International Journal of Medical and Health Research
ISSN: 2454-9142
Received: 28-10-2019; Accepted: 29-11-2019
www.medicalsciencejournal.com
Volume 5; Issue 12; December 2019; Page No. 128-133

Association of the thyroid stimulating hormone level and its relation to body weight in patients from Bihar region

Dr. Pawan Prakash[1], Dr. Madan Prakash[2*], Dr. Surendra Kumar[3]
[1, 2] Junior Resident, Department of General Medicine, Patna Medical College and Hospital, Patna, Bihar, India
[3] Associate Professor Department of General Medicine, (Endocrinology) Patna Medical College and Hospital, Patna, Bihar, India
[*] Corresponding Author: Dr. Madan Prakash

Abstract
The thyroid hormones are important for regulating weight. It is well known that hypothyroidism (an underactive thyroid gland) can lead to slower metabolism, weight gain and a higher body-mass index. Subclinical hypothyroidism (SCH) is one of the most common endocrine disorder which varies worldwide and has been most frequently found in women rather than males. In India, its prevalence varies from 9% to 12%. Thyroid hormones lead to increase basal metabolic rate in the body by inducing metabolic activities in most tissues. Frequent Increase in weight can be the cause of various diseases and also lead to obesity, which can affect the metabolism of the body. Several other diseases, e.g., cardiovascular risk, diabetes, etc. associated with obesity may be developed in later years. Hence the present study was planned for Association of the TSH Level and Its Relation to Body Weight in Patients from Bihar Region.
The present study was planned in Department of General Medicine, Patna Medical College and Hospital, Patna, Bihar, India. Total 50 cases of the patients undergone screening for thyroid illness were enrolled in the present study. The age, height, and weight of the individuals were noted and the body mass index (BMI) was calculated in all the individuals. The serum TSH levels were measured using ECLIA method.
The data generated from the present study concludes that variations of TSH are accompanied by differences in BMI perhaps due to the changes in the basal metabolic rate. The high incidence of the pathological disorders in thyroid function with associated various environmental factors (diet, exercise, etc.) cause weight gain with an unknown biological mechanism and lead to obesity.

Keywords: thyroid dysfunction, body weight, BMI, Bihar region, TSH (thyroid stimulating hormone) etc

Introduction
Thyroid disease is a medical condition that affects the function of the thyroid gland. The thyroid gland is located at the front of the neck and produces thyroid hormones [1] that travel through the blood to help regulate many other organs, meaning that it is an endocrine organ. These hormones normally act in the body to regulate energy use, infant development, and childhood development [2].
There are five general types of thyroid disease, each with their own symptoms. A person may have one or several different types at the same time. The five groups are:

1. Hypothyroidism (low function) caused by not having enough free thyroid hormones
2. Hyperthyroidism (high function) caused by having too much free thyroid hormones
3. Structural abnormalities, most commonly a goiter (enlargement of the thyroid gland)
4. Tumors which can be benign (not cancerous) or cancerous
5. Abnormal thyroid function tests without any clinical symptoms (subclinical hypothyroidism or subclinical hyperthyroidism).

In some types, such as subacute thyroiditis or postpartum thyroiditis, symptoms may go away after a few months and laboratory tests may return to normal [3]. However most types of thyroid disease do not resolve on their own. Common hypothyroid symptoms include fatigue, low energy, weight gain, inability to tolerate the cold, slow heart rate, dry skin and constipation [4]. Common hyperthyroid symptoms include irritability, anxiety, weight loss, fast heartbeat, inability to tolerate the heat, diarrhea, and enlargement of the thyroid [5]. Structural abnormalities may not produce symptoms, however some people may have hyperthyroid or hypothyroid symptoms related to the structural abnormality or notice swelling of the neck. Rarely goiters can cause compression of the airway, compression of the vessels in the neck, or difficulty swallowing. Tumors, often called thyroid nodules, can also have many different symptoms ranging from hyperthyroidism to hypothyroidism to swelling in the neck and compression of the structures in the neck [6].
Diagnosis starts with a history and physical examination. Screening for thyroid disease in patients without symptoms is a debated topic although commonly practiced in the United States [7]. If dysfunction of the thyroid is suspected, laboratory tests can help support or rule out thyroid disease. Initial blood tests often include thyroid-stimulating hormone (TSH) and free thyroxine (fT4). Total and free triiodothyronine (T3) levels are less commonly used [8]. If autoimmune disease of the thyroid is suspected, blood tests looking for Anti-thyroid autoantibodies can also be obtained. Procedures such as ultrasound, biopsy and a radioiodine scanning and uptake study may also be used to

