competitiveness and high tolerance) was associated with an increased risk of TNs[9].

Sleep quality was also reported to be critical factors for TNs[10]. Its underlying mechanism is linked to the dysfunction of the Hypothalamic-Pituitary-Adrenal (HPA) axis induced by circadian rhythm disturbances. Specifically, long-term sleep deprivation leads to the disruption of the sleep-wake cycle and the disorder of the circadian rhythmicity, which in turn interferes with the regulation of thyroid hormone secretion, thereby causing an imbalance in the internal environment of the body[11], and ultimately increasing the risk of TNs.

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These alterations are considered to be the pathophysiological basis for the increased risk of TNs development[12]. One study has indicated that individuals with insufficient nighttime sleep duration exhibit a significantly higher detection rate of TNs[13]. Another prospective study has revealed that maintaining good sleep quality is associated with a lower incidence of thyroid diseases[14].

Research showed that conscientiousness, agreeableness, openness, and extroversion, exerted protection against sleep quality[15]. Neuroticism, on the other hand, caused sleep disorders and was associated with increased distress and anxiety. Individuals with higher neuroticism are more sensitive to stressors. This may amplify and prolong sleep difficulties[16]. Previous studies reported that higher conscientiousness was associated with better sleep quality due to increased individual engagement in health-promoting behaviors, such as physical activities, healthy diet, and fewer risky behaviors[17]. This association may also be partly attributed to the stress-buffering effect of a sense of responsibility[18,19].

In view of the previously documented association between personality traits and incidence of TNs, as well as personality traits and sleep quality, our present study aimed at investigating whether the Big Five personality traits affect incidence of TNs through sleep. As of now, whether and how personality traits affect the incidence of TNs is largely elusive, and thus this study was designed so as to address this research gap, which would provide an empirical basis for formulating personalized intervention strategies for TNs based on the dual dimensions of personality traits and sleep health in clinical practice.

Methods

Participants

This cross-sectional study adopted the convenience sampling method to recruit participants who underwent health checkups and thyroid nodule screening at the Health Management Center of the First Affiliated Hospital of Jinzhou Medical University in Jinzhou, Liaoning Province between January and April 2025. The inclusion criteria of this study were: (1) Complete physical examination data; (2) Being over 18 years old and willing to participate. The exclusion criteria included: (1) Individuals with a significant medical history of severe illness such as heart, liver, and kidney diseases, or tumors; (2) Using hormones or other drugs that can affect study results; (3) Pregnant women. In this study, a total of 366 questionnaires were distributed. Participants with incomplete questionnaires or unreasonable responses ($n = 35$) were excluded. Ultimately, a total of 331 participants were included in the final analysis.

Questionnaire survey and ultrasound examination

General demographic questionnaire

The contents of the questionnaire included age, age group (Aged < 45 and ≥ 45 years old)[20,21], gender, educational background, occupation, smoking status, drinking status, blood pressure level, presence of hyperlipidemia, BMI (Body Mass Index) and blood glucose level. BMI was calculated as weight in kilograms divided by height in meters squared, and classified into four categories into according to WHO-approved guidelines: underweight (< 18.5 kg/m^2); normal weight (18.5–24.9 kg/m^2); overweight (25.0–29.9 kg/m^2); and obesity (≥ 30.0 kg/m^2)[22].

Ultrasound diagnosis

Thyroid ultrasound, with its characteristics of accuracy, safety, convenience and economy, has become the preferred tool for screening and diagnosing TNs[23,24]. All ultrasound examinations were conducted by a board-certified radiologist specializing in ultrasonography. Ultrasound was performed with portable color Doppler ultrasound systems using a transducer probe that operated at a frequency range of 7.5–15 MHz. Participants were placed in a supine posture with maximal head extension to ensure adequate exposure of the thyroid gland. Transverse and longitudinal scans of the thyroid were conducted to evaluate and document its location, morphology, size, echogenicity, margins, and the presence or absence of calcification.

TNs were categorized under the Thyroid Imaging Reporting and Data System (TI-RADS) guidelines[25] as Category 1 (nodule-free, normal thyroid structure), Category 2 (definitively benign lesions, such as typical subacute thyroiditis, thyroid cysts, nodular goiter, and isolated calcifications), Category 3 (nodules with no suspicious features for malignancy, considered probably benign), Category 4 (suspected malignant nodules, further subdivided into categories 4a, 4b or 4c according to the number of malignant features observed: 1 feature for 4a, 2 features for 4b, and 3–4 features for 4c), or Category 5 (TNs exhibiting five or more malignant features). Participants classified as TI-RADS 1 were deemed to have no TNs, while those in categories TI-RADS 2–5 were assigned to the TNs group.

