

# Is there a correlation between body mass index and thyroid stimulating hormone?

## Abstract

**Background:** It is believed that overt hyperthyroidism is associated with weight loss and hypothyroidism is associated with weight gain. Studies have shown that there is inter individual variations of thyroid function in persons with thyroid hormone levels within the normal physiological range. A clear epidemiological relation between thyroid hormone status and weight gain and obesity has not been established.

**Objectives:** The study was conducted to determine any correlation between thyroid hormone function indicated by thyroid stimulating factor (TSH) and body mass index (BMI).

**Methods:** This is cross-sectional study of 316 individuals (26 male and 292 female) out of which 22 individuals had subclinical hypothyroidism (SCH), 208 individuals had hypothyroidism and 88 individuals were euthyroid. TSH was estimated by Chemiluminescence immune assay. Anthropometric parameters were measured for all participants and comparisons were done according to gender and thyroid hormone status.

**Results:** median TSH level was 5.1mIU for total population, 11.29mIU in hypothyroid group, 6.86mIU in subclinical hypothyroid group and 2.60mIU in euthyroid group. Median BMI was 25.6kg/m<sup>2</sup> for total population, 25.5kg/m<sup>2</sup> for hypothyroid group, 26.2kg/m<sup>2</sup> for subclinical hypothyroid group and 25.6kg/m<sup>2</sup> for euthyroid group. Median waist circumference was 88.5cm for total population, 88.7cm for hypothyroid group, 88cm for subclinical hypothyroid group and 88cm for euthyroid group. R<sup>2</sup> for TSH and BMI for hypothyroid group was 0.0003, for subclinical hypothyroid group was 0.010 and for euthyroid group was 0.006 with p value being 0.80, 0.65 and 0.45 respectively. R<sup>2</sup> for TSH and waist circumference for hypothyroid group was 0.0051, for subclinical hypothyroid was 0.0002 and for euthyroid was 0.052 with p value being 0.30, 0.93 and 0.03 respectively.

**Conclusion:** There is no correlation between TSH and BMI. Further studies involving large number of subjects are needed to confirm the findings.

**Keywords:** body mass index, thyroid, hormone, TSH, BMI, hyperthyroidism, epidemiological, obesity

Volume 7 Issue 5 - 2019

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**Received:** October 09, 2019 | **Published:** October 31, 2019

## Introduction

According to popular belief overt hyperthyroidism is associated with weight loss<sup>1</sup> and hypothyroidism is associated with weight gain.<sup>2</sup> Inter individual variations of thyroid function occur in persons with thyroid hormone levels within the normal physiological range.<sup>3</sup> Even in individuals with normal thyroid function, recent data has led to the view that an increase in body weight can be due to varied thyroid functions.<sup>4,5</sup> The Danish Thyroid Study found a positive association between BMI and category of serum TSH and a negative association was found between BMI and category of serum free T<sub>4</sub>.<sup>6</sup> Another cross-sectional study it was found that obese euthyroid women had lower T<sub>4</sub> levels than did lean euthyroid women.<sup>7</sup> Other studies showed that serum TSH levels and the grade of obesity had a positive correlation in overweight individuals with a normal thyroid function.<sup>8</sup>

A statistically significant positive correlation was found between BMI and thyroid function in women, while in men the correlation was not so.<sup>9</sup> A community based survey suggested that a positive association exists between TSH and BMI in euthyroid non-smokers.<sup>10</sup> In healthy adults mean TSH showed an increasing trend with increasing BMI and there was a significant relationship between TSH

and increasing BMI.<sup>11</sup> In contrast to the above some studies have shown no significant relation between body weight or BMI and thyroid function. Beiler et al<sup>12</sup> concluded that a correlation between BMI and TSH doesn't exist in neither euthyroid nor hypothyroid individuals. Figueroa et al<sup>13</sup> stated that there is no association between thyroid hormone function and obesity and weight gain. Neither T<sub>4</sub> nor TSH had any correlation with BMI<sup>14,15</sup> Keeping the above facts in mind it is evident that a clear epidemiological association between thyroid function and body weight has not been established. The purpose of this study is to determine any correlation between thyroid hormone function indicated by TSH and BMI in hypothyroid and subclinical hypothyroid individuals with or without levothyroxine therapy and compare it with euthyroid individuals.