help with the diagnosis, particularly if a nodule is suspected [8].

Treatment of thyroid disease varies based on the disorder. Levothyroxine is the mainstay of treatment for people with hypothyroidism [9], while people with hyperthyroidism caused by Graves' disease can be managed with iodine therapy, antithyroid medication, or surgical removal of the thyroid gland. Thyroid surgery may also be performed to remove a thyroid nodule or to reduce the size of a goiter if it obstructs nearby structures or for cosmetic reasons [10].

Autoimmune thyroid disease is a general category of disease that occurs due to the immune system targeting its own body. It is not fully understood why this occurs, but it is thought to be partially genetic as these diseases tend to run in families. In one of the most common types, Grave's Disease, the body produces antibodies against the TSH receptor on thyroid cells. This causes the receptor to activate even without TSH being present and causes the thyroid to produce and release excess thyroid hormone (hyperthyroidism). Another common form of autoimmune thyroid disease is Hashimoto thyroiditis where the body produces antibodies against different normal components of the thyroid gland, most commonly thyroglobulin, thyroid peroxidase, and the TSH receptor. These antibodies cause the immune system to attack the thyroid cells and cause inflammation (lymphocytic infiltration) and destruction (fibrosis) of the gland.

Goiter is the general enlargement of the thyroid that can be associated with many thyroid diseases. The main reason this happens is because of increased signaling to the thyroid by way of TSH receptors to try to make it produce more thyroid hormone. This causes increased vascularity and increase in size (hypertrophy) of the gland. In hypothyroid states or iodine deficiency, the body recognizes that it is not producing enough thyroid hormone and starts to produce more TSH to help stimulate the thyroid to produce more thyroid hormone. This stimulation causes the gland to increase in size to increase production of thyroid hormone. In hyperthyroidism caused by Grave's Disease or toxic multinodular goiter, there is excess stimulation of the TSH receptor even when thyroid hormone levels are normal. In Grave's Disease this is because of an autoantibodies (Thyroid Stimulating Immunoglobulins) which bind to and activate the TSH receptors in place of TSH while in toxic multinodular goiter this is often because of a mutation in the TSH receptor that causes it to activate without receiving a signal from TSH. In more rare cases, the thyroid may become enlarged because it becomes filled with thyroid hormone or thyroid hormone precursors that it is unable to release or because of congential abnormalities or because of increased intake of iodine from supplementation or medication [11, 12].

There are many changes to the body during pregnancy. One of the major changes to help with the development of the fetus is the production of human chorionic gonadotropin (HCG). This hormone, produced by the placenta, has similar structure to TSH and can bind to the maternal TSH receptor to produce thyroid hormone. During pregnancy, there is also an increase in estrogen which causes the mother to produce more thyroxine binding globulin, which is what carries most of the thyroid hormone in the blood. These normal hormonal changes often make pregnancy look like a hyperthyroid state but may be within the normal range for pregnancy, so it necessary to use trimester specific ranges for TSH and free T4. True hyperthyroidism in pregnancy is most often caused by an autoimmune mechanism from Grave's Disease. New diagnosis of hypothyroidism in pregnancy is rare because hypothyroidism often makes it difficult to become pregnant in the first place. When hypothyroidism is seen in pregnancy, it is often because an individual already has hypothyroidism and needs to increase their levothyroxine dose to account for the increased thyroxine binding globulin present in pregnancy [13].