NEO five-factor inventory (NEO-FFI)

The NEO-FFI, a concise version of the personality inventory, is grounded in the Five-Factor Model (FFM) of personality and has been extensively utillized for personality assessment in both clinical and non-clinical populations. It was complied by American psychologists Paul Costa and Robert McCrae in 1992[26]. For the present study, the 60-item scale was used to evaluate personality traits of the participants. This scale includes five dimensions: neuroticism (N), extroversion (E), openness (O), agreeableness (A), and conscientiousness (C), with 12 items in each dimension[26]. A 5-point Likert scale (1 = strongly disagree, 5 = strongly agree)[27] is used for scoring. In this study, the Cronbach's α coefficient of this scale was 0.72.

Pittsburgh sleep quality index (PSQI)

The PSQI assesses the recent sleep quality in patients. The original version was developed in 1989, and thereafter confirmed to be psychometrically sound in the context of Chinese culture[28,29]. This scale consists of 18 items and 7 factors: subjective sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction. The score of each factor ranges from 0 to 3 points. The total score of

PSQI is obtained by adding the scores of the factors. The total score ranges from 0 to 21 points, with 7 as the cut-off value. A higher score corresponds to worse sleep quality. In this study, the Cronbach's α coefficient of this scale was 0.82.

Statistical analysis

Statistical analyses of the data were performed using Statistical Product and Service Solutions version 27.0 (SPSS 27.0, URL: https://www.ibm.com/docs/en/spss-statistics/27.0.0), and the reliability of the research project was evaluated using the Harman's Single-Factor Test for Common Method Bias (CMB). For continuous variables, data were examined for normality and homoscedasticity using Kolmogorov-Smirnov and Levene's tests, and either presented as mean ± standard deviation (M ± SD) or M (P_{25}, P_{75}) according to their distribution profiles. For non-normally distributed continuous variables, the Mann-Whitney U test was employed to assess intergroup differences. Categorical variables were described by their frequencies and percentages (n, %), and group comparisons for these variables were conducted using the chi-square test. The relationship between personality and TNs was analyzed using the Logistic regression model. Bonferroni correction method was used in order to control false positives ($P < 0.05/5 = 0.01$) for the five dimensions of the personality traits.

Subsequently, a structural equation model was constructed to analyze the mediating effect using stepwise regression analysis to examine the relationships among the independent variable (X), the mediating variable (M) and the dependent variable (Y). The resulting regression equations are: (1) $Y = cX + \varepsilon 1$; (2) $M = aX + \varepsilon 2$; (3) $Y = c'X + bM + \varepsilon 3$. Here, c represents the regression coefficient for the total effect of X on Y; a denotes the regression coefficient for the direct effect of X on M; c' and b are the regression coefficients for the direct effects of X and M on Y, respectively. The product ab signifies the indirect effect. First, the coefficient c is tested. If significant, the coefficients a and b are tested sequentially. If both are significant, the indirect effect is established. Finally, the coefficient c' was tested. If it is significant, the direct effect exists. Compare the signs of ab and c': if they are consistent, it suggests the presence of a partial mediating effect (ab/c); if they differ, it suggests a masking effect ($|ab|/c$). The masking effect refers to a scenario in mediation analysis where no significant relationship was observed between the independent variable (X) and the dependent variable (Y), which is likely attributable to the masking or influence of a third variable (The Masking Variable)[30]. The mediation effect analysis was conducted using the PROCESS 4.2 plug-in for SPSS. Parameter estimation was carried out through the Bootstrap method of bias reduction, with Model 4 selected for the analysis. A total of 5000 resample iterations were performed, and the 95% confidence intervals were provided. The significance level was set at a two-tailed α of 0.05.

Results

Harman's single-factor test

Since all the data in this study were collected through self-administered questionnaire, there may be common method bias. Therefore, the Harman's Single-Factor Test was used to test for potential methodological bias. As illustrated in Table 1, the eigenvalues of 19 factors exceeded 1, and the first unrotated factor accounted for 15.875% of the variance, which was lower than the 40% threshold suggested in the academic literature[31]. This suggested that significant common method bias did not exist in the data of this study.

