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Thyroid Volume Predicts Body Mass Index 2 and 6 Years Later

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Abstract

Background: Thyroid volume correlates positively with body mass index (BMI). This correlation holds true for both iodine-sufficient and mild/moderate iodine-deficient areas. We examined the association between thyroid volume and BMI and change in BMI over 4 years in middle-age adults recruited from the general population.

Methods: A total of 2,495 subjects, for whom thyroid volume, FT4 and TSH were available (women aged 35 - 60 years and men aged 45 - 60 years), were derived from the Supplementation en Vitamines et Mineraux Antioxydants (SU.VI. MAX) cohort study conducted in France since baseline (1994). Weight and height were measured 2 and 6 years after inclusion. Linear univariate and multiple regression analyses were performed to evaluate correlations between thyroid volume and BMI at 2 and 6 years and BMI change from year 2 to 6.

Results: Baseline thyroid volume was positively correlated with BMI at 2 years (men: $\beta = 0.09$, $P < 0.01$; women: $\beta = 0.09$, $P < 0.01$) and 6 years after inclusion (men: $\beta = 0.10$, $P < 0.01$; women: $\beta = 0.09$, $P < 0.01$). The correlation between thyroid volume and BMI at 2 and 6 years remained significant after adjusting for free T4, TSH, gender, age, smoking, alcohol consumption and TSH-thyroid volume interaction factor ($\beta = 0.11$, $P < 0.01$). Baseline thyroid volume was not correlated with BMI change from year 2 to 6 in linear regression analysis.

Conclusions: In French adults, thyroid volume predicted BMI at 2 and 6 years. Further studies are needed to explore the association between thyroid volume and BMI.

Keywords: Body mass index; Thyroid volume; Weight change; Population study

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Introduction

Observational epidemiological studies have reported a positive correlation between thyroid volume and body weight [1], body mass index (BMI) [2, 3], body surface area [2] and lean body mass [4]. These correlations are observed in both iodine-sufficient and mild/moderate iodine-deficient areas [1, 3, 5]. However, studies are cross-sectional and cannot define causality. To date, there have been no studies that have examined the association between thyroid volume and BMI a number of years later.

We examined the correlation between thyroid volume and BMI 2 and 6 years later in a group of middle-age adults participating to the Supplementation en Vitamines et Mineraux Antioxydants (SU.VI.MAX) French cohort.

Materials and Methods

Subjects

We undertook an analysis of data collected in the SU.VI.MAX study. This study was conducted in France. Subjects were participants of the SU.VI.MAX study, initially designed as a randomized, double-blind, placebo-controlled, primary prevention trial to test the potential efficacy of daily supplementation with antioxidant vitamins and minerals at nutritional doses (ascorbic acid, vitamin E, beta-carotene, selenium and zinc) on the risk of cancer, ischemic heart diseases and total mortality. The design and rationale of the SU.VI.MAX study (Supplementation en Vitamines et Mineraux Antioxydants) have been extensively detailed previ-

Table 1. Characteristics of SU.VI.MAX Cohort

Variables	Men n = 1,001		Women n = 1,494	
	Mean ± SD	n	Mean ± SD	n
Thyroid volume (mL)	14.3 ± 5.5	1,001	9.6 ± 3.7	1,494
TSH (mU/L)	1.7 ± 1.0	1,001	2.2 ± 1.5	1,494
Free T4 (pmol/L)	13.7 ± 1.9	1,001	14.0 ± 1.9	1,494
Weight 2 years after inclusion (kg)	76.3 ± 10.1	1,001	59.8 ± 9.4	1,494
Weight 6 years after inclusion (kg)	78.3 ± 10.6	1,001	61.8 ± 10.2	1,494
Weight change (kg)	2.0 ± 5.1	1,001	2.1 ± 5.6	1,494
BMI 2 years after inclusion (kg/m^2)	25.3 ± 2.9	1,001	22.8 ± 3.3	1,494
BMI 6 years after inclusion (kg/m^2)	26.0 ± 3.1	1,001	23.6 ± 3.6	1,494
BMI change (kg/m^2)	0.7 ± 1.7	1,001	0.8 ± 2.2	1,494
Alcohol Consumption (%)	76.4	994	51.7	1,490
Tobacco Consumption (%)	52.0	965	28.6	1,448

ously [6]. Eligible subjects, 7,713 women aged 35 - 60 years and 5,028 men aged 45 - 60 years at baseline, were included in 1994 - 1995 and followed up for 7.5 y [7]. During the follow-up, all participants underwent an annual visit, with alternating blood sampling (at baseline) or clinical examination (1995 - 1996), every other year. They also provided information regarding health, diet, drugs and various lifestyle indicators. On a subsample of 3,523 subjects, thyroid volume was assessed at baseline, through the use of a mobile unit ('ThyroMobil van'), equipped with an ultrasound machine. We analysed the relationship between thyroid volume and weight and BMI at 2 and 6 years. Twenty-one percent of male subjects and 13% of female subjects did not have weight measurement 2 and 6 years after inclusion. Thus, 1,001 men and 1,494 women completed weight and height measurement 2 and 6 years after inclusion.