Many people may develop a thyroid nodule at some point in their lives. Although many who experience this worry that it is thyroid cancer, there are many causes of nodules that are benign and not cancerous. If a possible nodule is present, a doctor may order thyroid function tests to determine if the thyroid gland's activity is being affected. If more information is needed after a clinical exam and lab tests, medical ultrasonography can help determine the nature of thyroid nodule (s). There are some notable differences in typical benign vs. cancerous thyroid nodules that can particularly be detected by the high-frequency sound waves in an ultrasound scan. The ultrasound may also locate nodules that are too small for a doctor to feel on a physical exam, and can demonstrate whether a nodule is primarily solid, liquid (cystic), or a mixture of both. It is an imaging process that can often be done in a doctor's office, is painless, and does not expose the individual to any radiation [14].

Hypothyroidism is one of the common endocrine disease in the world. The prevalence of hypothyroidism worldwide is 2 – 5%, which increases to 15% by 75years of age. Thyroid disease normally dominates in females, with prevalence of 2-8 times higher than in males [15].

Thyroid disorder is one of the most common among all the endocrine diseases in India. Forty two million Indians suffer from thyroid disorder in the post iodization phase [16]. Hypothyroidism is the most common form of thyroid disorder and is a very commonly encountered problem in clinical practice.

Hypothyroidism usually results from either non-functioning of the thyroid gland or from the aggressive treatment of hyperthyroidism. It may be due to failure to secrete at the glandular level or defect in the synthesis of hormone like iodination or combination with amino acid tyrosine. The process of formation and release depends upon TSH levels.

Hypothyroidism is known to be associated with mental retardation, lack of concentration, motor dysfunction, memory deficits, lethargy, visual and hearing impairment, rarely delirium and coma. So it becomes important to assess the effect of hypothyroidism on visual and auditory pathways as well, measure the sensory motor association in them.

In order to assess and treat the hypothyroid cases, a number of thyrocare centers have been established with the purpose of early diagnosis and prompt treatment of hypothyroidism. Indian thyroid society declared January month as “Think Thyroid Month” and similarly Mother’s day as “Awareness day of Thyroid”.

Reaction time is an indicator of sensory motor association, which is the time required to respond to the stimulus. Visual stimulus, pain, temperature, auditory stimulus and touch, are the various modalities of sensory stimulus which are used to asses the reaction time [17]. The purpose of the study is to determine, if there is any alteration of simple auditory and visual reaction time in hypothyroids before and after

treatment. Hyperthyroidism and hypothyroidism are more frequent in women. Worldwide, the most common cause of hypothyroidism is iodine deficiency [18]. Statistics suggest that 1 in 50 women and 1 in 1000 men will develop symptoms of hypothyroidism6 among 42 million people are suffering with thyroid problems in India [19]. Hashimoto's thyroiditis are the most common cause of hypothyroidism in the United States. The annual incidence of Hashimoto's thyroiditis world-wide is estimated to be 0.3 – 1.5 cases per 1000 people. The incidence of Hashimoto's thyroiditis is estimated to be 10-15 times higher in females. The most commonly affected age range in Hashimoto's thyroditis is 30-50 years, with the peak incidence in men occurring 10-15 years later [20].

The subclinical hypothyroidism occurs in 5% to 10% prevalent in elderly women. Potential risks of subclinical hypothyroidism in the elderly includes progression to overt hypothyroidism, cardiovascular effects, hyperlipidemia, neurological and neuro psychiatric effects. Functional studies of the goitrous subjects showed overall prevalence of 5.4% hypothyroidism was demonstrated by fine needle aspiration biopsy [21].

Hypothyroidism or low thyroid function is far common in women than men for two reasons. Hashimoto's disease is characterized by gradual auto-immune mediated thyroid failure. Effects of female hormonal imbalance are the another reason to develop hypothyroidism [22]. So, women should have an awareness about the prevention and management of hypothyroidism via we can prevent the further complications associated with the disease.