	Initial eigenvalues			Rotation sums of squared loadings		
Component	Total	Variance Percentage	Cumulative (%)	Total	Variance Percentage	Cumulative (%)
1	12.383	15.875	15.875	12.383	15.875	15.875
2	9.875	12.660	28.535	9.875	12.660	28.535
3	4.885	6.263	34.799	4.885	6.263	34.799
4	2.934	3.761	38.560	2.934	3.761	38.560
5	2.211	2.834	41.394	2.211	2.834	41.394
6	2.120	2.718	44.112	2.120	2.718	44.112
7	1.870	2.398	46.510	1.870	2.398	46.510
8	1.719	2.204	48.714	1.719	2.204	48.714
9	1.552	1.990	50.703	1.552	1.990	50.703
10	1.443	1.850	52.553	1.443	1.850	52.553
11	1.421	1.822	54.375	1.421	1.822	54.375
12	1.301	1.668	56.043	1.301	1.668	56.043
13	1.284	1.646	57.690	1.284	1.646	57.690
14	1.265	1.622	59.311	1.265	1.622	59.311
15	1.220	1.585	60.876	1.220	1.585	60.876
16	1.171	1.501	62.377	1.171	1.501	62.377
17	1.073	1.376	63.752	1.073	1.376	63.752
18	1.049	1.345	65.098	1.049	1.345	65.098
19	1.008	1.292	66.390	1.008	1.292	66.390

Table 1. Total variance Explained.

General characteristics of the participants

Ultimately, a total of 331 participants were included in the data analysis for this study. The sociodemographic characteristics of the study population are presented in Table 2. Ultrasound examination revealed that 42.90% (142/331) of the participants had TNs. As the age data were non-normally distributed, the cohort's median age

Variable	Total *n*(%)/M(IQR)	Non-TN group *n*(%)/M(IQR)	TN group *n*(%)/M(IQR)	χ^2/Z-value	*P*-value
Gender				24.845	< 0.001
Male	91(27.49)	72(38.09)	19(13.38)		
Female	240(72.51)	117(61.91)	123(86.62)		
Age(years)	41.00(36.00,46.00)	40.00(35.00,44.00)	42.50(38.00,51.00)	-4.069	< 0.001
Age Group				7.719	0.005
< 45	234(70.69)	145(76.72)	89(62.68)		
≥ 45	97(29.31)	44(23.28)	53(37.32)		
Education				9.649	0.047
Secondary school or below	26(7.85)	12(6.45)	14(9.86)		
Junior high school	65(19.63)	42(22.22)	23(16.20)		
Undergraduate	139(41.99)	78(41.27)	61(42.96)		
Master's degree	75(22.68)	48(25.39)	27(19.01)		
Doctoral Degree	26(7.85)	9(4.67)	17(11.97)		
Occupation				10.850	< 0.001
Healthcare workers	114(34.44)	51(26.98)	63(44.37)		
Non-healthcare workers	217(65.56)	138(73.02)	79(55.63)		
Smoking				8.543	0.003
No	302(91.24)	165(87.30)	137(96.48)		
Yes	29(8.76)	24(12.70)	5(3.52)		
Alcohol consumption				1.233	0.267
No	301(90.94)	169(89.42)	132(92.96)		
Yes	30(9.06)	20(10.58)	10(7.04)		
Personality					
Neuroticism	33(27, 37)	33(27, 37)	33(27, 37)	-0.194	0.473
Extroversion	39(35, 43)	39(35, 44)	38(33.75, 42)	1.677	0.094
Openness	38(35, 41)	38(35, 41)	38(34, 42)	0.349	0.727
Agreeableness	42(38, 45)	41(37, 46)	42(39, 45)	-1.487	0.137
Conscientiousness	45(40, 50)	44(29, 49)	46(41.75, 51)	-2.449	0.035
PSQI Score					
Subjective sleep Quality	1(0, 1)	1(0, 1)	1(0, 2)		0.058
Sleep onset latency	1(0, 1)	1(0, 1)	1(0, 1)		0.449
Sleep duration	1(1, 2)	1(0.50, 2)	1(1, 2)		0.352
Sleep efficiency	0(0, 1)	0(0, 1)	0(0, 1)		0.861
Sleep disturbances	1(0, 1)	1(0, 1)	1(1, 1)	-1.987	0.047
Sleep medication use	0(0, 0)	0(0, 0)	0(0, 0)		0.734
Daytime dysfunction	1(0, 2)	1(0, 2)	1(1, 2)	-3.388	< 0.001
Total PSQI score	5(3, 8)	5(3, 7)	6(4, 9)	-2.368	0.018
Hyperlipidemia				7.092	0.008
No	17(5.14)	15(7.94)	2(1.415)		
Yes	314(94.86)	174(92.06)	140(98.595)		
Hypertension				6.825	0.009
No	188(56.79)	119(62.96)	69(48.59)		
Yes	143(43.21)	70(37.04)	73(51.41)		
Blood glucose(mmol/L)	5.00(4.56,5.40)	5.00(4.50,5.37)	5.10(4.64,5.52)	-2.353	0.019
BMI(kg/m^2)	24.00(21.20,26.87)	23.80(21.03,26.95)	24.01(21.48,26.72)	-0.001	1.000