Several exclusion criteria were applied: goitre, signs of previous or current thyroid disease, treatment with thyroid hormones, antithyroid drugs and lithium treatment. Twenty subjects with urinary iodine concentration ≥ 60 µg/100 mL were eliminated, as was one subject with thiocyanate overload (urinary thiocyanate concentration ≥ 50 mg/L). The final study group consisted of 1,274 men and 1,713 women.

The SU.VI.MAX study was approved by the Ethical Committee for Studies with Human Subjects of the Paris-Cochin Hospital (CCPPRB No. 706) and the "Commission Nationale Informatique et Liberté" (CNIL No. 334641), which ensures that medical information be kept confidential and anonymous.

Thyroid volume

Thyroid volume was estimated using a high frequency 7.5 MHz linear array transducer (Sonoline SI-400, Siemens, Erlangen, Germany). The examination was performed with the patient in a supine position with the neck hyperextended. The isthmus was not taken into account in volume calculation. Nodules and/or cystic areas were included in volume determination. All ultrasonographic examinations were performed and interpreted by the same radiologist.

Anthropometry

Weight was measured 2 and 6 years after inclusion with an electronic scale (Seca, Germany) with subjects in indoor clothing and no shoes. Height was measured with a wall-mounted stadiometer with no shoes to the nearest 0.5 cm. BMI was calculated as weight divided by height squared (kg/m^2).

Statistical analysis

Men and women were evaluated separately. The relationship between baseline thyroid volume and BMI at 2 and 6 years was estimated by linear univariate analysis. Multiple linear regression was used to adjust for potential confounders in-

Table 2. Linear Regression Analysis of BMI 2 and 6 Years After Inclusion With Baseline Characteristics (n = 2,413)

2 years	Men		Women	
	Beta	**P value**	**Beta**	**P value**
Age (yr)	0.05	0.02	0.12	< 0.001
TSH (mU/L)	0.05	0.55	0.09	0.12
Free T4 (pmol/L)	-0.08	0.09	0.01	0.77
Thyroid volume (mL)	0.09	< 0.001	0.09	< 0.001
Alcohol consumption (%)	0.42	0.06	0.10	0.54
Tobacco consumption (%)	0.38	0.04	0.30	0.12
6 years				
Age (yr)	0.04	0.05	0.10	< 0.001
TSH (mU/L)	0.001	0.99	-0.02	0.73
Free T4 (pmol/L)	-0.07	0.17	0.004	0.94
Thyroid volume (mL)	0.10	< 0.001	0.09	< 0.001
Alcohol consumption (%)	0.08	0.74	0.21	0.26
Tobacco consumption (%)	0.44	0.03	0.36	0.09

cluding age, TSH, free T4, alcohol and tobacco consumption to consolidate the relationship between baseline thyroid volume and BMI at 2 and 6 years. Data were analysed using 'version 9.1' SAS statistical software (SAS Institute, Cary, USA).

Results

Baseline thyroid volume, TSH, free T4 (fT4) and BMI 2 and 6 years after inclusion are shown in Table 1. Mean BMI 2 years after inclusion was 25.3 ± 2.9 kg/m^2 in men and 22.8 ± 3.3 kg/m^2 in women; mean BMI 6 years after inclusion was 26.0 ± 3.1 kg/m^2 in men and 23.6 ± 3.6 kg/m^2 in women. The mean weight change between the 2nd and 6th years was 2 ± 5.4 kg. Mean thyroid volume at inclusion was 11.5 ± 5 mL. The median thyroid volume was 13.2 mL in men and 9.1 mL in women.

Baseline thyroid volume was positively correlated with BMI 2 years (men: $\beta = 0.09$, $P < 0.01$; women: $\beta = 0.09$, $P < 0.01$) and 6 years (men: $\beta = 0.01$, $P < 0.01$; women: $\beta = 0.09$, $P < 0.01$) after inclusion (Table 2). In the total cohort, correlations between baseline thyroid volume and BMI at 2 and 6 years remained significant after adjusting for gender, age, TSH, fT4, smoking and alcohol consumption (BMI 2 years: $\beta = 0.11$, $P < 0.01$; BMI 6 years: $\beta = 0.11$, $P < 0.01$).