Methodology

The present study was planned in Department of General Medicine, Patna Medical College and Hospital, Patna, Bihar, India. Total 50 cases of the patients undergone screening for thyroid illness were enrolled in the present study. The age, height, and weight of the individuals were noted and the body mass index (BMI) was calculated in all the individuals. The serum TSH levels were measured using ECLIA method.

After enrolment, a general and systemic examination was done and a proper case history was recorded to confirm that the subjects selected were apparently healthy. These subjects then underwent recording of anthropometric parameters like height (in meters) and weight (in kilograms) and Body Mass Index (BMI) was calculated.

The individuals were divided into 4 groups based on the BMI values. Underweight BMI<18 kg/m2 were considered as underweight, BMI between 18 and 22.9 kg/m2 were considered as normal, BMI between 23 and 24.9 kg/m2 were as overweight, and BMI ≥25 kg/m2 as obese.

All the patients were informed consents. The aim and the objective of the present study were conveyed to them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Following was the inclusion and exclusion criteria for the present study.

Inclusion criteria: All the volunteers wishing to participate in our study were enrolled. Volunteers without any self-reported thyroid illness, never treated for any thyroidal illness, with TSH value between 0.4mIU/L and 10mIU/L have been taken for the purpose of studying relationship between TSH and BMI.

Exclusion criteria: Subjects with any past history of thyroid illness or treatment taken for thyroid illness have been excluded. Volunteers with TSH <0.4mIU/L or >10mIU/L have been excluded. Any patient with chronic liver disease (CLD), chronic renal disease (CRD), pregnancy or taking any drug altering serum TSH levels (octreotide, somatostatin, opiates, dopamine, glucocorticoids, growth hormone, L-dopa, bromocriptine, pimozide, phentolamine, thioridazine, methysergide, cyproheptadine, iodine, dopamine antagonists, amiodarone) have been excluded [23].

Results & Discussion

The prevalence of obesity in India is lower when compared to the western countries. The Indians body composition and the centrally distributed body fat makes them to prone for significant morbidity not only in adults but also in children [24]. The thyroid stimulating hormone (TSH) is secreted from the pituitary gland. The secretion of thyroid stimulating hormone is controlled by thyrotropin releasing hormone (TRH) which is produced by the paraventricular nucleus of hypothalamus. This thyroid stimulating hormone stimulates the receptors on the thyroid to synthesise and release the tetraiodothyronine (T4) and triiodothyronine (T3). In case of the primary hypothyroidism, the increased production of thyrotrophin releasing hormone from the paraventricular nucleus of hypothalamus leads to increased production of TSH [25].

The association between TSH and BMI could be due to TSH directly stimulating preadipocyte differentiation and resulting in adipogenesis [26]. Leptin is another explanation of the association [8]. Smoking has been considered confounder and variously studied. Smokers were found to have lower TSH and BMI. A study in Norway found association only in nonsmokers, another study found TSH and BMI correlation as strong in current smokers as never smokers. Age is a confounder as well. A gradual increase in serum TSH has been found with age in men and women. The effects of excess bodyweight on thyroid could differ between lower grades of overweight and morbid obesity.The need arises to ascertain if slightly high TSH can cause obesity, and furthermore if the reverse is true i.e. high leptin levels in obesity, can increase thyroid dysfunction or autoimmunity causing higher risk of subclinical or overt hypothyroidism [27, 28, 29].