Table 2. General characteristics of the participants. Categorical Variable: n (%); Continuous Variable: all continuous variables were tested for normality using the Kolmogorov-Smirnov test and found to be non-normally distributed ($P < 0.05$), data are presented as M(P_{25}, P_{75}). Group comparisons were made using the Mann-Whitney U test. BMI, Body Mass Index; Non-TN group, Non-Thyroid Nodule Group; TN group, Thyroid Nodule Group; M(IQR), M($P_{25,}$ P_{75}).

was 41.00 years (IQR: 36.00–46.00 years), with 70.69% (234/331) of participants being younger than 45 years and 72.51% (240/331) being female. Participants with an educational attainment at the undergraduates level and lower comprised 69.48% (230/331) of the total. As for BMI, which was non-normally distributed, the median BMI was 24.00 (IQR: 21.20-26.87). The proportions of non-drinkers and non-smokers were 90.94% (301/331) and 91.24% (302/331), respectively. The proportions of participants with hypertension and hyperlipidemia were 43.21% (143/331) and 94.86% (314/331), respectively.

There were statistically significant differences between the TNs and non-TNs groups in terms of gender, age, age group, education, occupation, conscientiousness, smoking status, sleep disturbances, daytime dysfunction, total PSQI score, hyperlipidemia, hypertension and blood glucose (all $Ps < 0.05$). In total population, conscientiousness dimension of the big five personality was significantly different between the two groups ($P = 0.035$), whereas no significant group differences were identified in other personality traits. Further stratified analysis showed that this difference in conscientiousness was present only among participants younger than 45 years, while no significant differences in personality traits were detected in those aged ≥ 45 years. Details are shown in Figs. 1 and 2.

Multivariate logistic regression analysis of TNs by the big five personality dimensions

In the overall populations, extroversion and conscientiousness were shown to be significantly associated with the occurrence of TNs in the unadjusted Model 1. However, in the adjusted Models 2 and 3, the occurrence of TNs was not associated with any personality dimension in the overall population. As for those aged ≥ 45 years old, personality traits showed no significant association with TNs risk in either the unadjusted Model 1 or the adjusted Models 2 and 3. As for those under 45 years old, conscientiousness was significantly associated with TNs risk in all the three models, with OR [95% CI] being 1.110 [1.043, 1.181] in adjusted final Model 3, suggesting an unfavorable impact of conscientiousness on TNs occurrence. Details are shown in Table 3.

Mediating model tests

According to the results of the regression analysis, we subsequently performed mediation analysis based on the three-step mediating effect method[32–34] among those under 45 years old. In this analysis, conscientiousness was used as an independent variable, sleep disorders as a mediating variable, the occurrence of TNs as the