Baseline TSH was negatively correlated with weight change ($\beta = -0.25$, $P < 0.01$), but not thyroid volume ($P = 0.77$) or free T4 ($P = 0.96$). The correlation between TSH and weight change was eliminated after adjusting for other variables including gender, free T4, alcohol/tobacco consumption (men: $P = 0.84$, women: $P = 0.88$).

Discussion

Our study demonstrates that thyroid volume is positively correlated with BMI at 2 and 6 years, even after adjusting for other variables, such as fT4, TSH, gender and age. This is the first study to examine the correlation between thyroid volume and BMI 2 and 6 years later. Previous studies have

Table 3. Literature Review of Correlation Between Thyroid Volume and Body Weight or BMI

First author, year	Sample Size	Country	Gender	Age (yr)	Subjects with thyroid disease	Iodine status	BMI/Weight	Results
Hegedus, 1983 [1]	271	Denmark	Both	16 - 91	Excluded	Borderline iodine-deficient	Weight	$\beta = 0.21$, $P < 0.001$
Berghout, 1987 [10]	50	Netherland	Males	20 - 70	Excluded	Iodine-replete	Weight	$r = 0.34$, $P = 0.05$
Barrere, 2000 [2]	2987	France	Both	Women (35 - 60) men (45 - 60)	Excluded	Borderline iodine-deficient	BMI	Males $\beta = 0.02$ ($P = 0.0001$) females $\beta = 0.007$ ($P = 0.005$)
Gomez, 2000 [3]	268	Spain	Both	15 - 70	Excluded	Iodine-replete	BMI and weight	BMI ($r = 0.13$, $P = 0.02$) Weight ($r = 0.39$, $P = 0.0001$)
Semiz, 2001 [5]	605	Turkey	Both	6 - 11	Not available	Mild-moderate iodine-deficient	BMI and weight	BMI ($r = 0.13$, $P < 0.001$) Weight ($r = 0.3$, $P < 0.001$)
Sari, 2003 [8]	129	Turkey	Females	40.5 ± 11.4 38.6 ± 12.9[a]	Excluded	Mild-moderate iodine-deficient	BMI and weight	BMI ($r = 0.50$, $P < 0.001$) Weight ($r = 0.32$, $P = 0.002$)
Hansen, 2004 [11]	520	Denmark twins	Both	33.7 ± 11.7 36.4 ± 11.5 33.7 ± 11[b]	Excluded	Borderline iodine-deficient	BMI	Males ($r = 0.03$, $P = 0.003$) females ($r = 0.02$, $P < 0.001$)
Boyanov, 2004 [12]	212	Bulgaria	Both	11 - 15	All euthyroid	Iodine-replete	BMI and weight	BMI (males $r = 0.26$, females $r = 0.16$) Weight (males $r = 0.35$, females $r = 0.43$) All: $P < 0.05$
Kaloumenou, 2007 [13]	440	Greece	Males	5 - 18	Not available	Iodine-replete	BMI	$r = 0.17$, $P = 0.023$

[a]Mean age in obese/non-obese group; [b]Mean age in monozygotic twins/dizygotic twins/opposite sex twins.

evaluated the association between thyroid volume and BMI or body weight at one point in time (Table 3). These studies have all demonstrated a positive correlation between thyroid volume and BMI/body weight.

Our study did not show any significant correlation between baseline thyroid volume and weight change between 2 and 6 years. Although TSH correlated negatively with weight change, this correlation became insignificant after adjusting for other confounders. The lack of marked weight change over 4 years may undermine any possible significant correlation between thyroid volume and weight change. Other explanations could be due to the low heterogeneity in the study population and a short follow-up period between measurements. Two studies have examined the effect of weight loss on thyroid volume changes. Sari [8] examined intentional weight loss over 6 months using sibutramine 15 mg/day and/or orlistat 360 mg/day and its effect on thyroid volume. Wesche [9] evaluated correlation between 6 months of intensive rowing training and thyroid volume in lean subjects. Both studies achieved significant weight loss (> 10% of body weight and mean weight loss of 2.5 kg respectively) and demonstrated a positive correlation between weight loss and reduction in thyroid volume.

Our study had some limitations. Firstly, thyroid volume was only measured at baseline. Secondly, as this was an observational study, we cannot draw causal inferences regarding to the association between thyroid volume and BMI. Therefore, there may be potential confounders that contribute to BMI other than baseline thyroid volume.

In summary, our study shows that baseline thyroid volume predicts BMI 2 and 6 years later. Further studies are needed to explore the association between thyroid volume, and BMI.

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Conflict of Interest

All authors declare no conflict of interest.

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