Table 1: Demographic Details

Parameters	No. of Cases
Sex	
Male	30
Females	20
Age	
30 – 40 years	5
41 – 50 years	35
51 – 60 years	10
Total	50

Table 2: Distribution according to BMI

Parameters	No. of Cases
Underweight	3
Normal weight	5
Overweight	10
Obese	32
Total	50

Table 3: TSH Levels

Parameters	No. of Cases	TSH Level
Underweight	3	0.85 – 2.52
Normal weight	5	1.01 – 3.24
Overweight	10	1.15 – 3.39
Obese	32	1.11 – 7.52
Total	50	

Solanki *et al* reported that the level of TSH is quite higher in obese patients and it increases as BMI increases [30]. Velivela *et al* supported this study that the prevelance of subclinical hypothyroidism is higher in females and increased with BMI [31]. Azza M. Abdu-Allah *et al* studied the patients with thyroid dysfunction. BMI was calculated. A higher BMI was found in the hypothyroid group compared with the hyperthyroid group [32]. As the lipid profile is deranged with higher BMI, it imparts resistant to TSH in peripheral tissue further aggravating the thyroid problem [33]. Nagila *et al* studied the correlation between serum TSH level and lipid profile in patients of varying degrees of obesity depending on the body mass index (BMI) [34]. A positive correlation was found between TSH and BMI in SCH women as well as a control group. Milionis and Milionis investigated that thyroid disorder associated with influence of various environmental factors can increase body weight and leads to obesity [35]. Zhang *et al*. described that the risk of obesity is quite higher in patients with SCH in Chinese adolescents [36]. Velivala *et al*. supported this study by finding that prevalence of SCH is higher in females and increased with BMI [37]. On the other hand Karthick *et al*. found that patients with SCH represent lower BMI when compared to euthyroid control group [38]. While Solanki *et al*. reported that the level of TSH is quite higher in obese patients and it increases as BMI increases as described by this study [39].

Overweight and obesity causes more deaths than the underweight or normal weight groups globally. In developing countries higher rates of mortality and morbidity was observed in obese individuals when compared to non-obese individuals [40]. Obesity is an emerging health problem in the urban areas of India accounting 30 to 65% in adult population [41]. The prevalence of obesity is gradually increasing not only in urban but also in rural areas of India which was reported by the previous studies on the prevalence of obesity and overweight [42]. Elevated serum TSH levels in hypothyroidism is a main cause of overweight and obesity. The association between the serum TSH levels and body mass index in adults is of a great medical concern. Thus, the present study was aimed to find out the association between the serum thyroid stimulating hormone levels and body mass index [43].

Body composition and thyroid hormones appear to be closely related. Thyroid hormones regulate basal metabolism, thermogenesis and play an important role in lipid and glucose metabolism, food intake and fat oxidation [44]. Thyroid dysfunction is associated with changes in body weight and composition, body temperature and total and resting energy expenditure (REE) independent of physical activity.

Hypothyroidism is associated with decreased thermogenesis, decreased metabolic rate, and has also been shown to correlate with a higher body mass index (BMI) and a higher prevalence of obesity. There is clinical evidence suggesting that even mild thyroid dysfunction in the form of subclinical hypothyroidism is linked to significant changes in body weight and represents a risk factor for overweight and obesity [45]. however, this remains a gray area. It has been further noted that small variations in serum TSH caused by minimal changes in L-T4 dosage during replacement therapy are associated with significantly altered REE in hypothyroid patients [46]. However, there is a paucity of data regarding the actual extent of weight gain and weight loss with L-T4 treatment in hypothyroidism.

TSH levels are at the upper limit of the normal range or slightly increased in obese children, adolescents, and adults and are positively correlated with BMI. Low fT4 with a moderate increase in T3 or free T3 (fT3) levels has been reported in obese subjects [47]. Progressive fat accumulation was associated with a parallel increase in TSH, and fT3 levels irrespective of insulin sensitivity and metabolic parameters and a positive association has been reported between the fT3 to fT4 ratio and both waist circumference and BMI in obese patients [48]. Although the typical picture of high TSH, low fT4, and high fT3 is the most common, various studies on adult obese individuals report thyroid hormone and TSH concentrations as normal, elevated, or reduced.