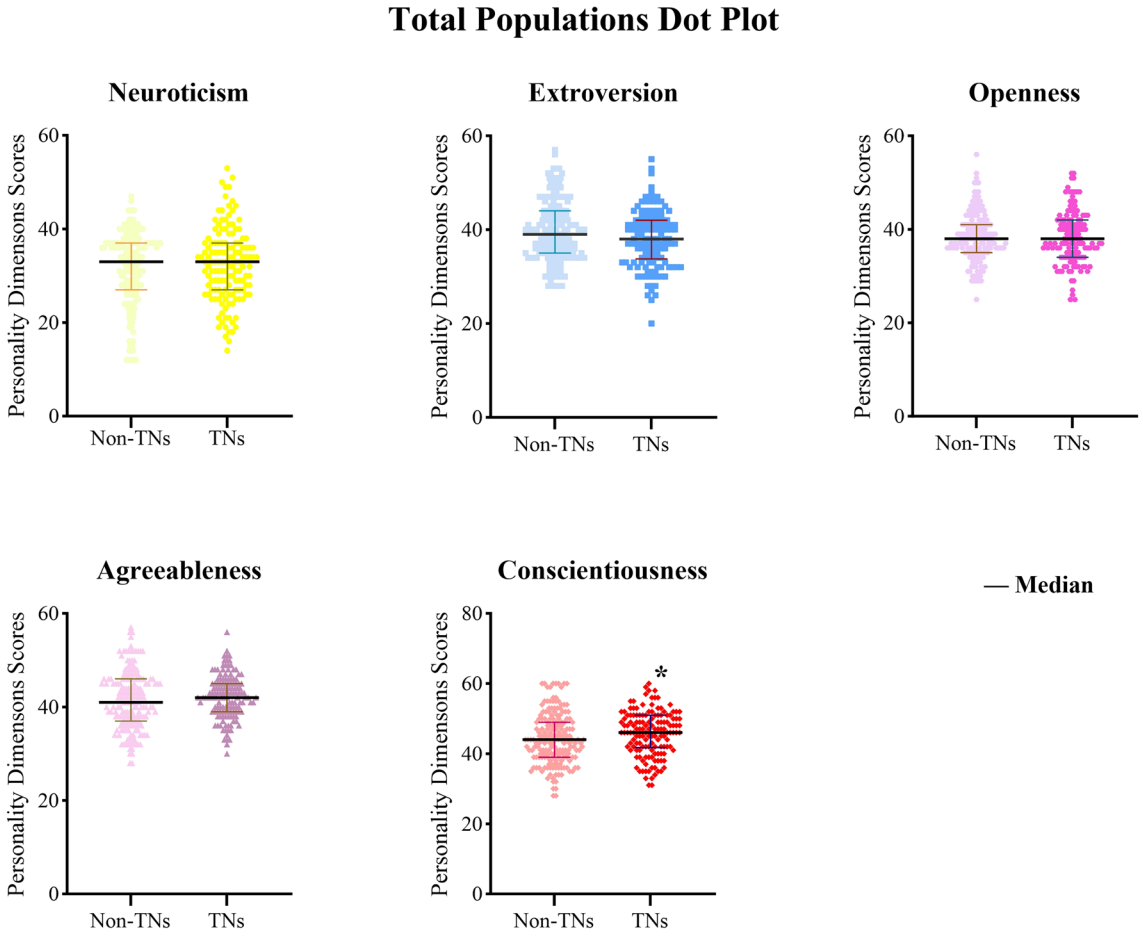

Fig. 1. Scores on the Big Five personality dimensions scores in the overall population for the thyroid nodule group and the non-thyroid nodule group. *$p < 0.05$.

