A total of 103 eu-thyroid female subjects (i.e TSH level within 0.4 µIU/ml to 3µIU/ml) (9) who fulfilled the study criteria were included in the study. Body Mass Index and Body fat percent were measured in these subjects. Body Mass Index was estimated by Metric method. (10) The standing height of the subjects was measured with the same stadiometer, without footwear; to the nearest centimeter. Weight was measured, which was the nearest to 0.1 kg, with the subjects in the standing position, before lunch, with light clothes and without footwear, by using a standardized weighing scale [11].Depending on their BMI values, the subjects were classified into three groups. The subjects with a BMI value of less than 23 was be classified as normal weight, subjects with a BMI value between 23 to 24.99 [Kg/M2] was classified as the overweight group and those who have a BMI value more than 25 [Kg/M2] was classified as obese [12]

Harpenden Skin fold Caliper was used to measure percent of body fat. The four site system was used in female subjects. Site 1-Biceps, Site 2- Triceps, Site 3- Sub-scapular, Site 4- Supra-iliac. To calculate % Body fat linear regression equations of Durnin and Wormersley was used. (11). Body Density= C [M (log10 Sum of all four skin folds)]

MALE	17-19 YRS	20-29 YRS	30-39YRS	40-49 YRS	50+ YRS
C	1.1620	11631	1.1422	1.1620	1.1715
M	0.0630	0.0632	0.0544	0.0700	0.0779

FEMALE	16-19 YRS	20-29 YRS	30-39YRS	40-49 YRS	50+ YRS
C	1.1549	1.1599	1.1423	1.1333	1.1339
M	0.0678	0.0717	0.0632	0.0612	0.0645

Fat %= [(4.95/Body Density)-4.5]*100

Serum TSH was estimated by Enzyme-linked-immuno-sorbant assay (ELISA). Five ml of cord blood samples were collected from the peripheral veins in sterile test tubes. The serum separated by centrifugation was used for quantitative estimation of TSH, Total T3, Total T4 by a micro plate immuno-enzymatic assay. (Ranbaxy) The intra and inter-assay coefficient of variation (CV) for TSH estimation were 4.33% and 7.5% respectively and the sensitivity limit was 0.078 µ IU/ml. That for total T3 was 5.73% and 6.7% respectively with the sensitivity limit 0.04 ng/ml and total T4 were 4.7% and 5.4% respectively with the sensitivity limit 0.4 µg/dl.

The collected data was analyzed with SPSS (version 18) statistical package using Pearson's correlation test. The study population were further subdivided into three groups Normal weight (BMI<23 kg/m^2), Over-weight (BMI 23.00-24.99 kg/m^2) and obese (BMI>25 kg/m^2) in accordance with their BMI. Analysis of Variance (ANOVA) Test among the above three groups was done to see the changes of TSH level with increasing body mass index.

3. Result and Analysis

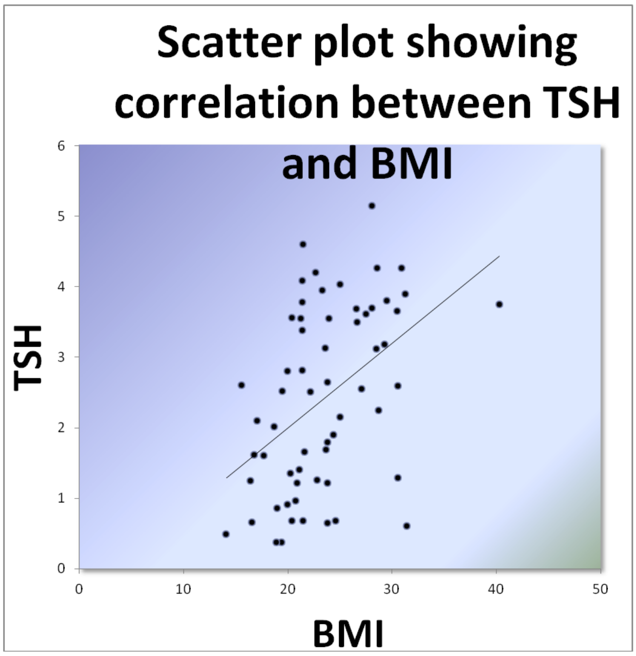
A total of 103 eu-thyroid female subjects were included in the study. Their mean age was 56 years (Range 30-82).A positive linear correlation was observed between BMI and serum TSH in eu-thyroid female subjects (95% CI, p <.002, r=0.342) (Table 1). Body fat percentage and serum TSH level of eu-thyroid female subjects were also been found to have strong positive linear correlation (95% CI, p <.000, r=0.851) (Table 1). Figure 1 and 2 depict the linear association between BMI-TSH and Body fat percentage-TSH respectively. There are significant inter-group variations among BMI and serum TSH concentration (Table 2). Figure 3 depicts the gradual increase in serum TSH values among three BMI groups i.e normal weight, over-weight and obese.