The causes underlying these alterations in thyroid functions are not known. One theory suggests an increased deiodinase activity leading to a high conversion rate of T4 to T3. This is interpreted as a defense mechanism in obese subjects capable of counteracting the accumulation of fat by increasing energy expenditure [49]. Another probable mechanism is the compensatory increase in secretion of TSH and fT3 in an attempt to overcome decreased tissue responsiveness to circulating thyroid hormones due to the reduced expressions of both TSH and thyroid hormones in adipocytes of obese subjects. High levels of leptin, found in obese subjects, is another potential cause. The main action of leptin is to report centrally the amount of fat, leading to a decrease in appetite and food intake. Leptin has also been shown to stimulate centrally the transcription of pro-thyrotropin-releasing hormone (TRH) and consequently also that of TRH and TSH. Leptin also enhances the activity of deiodinases. Further explanation is that inflammatory cytokines secreted from adipose tissue such as tumor necrosis factor alpha, interleukin (IL)-1 and IL-6, inhibit sodium/iodide symporter mRNA expression and iodide uptake activity [50].

Conclusion

The data generated from the present study concludes that variations of TSH are accompanied by differences in BMI perhaps due to the changes in the basal metabolic rate. The high incidence of the pathological disorders in thyroid function with associated various environmental factors (diet, exercise, etc.) cause weight gain with an unknown biological mechanism and lead to obesity.

References

1. Guyton C, Arthu Guyton, Hall. Textbook of medical physiology. OCLC 434319356.
2. Bauer DC. *et al*. Pathophysiology of Disease: An Introduction to Clinical Medicine, Seventh Edition. New York, NY. McGraw-Hill – via Access Medicine. Editor. Papadakis, Maxine A., editor. McPhee, Stephen J., editor. Rabow, Michael W. (2018-09-07). "Endocrine Disorders". Current medical diagnosis &