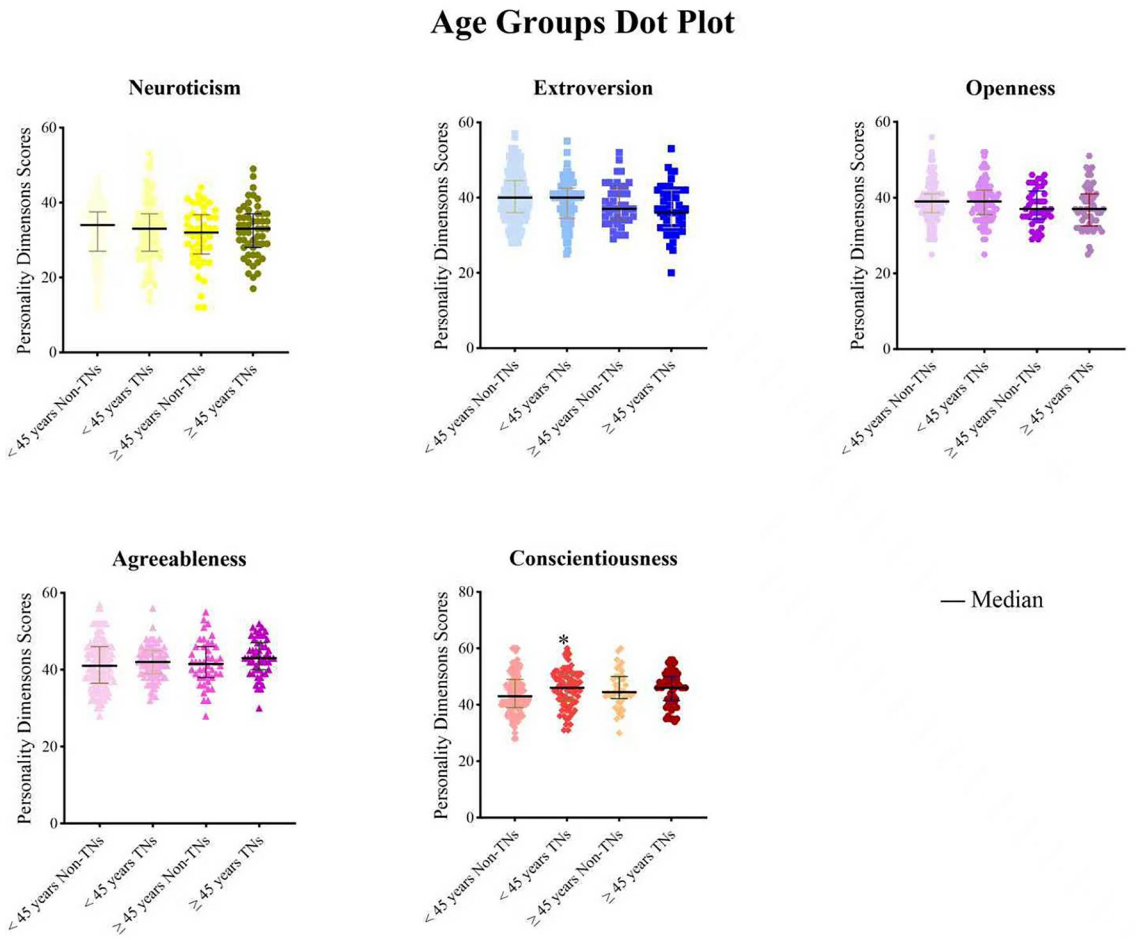

Fig. 2. Scores on the Big Five personality dimensions scores in the population aged < 45 years and ≥ 45 years for the thyroid nodule group and the non-thyroid nodule group. $^{*}p < 0.05$.

Variables		Overall population($n = 331$)		Aged < 45 years($n = 234$)		Aged ≥ 45 years($n = 97$)	
		OR[95%CI]	Bonferroni corrected *P*-value	OR[95%CI]	Bonfferroni corrected *P*-value	OR[95%CI]	Bonferroin corrected *P*-value
Neuroticism	Model1	1.035[0.996,1.075]	0.390	1.029[0.981,1.079]	1.240	1.049[0.981,1.122]	0.825
	Model2	1.033[0.993,1.075]	0.540	1.025[0.976,1.076]	1.640	1.065[0.988,1.147]	0.495
	Model3	1.029[0.987,1.072]	0.890	1.029[0.977,1.084]	1.410	1.095[0.997,1.202]	0.295
Extroversion	Model1	0.934[0.894,0.976]	0.010	0.934[0.884,0.987]	0.080	0.949[0.875,1.028]	1.000
	Model2	0.952[0.908,0.998]	0.200	0.939[0.887,0.994]	0.155	0.966[0.885,1.055]	2.205
	Model3	0.948[0.901,0.997]	0.190	0.930[0.873,0.991]	0.130	0.959[0.852,1.078]	2.405
Openness	Model1	1.002[0.957,1.050]	4.645	1.011[0.953,1.072]	3.605	1.009[0.926,1.098]	4.205
	Model2	1.018[0.969,1.069]	2.415	1.014[0.955,1.077]	3.260	1.007[0.918,1.105]	4.405
	Model3	1.008[0.957,1.061]	3.880	0.999[0.937,1.065]	4.910	0.962[0.855,1.081]	2.565
Agreeableness	Model1	1.032(0.981,1.086)	1.085	1.001[0.942,1.064]	4.860	1.106[1.000,1.223]	0.245
	Model2	1.015[0.961,1.071]	3.015	0.992[0.930,1.057]	4.010	1.077[0.966,1.202]	0.915
	Model3	1.001[0.945,1.061]	4.84	0.977[0.910,1.048]	2.575	1.065[0.925,1.227]	1.905
Conscientiousness	Model1	1.075[1.028,1.123]	0.005	1.091[1.034,1.151]	0.010	1.005[0.922,1.097]	0.470
	Model2	1.060[1.011,1.111]	0.075	1.086[1.028,1.148]	0.015	1.000[0.910,1.098]	4.980
	Model3	1.028[0.990,1.068]	0.735	1.110[1.043,1.181]	< 0.005	0.953[0.838,1.084]	2.325

Table 3. Logistic regression analysis of the big five personality traits and thyroid Nodules. Model 1, unadjusted variables; Model 2, Adjusting gender and age; Model 3, Based on model 2, education background, occupation, smoking status, drinking status, hyperlipidemia, hypertension, blood glucose and BMI were further included.

Steps	Independent Variables	Dependent Variable	Mediator	β	SE	z/t	*P*	95%CI
Step 1	Conscientiousness	TNs		0.046	0.023	3.934	0.047	(1.001,1.096)
Step 2	Conscientiousness	Sleep Disorders		− 0.142	0.036	− 2.107	0.036	(− 0.199,− 0.085)
Step 3	Conscientiousness	TNs	Sleep Disorders	0.066	0.031	10.463	0.001	(0.019, 0.112)

Table 4. Mediation effect analysis of sleep disorders between conscientiousness and TNs in < 45 years old. TN: Thyroid Nodules. Step 1: A logistic regression analysis was conducted with conscientiousness as independent variables and thyroid nodule occurrence as the dependent variable in Step 1, which yielded the total effect coefficient c. Step 2: A linear regression analysis was conducted on the dependent variable sleep disorder with the independent variables conscientiousness, resulting in the coefficient a. Step 3: A logistic regression analysis was conducted on the dependent variable thyroid nodule occurrence, the mediating variable sleep disorders and the independent variables conscientiousness, resulting in the direct effect c'.