The study was conducted with the following objectives:

- To determine any correlation between thyroid hormone function indicated by Thyroid Stimulating Hormone and Body Mass Index
- To compare BMI in hypothyroid individuals with or without levothyroxine therapy and euthyroid individuals with the respective Thyroid Stimulating Hormone levels.

## Materials and methods

The study was a cross sectional study conducted in The Department of General Medicine, RIMS, Imphal for 2 years starting from September 2016 to August 2018 with a study population that included euthyroid, hypothyroid or patients with subclinical hypothyroidism irrespective of their treatment status.

Inclusion criteria:

- I. Age – 18 to 65years
- II. Euthyroid individuals as control
- III. Documented or newly diagnosed hypothyroidism (irrespective of treatment status)
- IV. Documented or newly diagnosed subclinical hypothyroidism.

Exclusion criteria:

- i. Any endocrine disorder other than diabetes with controlled blood glucose for at least 3months and hypothyroidism
- ii. Hyperthyroidism
- iii. Pregnant women
- iv. Significant renal, liver or heart disease
- v. Taking medications that can disrupt thyroid hormone function

Written informed consent was obtained from all the study subjects, prior to the testing of thyroid hormones profile. The subjects underwent a detailed history taking, general physical examination, anthropometric measurements (height, weight, body mass index, waist circumference) and systemic examination. Relevant laboratory investigations were done.

### Sample size

For calculating sample size we utilized correlation value of  $r=0.20$  based on a previous study.<sup>14</sup> A sample size of 194 was calculated based on the above correlation at 5% significance level with 80% power. The study was conducted on 318 individuals. The sample size is calculated with the help of an online calculator device owned by University of California and San Francisco (<http://www.sample-size.net/correlation-sample-size/>).

### Working definitions

Hypothyroidism is defined as low T4 and T3 level with an increased TSH level.

Euthyroid patients is defined as individuals having normal T4, T3 and TSH

Diabetes mellitus is defined as having a diagnosis of diabetes listed

in medical history or blood fasting blood glucose levels  $\geq 126\text{mg}\%$  and post prandial blood glucose  $\geq 200\text{mg}\%$ .

For diagnosis of hypothyroidism elevated TSH with low T4 was used.<sup>17</sup>

Elevated TSH with normal T4 was taken as subclinical hypothyroidism.

### Procedures

The study was conducted after clearance from the Institute's Ethics Committee. Participants were explained about the purpose and procedure of the study. With the participants consent height, weight and waist circumference were measured and blood samples were taken for measurement of serum TSH level. Test was carried out by Chemilluminescence immune assay kit using vitros<sup>R</sup> ECiQ immunodiagnostic system, Ortho Clinical Diagnostics. Reference range for TSH is 0.465-4.68mIU/L. BMI calculated according to the formula:  $\text{Weight(Kg)}/\text{Height(m)}^2$

### Statistical analysis

The data obtained from the participants were expressed as median and range and comparison of median between the different groups was done using simple linear regression equation and one way analysis of variance. Microsoft excel 2016 was used for analysis of the collected data. A p value of less than 0.05 was considered significant.