treatment, 2013. ISBN 978-1260117431. OCLC 1050994785.
3. "Hypothyroidism (Underactive Thyroid)". Www.niddk.nih.gov. Retrieved 2016-12-16.
4. "Hyperthyroidism". Www.niddk.nih.gov. Retrieved 2016-12-16.
5. Kasper Dennis L, Fauci Anthony S, Hauser Stephen L, Longo Dan L, Larry Jameson J, Loscalzo Joseph. "Thyroid Nodular Disease and Thyroid Cancer". Harrison's principles of internal medicine. Jameson, J. Larry,, Kasper, Dennis L.,, Fauci, Anthony S., 1940-, Hauser, Stephen L.,, Longo, Dan L. (Dan Louis), 1949-, Loscalzo, Joseph (Twentieth ed.). New York, 2018. ISBN 9781259644047. OCLC 990065894.
6. "Final Recommendation Statement: Thyroid Dysfunction: Screening - US Preventive Services Task Force". Www.uspreventiveservicestaskforce.org. Retrieved, 2018.
7. Hammer Gary D, McPhee Stephen J. Pathophysiology of disease: an introduction to clinical medicine. Hammer, Gary D. McPhee, Stephen J. (Eighth ed.). New York, 2018. ISBN 9781260026504. OCLC 1056106178.
8. Garber Jeffrey, Cobin Rhoda, Gharib Hossein, Hennessey James, Klein Irwin, Mechanick Jeffrey. *et al*. "Clinical Practice Guidelines for Hypothyroidism in Adults: Cosponsored by the American Association of Clinical Endocrinologists and the American Thyroid Association". Endocrine Practice. 2012; 18(6):988-1028. doi:10.4158/ep12280.gl. PMID 23246686.
9. Ross Douglas S, Burch Henry B, Cooper David S, Greenlee M. Carol; Laurberg, Peter; Maia, Ana Luiza; Rivkees, Scott A.; Samuels, Mary; Sosa, Julie Ann (2016-08-12). American Thyroid Association Guidelines for Diagnosis and Management of Hyperthyroidism and Other Causes of Thyrotoxicosis" (PDF). Thyroid (Submitted manuscript). 2016; 26(10):1343-1421. doi:10.1089/thy.2016.0229. ISSN 1050-7256. PMID 27521067.
10. Hammer Gary D, McPhee Stephen J. "Thyroid Disease". Pathophysiology of disease: an introduction to clinical medicine. Hammer, Gary D. McPhee, Stephen J. (Eighth ed.). New York, 2018. ISBN 9781260026504. OCLC 1056106178.
11. Papadakis Maxine A. editor. McPhee, Stephen J., editor. Rabow, Michael W. "Endocrine Disorders". Current medical diagnosis & treatment, 2019. ISBN 978-1260117431. OCLC 1050994785.
12. Gardner David G. editor. Shoback, Dolores M., editor. Greenspan, Francis S. (Francis Sorrel). "The Endocrinology of Pregnancy". Greenspan's basic & clinical endocrinology. OCLC 995848612.
13. "Thyroid Nodules - American Thyroid Association". Www.thyroid.org. Retrieved, 2016.
14. Hypothyroidism http://emedicine.medscape.com/article/122393-overview.
15. Kochupillai N. Clinical Endocrinology in India. Current science. 2000; 79(8):1061-1067.
16. Niruba Maruthy. Glycosylated hemoglobin verses reaction time in Diabetics-A cross sectional study. National Journal of Basic Medical Sciences. 2011; 1(4):198-201.
17. Klein I Danzis. Thyroid disease and the heart circulation [internet], 2007. Available from http//www.thyroid disorders.com.
18. Lemone Burke. Medical surgical nursing. India: Pearson education, 2008.
19. Albertini. Radioimmunoassay [internet], 1984. Available from www.infibeam.com// Radioimmunoassay.
20. Lewis Heitkemper Dirksen. Medical surgical nursing. New York: Mosby publishers. 2005.
21. Vander Pump M.P. The epidemology of thyroid disorders. London: Pearson publishers, 2005.
22. Surks MI, Sievert R. Drugs and thyroid function. N Engl J Med. 1995; 333:1688-94.
23. Kelishadi R. Childhood obesity today's and tomorrow's health challenge. Indian Pediatrics, 2008; 45:451-2.
24. Flier JS, Harris M, Hollenberg AN. Leptin, nutrition, and the thyroid: the why, the wherefore, and the wiring. Journal of Clinical Investigation, 2000; 105:859-861.
25. Valyasevi RW, Harteneck DA, Dutton CM, Bahn RS. Stimulation of adipogenesis, peroxisome proliferator-activated receptor gamma (PPARgamma), and thyrotropin receptor by PPARgamma agonist in human orbital preadipocyte fibroblasts. J Clin Endocrinol Metab, 2002; 87:2352-8.
26. Feldt-Rasmussen U. Thyroid and leptin. Thyroid, 2007; 17:413-9.
27. Rotondi M, Leporati P, La Manna A, Pirali B, Mondello T, Fonte R. *et al*. Raised serum TSH levels in patients with morbid obesity: Is it enough to diagnose subclinical hypothyroidism? Eur J Endocrinol, 2009; 160:403-8.
28. Zimmermann-Belsing T, Brabant G, Holst JJ, Feldt-Rasmussen U. Circulating leptin and thyroid dysfunction. Eur J Endocrinol. 2003; 149(4):257-71.
29. Solanki A, Bansal S, Jindal S, Saxena V, Shukla US. Relationship of serum thyroid stimulating hormone with body mass index in healthy adults. Indian J Endocrinol Metab. 2013; 17(1):S167-9.
30. Velivala AP, Paladugu L, Koyyala VP. Subclinical hypothyroidism in obese patients in rural general hospital. IOSR J Dent Med Sci. 2013; 5(4):8-10.
31. Azza M, Abdu-Allah, Riham G, Mahfouz Seham A, Khodeer Walid A, Shehab-Eldin. *et al*. Study of Resistin and Leptin in patients with Thyroid Dysfunction. Journal of American Science. 2011; 7(3):569-76.
32. http: /www. independent. co. uk. Retrieved 12 April, 2015.
33. Nagila A, Bhatt M, Poudel B, Mahato P, Gurung D, Prajapati S. *et al*. Thyroid Stimulating Hormone and its Correlation with Lipid Profile in the Obese Nepalese Population. Journal of Clinical and Diagnostic Research. 2008; (2):932-937.
34. Milionis A, Milionis C. Correlation between body mass index and thyroid function in euthyroid individuals in Greece. ISRN Biomark, 2013; 2013:651494.
35. Zhang J, Jiang R, Li L, Li P, Li X, Wang Z. *et al*. Serum thyrotropin is positively correlated with the metabolic syndrome components of obesity and dyslipidemia in chinese adolescents. Int J Endocrinol, 2014; 2014:289503.
36. Velivala AP, Paladugu L, Koyyala VP. Subclinical hypothyroidism in obese patients in rural general hospital. IOSR J Dent Med Sci. 2013; 5(4):8-10.