Effect relationship	Effect size	LLCI	ULCI	Proportion of effect
Direct effect	0.066	0.019	0.112	
Indirect effect	− 0.018	− 0.424	− 0.004	27.96%

Table 5. Mediation effect proportion Analysis. LLCI, Lower-limit of confidence interval; ULCI, Upper-limit of confidence interval.

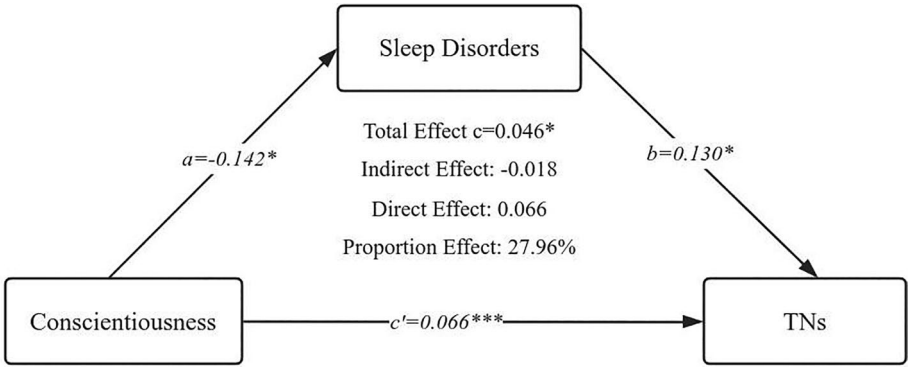

Fig. 3. A simple mediation model diagram for conscientiousness, sleep quality, and the presence of thyroid nodules in the young adult group (< 45 years old). *p<0.05, ***p<0.001; TNs: Thyroid Nodules; Proportion Effect: |ab|/c.

dependent variable, and age, gender, occupation, educational background, hypertension and blood glucose as control variables.

The total effect (c = 0.046, P = 0.047) was significant. Conscientiousness significantly negatively predicted sleep disorders (a=-0.142, P = 0.036), while sleep disorders significantly positively predicted the occurrence of TNs (b = 0.130, P = 0.015), and the indirect effect (ab) reached statistical significance. The absolute magnitude of the direct effect (c') exceeded that of the total effect (c') and the indirect effect (ab) and direct effect (c') had opposing signs. Therefore, among people under 45 years old, sleep disorders have a masking effect between conscientiousness and TNs. The total effect of conscientiousness on TNs was 0.046, the direct effect was 0.066 (P < 0.001), and the masking effect produced by the masking variable was − 0.018. The indirect effect represented 27.96% of the magnitude of the direct effect (|ab|/c). Details are shown in Tables 4 and 5; Fig. 3.

Discussion

The results of this study show that sleep disorders may be a risk factor for the occurrence of TNs, and the conscientiousness dimensions of the Big Five personality have a significant impact on the occurrence of TNs. It is notable that among individuals under the age of 45, the impact of conscientiousness dimension on the occurrence of TNs was influenced by the masking effect of sleep quality. This offers a novel perspective for the prevention and management of TNs.

The research results show that the prevalence rate of TNs was 42.90%, which emphasizes the current situation of TNs as an important public health issue and the need to strengthen prevention and intervention measures. Univariate analysis identified statistically significant differences in gender and age (group) between the TNs and non-TNs groups. The higher prevalence of TNs in women, compared to men, is consistent with the findings of Dauksiene.D et al.[35]. Furthermore, with the increase of age, the prevalence of TNs shows an upward trend.

Younger age becomes a protective factor for the occurrence of TNs, which may be related to the gradual decline of endocrine function during the aging process of the body. This is consistent with previous research results[36,37].