### Results

This study included a total of 318 individuals (26male and 292female) out of which 22 individuals had subclinical hypothyroidism (SCH), 208 individuals had hypothyroidism and 88 individuals were euthyroid. Female preponderance was seen as 292 out of 318(91.823%) participants were female. Median TSH level was 5.1mIU for total population, 11.29mIU in hypothyroid group, 6.86mIU in subclinical hypothyroid group and 2.60mIU in euthyroid group. Median BMI was 25.6 kg/m<sup>2</sup> for total population, 25.5kg/m<sup>2</sup> for hypothyroid group, 26.2kg/m<sup>2</sup> for subclinical hypothyroid group and 25.6kg/m<sup>2</sup> for euthyroid group. Median waist circumference was 88.5cm for total population, 88.7cm for hypothyroid group, 88cm for subclinical hypothyroid group and 88cm for euthyroid group as shown in Table 1. R<sup>2</sup> for TSH and BMI for hypothyroid group were 0.0003, for subclinical hypothyroid group were 0.010 and for euthyroid group were 0.006 with p value being 0.80, 0.65 and 0.45 respectively (Table 2). R<sup>2</sup> for TSH and waist circumference for hypothyroid group was 0.0051, for subclinical hypothyroid was 0.0002 and for euthyroid was 0.052 with p value being 0.30, 0.93 and 0.03 respectively as shown in Table 3. The above data showed that there is no significant correlation between TSH with BMI or waist circumference in hypothyroid, euthyroid or subclinical hypothyroid individuals.

**Table 1** Anthropometric parameters and TSH according to thyroid status

Parameters	Total	Hypothyroid	Subclinical	Euthyroid
Median (Range)	(n=318)	(n=208)	(n=22)	(n=88)
Age (in years)	36(17-65)	37(17-65)	36(21-63)	36(18 – 65)
Weight (in kg)	60(37- 98)	60(37-95)	62.5(42-90)	60(44 – 98)
BMI (kg/m <sup>2</sup> )	25.6(17.7-37.1)	25.5(17.7-37.1)	26.2(21.4-35.7)	25.6(19.0 –37.0)
WC (cm)	88.5(60-164)	88.7(62-163)	88(60-107)	88(60-164)
TSH (mIU/L)	5.1(0.01-321.2)	11.29(0.01-321.2)	6.86(4.6-9)	2.60(0.43–4.5)

BMI – body mass index;WC – waist circumference;TSH – thyroid stimulating hormone

**Table 2** Coefficient of variation between different groups of thyroid status and BMI

	Hypothyroid	Subclinical	Euthyroid
R <sup>2</sup>	0.0003	0.01	0.006
P value	0.8	0.65	0.45

**Table 3** Coefficient of variation between different groups of thyroid status and waist circumference

	Total	Hypothyroid	Subclinical	Euthyroid
R <sup>2</sup>	0.0035	0.0051	0.0002	0.052
P value	0.28	0.303	0.939	0.03

## Discussion

The aim of this study was to determine any correlation between thyroid hormone function and body mass index. Our study included 318 individuals, 22 with subclinical hypothyroidism, 208 with hypothyroidism and 88 with euthyroid status. There was a clear female preponderance in all the three groups of patients with female constituting 292 out of 318 (91.82%) individuals who participated. Similar to study conducted by Meng et al.<sup>19</sup> females had a higher incidence of thyroid dysfunction than males along with a higher BMI. Similar to a study conducted by Anderson et al.<sup>3</sup> we found a wide variation in the TSH value in healthy euthyroid subjects. Our patients were divided into three groups according to their thyroid hormone status after fulfilling all the inclusion criteria namely hypothyroid group, subclinical hypothyroid group and euthyroid group. The median age, weight and BMI were comparable in all the three groups. This is contradictory to the study conducted by Michalaki et al.<sup>20</sup> in which they concluded that prevalence of overt and subclinical hypothyroidism was higher in obese subjects. From this we can infer that although there is a significant difference between the TSH values in the 3 groups, the difference between the weight and BMI is insignificant. These findings were similar to a studies conducted by Bieler et al.<sup>17</sup> and Figueroa et al.<sup>16</sup> in which they concluded that there was no significant relationship between BMI and TSH of neither hypothyroid nor euthyroid individuals and no association between thyroid hormone status and obesity or weight gain. Similar findings were also noted by Akshoy et al.<sup>21</sup> in a study of BMI in euthyroid and subclinical hypothyroid individuals where they found no difference in the BMI between the two groups. Manji et al.<sup>22</sup> also stated that there is no difference between TSH/fT<sub>4</sub> in obese and lean subjects.