37. Karthick N, Dillara K, Poornima KN, Subhasini AS. Dyslipidaemic changes in women with subclinical hypothyroidism. J Clin Diagn Res. 2013; 7(10):2122-5.
38. Solanki A, Bansal S, Jindal S, Saxena V, Shukla US. Relationship of serum thyroid stimulating hormone with body mass index in healthy adults. Indian J Endocrinol Metab. 2013; 17(1):S167-9.
39. WHO. Geneva; Switzerland. World Health Organization (WHO). Global health risks: mortality and burden of disease attributable to selected major risks, 2009.
40. Misra A, Khurana L. Obesity and the metabolic syndrome in developing countries. J Clin Endocrinol Metab. 2008; 93:9-30. 3.
41. Pradeepa R, Anjana RM, Joshi SR, Bhansali A, Deepa M, Joshi PP. *et al*. Prevalence of generalized and abdominal obesity in urban and rural India- the ICMR - INDIAB Study (Phase-I) [ICMR- INDIAB3]. Indian J Med Res. 2015; 142:139-50.
42. Milionis A, Milionis C. Correlation between body mass index and thyroid function in euthyroid individuals in Greece. ISRN Biomarkers, 2013; 2013:7.
43. Danforth E Jr, Horton ES, O'Connell M, Sims EA, Burger AG, Ingbar SH. *et al*. Dietary-induced alterations in thyroid hormone metabolism during overnutrition. J Clin Invest, 1979; 64:1336-47.
44. Knudsen N, Laurberg P, Rasmussen LB, Bülow I, Perrild H, Ovesen L. *et al*. Small differences in thyroid function may be important for body mass index and the occurrence of obesity in the population. J Clin Endocrinol Metab. 2005; 90:4019-24
45. Biondi B. Thyroid and obesity: An intriguing relationship. J Clin Endocrinol Metab, 2010; 95:3614-7.
46. Tagliaferri M, Berselli ME, Calò G, Minocci A, Savia G, Petroni ML. *et al*. Subclinical hypothyroidism in obese patients: Relation to resting energy expenditure, serum leptin, body composition, and lipid profile. Obes Res, 2001; 9:196-201.
47. Chomard P, Vernhes G, Autissier N, Debry G. Serum concentrations of total T4, T3, reverse T3 and free T4, T3 in moderately obese patients. Hum Nutr Clin Nutr, 1985; 39:371-8.
48. Longhi S, Radetti G. Thyroid function and obesity. J Clin Res Pediatr Endocrinol 2013; 5(1):40-4.
49. Nannipieri M, Cecchetti F, Anselmino M, Camastra S, Niccolini P, Lamacchia M. *et al*. Expression of thyrotropin and thyroid hormone receptors in adipose tissue of patients with morbid obesity and/or type 2 diabetes: Effects of weight loss. Int J Obes (Lond), 2009; 33:1001-6.