Previous studies have demonstrated that higher neuroticism is associated with poorer health, and higher scores in extroversion and openness are sometimes associated with poorer health and sometimes with better health, higher conscientiousness is associated with better physical health outcomes[38,39], while agreeableness may usually not be related to health. In this study, in the population under 45 years old, conscientiousness is significantly positively correlated with the occurrence of TNs. Individuals with high conscientiousness often set higher expectations for themselves and focus on goal achievement[17]. However, excessive individual conscientiousness[40,41] may lead them to details fixation, perfectionism, and increased pressure, potentially increasing the risk of TNs. No statistically significant association was observed between personality traits and TNs among individuals aged 45 and above. This may relate to the developmental changes in personality[42]. The overall or general pattern of personality change is ontology-free or variable-centered. These patterns capture how a given feature in a given sample changes over time and how different people change over time[43]. Generally, personality evolves from youth to middle age with increased conscientiousness, extroversion, openness, and agreeableness, alongside a decrease in neuroticism[44–46]. However, increased conscientiousness may not persist into old age. One of the most convincing explanations for later life involves Baltes' theory[47,48] which holds that development encompasses both gains and losses. Therefore, a typical characteristic of old age is greater losses[49]. As time goes by, social demands begin to weaken in old age, and the trait of conscientiousness also weakens accordingly[50]. Additionally, previous a study showed that introverted individuals are more prone to TNs[9]. However, in this study, no significant relationship was found between extroversion and the occurrence of TNs. Secondly, sleep disorders may impact the occurrence of TNs, which aligns with prior research[10,36]. This may be attributed to the bidirectional interaction between sleep disorders and HPT axis, where sleep disorders disrupt the circadian rhythm of the HPT axis, subsequently inducing thyroid hormone synthesis dysfunction[11]. Conversely, psychological stress may escalate in patients with TNs, contributing to sleep disorders[51].

Furthermore, conscientiousness significantly negatively predicts sleep disorders, suggesting that higher levels of this trait serve as a protective factor for sleep quality. This is consistent with prior research[52]. Sleep quality positively predicts TNs. Therefore, conscientiousness may offset part of its promoting effect on TNs occurrence through the positive role of sleep. High sleep quality may reduce the possibility of TNs. Overall, the mediating model constructed in this study determined that sleep quality serves as a masking effect in the association between conscientiousness and the occurrence of TNs in the under-45 population[30,53], suggesting that there are two possible association pathways between conscientiousness and TNs. Existing research predominantly focuses on physiological risk factors for TNs, but studies on psychosocial determinants remain scarce. The current study indicates a pathway spanning psychological traits, lifestyle modifications, and disease, offering a novel perspective for TNs prevention. Clinically, we advocate for the assessment of personality traits and sleep quality among high-risk populations for TNs. Develop tailored intervention plans and design personalized sleep improvement protocols to address sleep difficulties in individuals with poor sleep quality.

In this study, there were still some limitations. Firstly, due to its cross-sectional design, this study is unable to clarify the causal relationship between conscientiousness, sleep disorders and TNs. Therefore, further longitudinal studies are warranted to investigate these potential casual links and verify our findings in the future. Secondly, The data was collected from the Health Management Center in this study. Although some control variables were included, the selection of indicators lacked comprehensiveness or depth, such as FT3, FT4, thyroid-stimulating hormone (TSH) levels and iodine intake. Finally, as the sample of this study was solely from a tertiary hospital in Jinzhou City, Liaoning Province, the universality of the research results might be limited. We will address the above limitations in our subsequent research in the future. Specifically, we will strictly control for various confounding factors by adopting a prospective approach. Additionally, we will utilize innovative statistical methodologies to enable a rigorous examination of the causal relationship between personality traits and the risk of TNs, as well as the influence of diverse mediating and moderating factors. Ultimately, our goal is to offer a scientific basis for TNs management from a personality-oriented perspective.

Conclusion

Our research results indicate that the conscientiousness dimensions of the Big Five personality may influence the occurrence of TNs. Sleep quality can significantly predict the occurrence of TNs and may mask the relationship between conscientiousness and the occurrence of TNs in individuals under 45 years old. These findings provide novel insights for the prevention and healthcare of TNs. In daily life, individuals should maintain a balanced and optimistic attitude, avoid excessive self-discipline that may lead to greater psychological pressure, prioritize health sleep patterns, and foster positive emotional experiences, all these will help lower the risk of TNs. In order to verify and establish the causal relationship between conscientiousness, sleep quality and the occurrence of TNs, a prospective cohort study needs to be conducted in the future. Secondly, it is necessary to evaluate whether targeted psychological therapies or sleep intervention measures can effectively lower the risk of TNs. By carrying out these studies, we can further optimize preventive strategies for TNs and improve the prognosis of high-risk populations.

Data availability

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

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Author contributions

Conceptualization – H.Z., C.Z., S.W., G.J., H.D.; Design – H.Z., G.J., H.D.; Supervision – H.D.; Materials – H.Z., C.Z., S.W., G.J.; Data collection and/or processing - H.Z., C.Z., S.W.; Analysis and/or Interpretation – H.Z., C.Z.; Literature Search Design – H.Z., G.J., H.D.; Writing– H.Z., C.Z., S.W.; Critical Review Design – G.J., H.D.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval consent to participate

This study was approved by the Ethics Committee of Jinzhou Medical University (JZMULL2025108). This study was in compliance with the Helsinki Declaration. Written informed consent was obtained from all the participants.

Additional information

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