Table 1: The association between BMI, Body Fat Percent and serum TSH in eu-thyroid female subjects

BMI (kg/M^2)	N	TSH(µ IU/ml) Mean± S.D	Calculated F ratio	Significance
<23 (normal weight)	79	1.99±1.49	6.176	0.003**
23.00-24.99 (over-weight)	8	3.30±2.78		
>25.00 (obese)	16	3.28±2.29		

Table 2: Serum TSH concentration in Normal weight, Over-weight and Obese eu-thyroid females

		BMI(kg/M^2)	% Body Fat
TSH (µ IU/ml)	Pearson Correlation (r)	0.342***	0.628***
	Sig. (2 tailed)	<0.002	0.000
	N	103	103



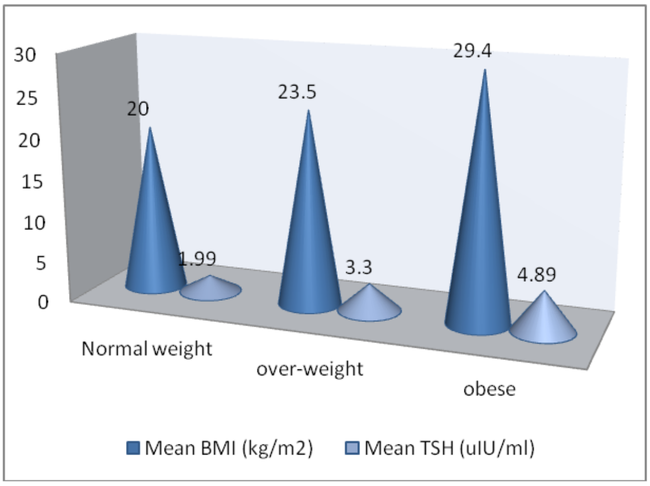


Figure 1 & 2: Scatter plots showing linear relationship between TSH-BMI and TSH-Body fat percentage

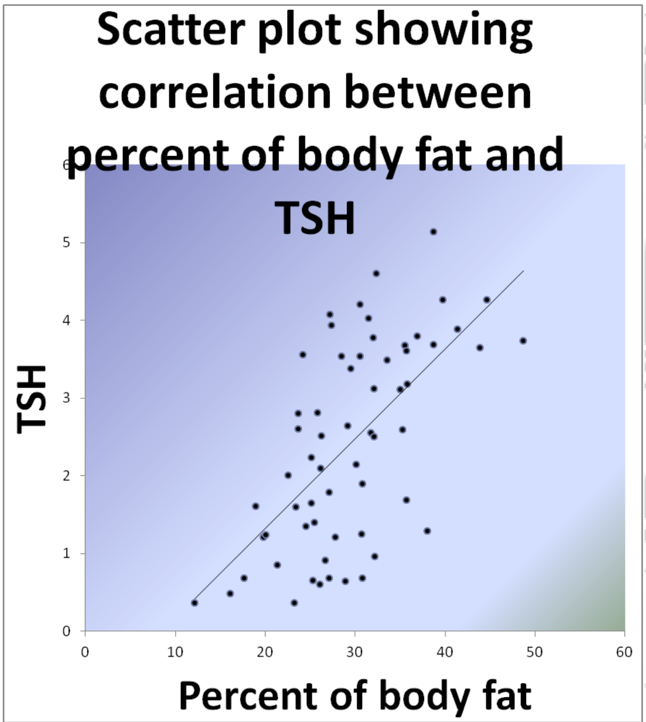


Figure 3: Serum TSH values in normal weight, over-weight and obese eu-thyroid females

4. Discussion

In the present study, we have found that although in the normal range, serum TSH is positively associated with BMI and body fat percent in eu-thyroid female subjects. Furthermore, there are significant inter-group variations among BMI and TSH concentration. Serum TSH values gradually increases among three BMI groups i.e normal weight, over-weight and obese. As TSH and BMI could both be affected by a third factor, which according to our observation may be age, we included age as an independent variable in multiple regression analysis. We found the association between age and BMI above the age 50, in which age group BMI starts falling with age in male and remains unaffected in female. Hence age is unlikely to be the cause of association between TSH and BMI.

There are agreements for a causal relationship between TSH and BMI in few previous studies. Our observation is in accordance with those of A Nymes et al who found serum TSH is positively associated with BMI especially among non-smokers. Mehmet Bastemir et al also found a positive association of BMI with serum TSH level, independent of thyroid function. Although one study report by S. Yardemei et al found alteration in serum T3, T4 and TSH level in normal ranges did not affect the body fat percentage, fat distribution and lean body mass in elderly women.

Although physiologically elevated TSH is likely to be associated with decreased lipid stores and increased lipolysis in adipose tissue but the contradictory evidence of serum TSH levels, positively correlated with BMI can be explained by leptin. Free T4 at lower limit of normal range and elevated serum TSH although in a normal range is seen in sub-clinical hypothyroidism. This may cause alteration of energy expenditure with subsequent rise in BMI and body weight. This increased fat mass may increase leptin. And it is already known that leptin is an important neuro-endocrine regulator of the Hypothalamo-Pituitary- Thyroid axis () by regulation of TRH gene expression in para-ventricular nucleus. Hence it further rises TSH.

The present study has few limitations. Ours is cross-sectional study and we have not measured free T4 and free T3 level. A longitudinal study with more sample size is required to see the hormonal pattern and concentration of leptin in same patient with progressive weight loss or gain.

In conclusion, this study shows a positive and significant association between serum TSH within normal range and BM. Furthermore, there are significant inter-group variations among BMI and TSH concentration. Serum TSH values gradually increases among three BMI groups i.e. normal weight, over-weight and obese. Future research work with more sample size is necessary to see the impact of body fat and body fat distribution on the alternate of thyroid function.

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Author Profile

Dr.Sanhita Mukherjee, Associate Professor, Physiology, B.S.Medical College, Bankura

Dr. Diptakanti Mukhopadhyay, Associate Professor, Community Medicine, COMSDH, Kolkata

Dr. Phalguni Chakraborty, Assistant Professor, Biochemistry, B.S.Medical College, Bankura