Nakamura et al.<sup>23</sup> concluded that there was no correlation between percentage body fat and serum leptin (which is increased in hypothyroid individuals) in euthyroid and hyperthyroid individuals. Bjerved et al.<sup>11</sup> suggested that TSH levels are not a determinant of future weight changes and BMI is not a determinant of TSH changes. Similar to this study our results also suggest that there might not be any benefit with regard to body weight in keeping TSH in the lower half of the normal range. On plotting our findings on a scatter diagram by taking TSH as independent variable and BMI as dependent variable and applying simple linear regression equation we found no correlation between TSH and BMI in all the three groups in both males and females which is contrary to what was suggested by Asvold et al.<sup>13</sup> and Sakurai et al.<sup>24</sup> There are several studies that indicate that weight gain is associated with increase in TSH.<sup>4-10</sup> In a retrospective study conducted by Bastemir M et al.,<sup>8</sup> on 226 euthyroid obese or overweight females they found that serum TSH were higher in the obese than in the lean individuals, but it is not clear whether the reverse is true.

While some other studies have suggested that TSH and BMI have a significant association within the normal TSH range<sup>4,13</sup> our study which also include healthy individuals with normal TSH did not show any such association and in fact there was no significant difference between the BMI of the 3 study population. As opposed to a study which concluded that hypothyroidism is associated with an increase in BMI and serum leptin levels,<sup>25</sup> we did not find a significant difference between the BMI in hypothyroid, euthyroid and subclinical hypothyroid individuals. We also noticed that although the incidence of thyroid hormone disorders are more in females than in males there was no correlation between TSH and BMI in both males and females irrespective of their thyroid hormone status. This finding is contradictory to a study conducted by Millionis et al.<sup>9</sup> in which correlation between BMI and thyroid function was statistically significant in women and another study conducted by Pergola et al.<sup>26</sup> where they suggested a relation between body weight, waist circumference and thyroid hormone function. Although there is well known association between energy expenditure, thermogenesis and thyroid function<sup>27</sup> and lower serum T3 is associated with decreased resting metabolic rate,<sup>28</sup> the possible role of diet and lifestyle were not assessed. We also measured waist circumference in all the subjects and we noticed that the median and range of waist circumference were similar in the three groups. There was no correlation between TSH and waist circumference in all the three groups in our study irrespective of their thyroid hormone status. This finding is similar to a study conducted by Kitahara et al.<sup>15</sup> in which they concluded that there is no significant interaction between BMI or waist circumference with TSH, fT<sub>3</sub> and fT<sub>4</sub>. Measurement of fT<sub>3</sub> and fT<sub>4</sub> and comparing it with waist circumference would perhaps confirm this finding. Our results contradict the arguments for a causal relationship between TSH and BMI. Further prospective analysis where follow up data is available may help to confirm or refute our findings.

The strengths of this study include a reasonably large sample size that includes euthyroid controls, subclinical and hypothyroid patients. We excluded patients with hyperthyroidism and those with diseases or disorders or on drugs that may have any impact on weight and BMI. Diabetic patients with poor blood sugar control were also excluded and those whose blood glucose was controlled for atleast 3months were included. We also excluded individuals who are in the extreme age groups as old age itself can lead to weight gain and increase in BMI due to reduced resting metabolic rate.<sup>29</sup> Our study also has major weaknesses. Firstly, the observational design of the study with no follow up data available. Secondly, although T<sub>4</sub> was measured for diagnosis of thyroid disorder with TSH, free T<sub>3</sub> and free T<sub>4</sub> were not measured, which could have added additional information on the subject's thyroid hormone status. Thirdly, lifestyle, dietary habits and exercise were not considered which could act as independent confounding factor and which could play a major role in TSH receptor expression in abdominal adipose tissue<sup>30,31</sup>

## Conclusion

We conclude that there is no association between thyroid stimulating hormone and body mass index. And that there is unlikely to be any benefit in maintaining TSH in the lower half of the normal range with regard to weight loss. Other options like dietary changes, lifestyle modification and exercise should be advised instead.

## Acknowledgments

None.

## Conflicts of interest

The authors declare that there is no conflict of interest.

## Funding

None.

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