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ORIGINAL ARTICLE

Association between Thyroid Function and Body Mass Index in Normal Population

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Abstract: The purpose of this study was to investigate the association between thyroid function and body mass index in a normal population. The study population consisted of a sample of four hundred healthy kashmiri subjects aged 20 – 60 yrs of both sexes. On detailed general physical examination and systematic clinical examination exclusion of the subjects was done with previous or present overt thyroid dysfunction. The study examined the association between serum TSH or T3, T4 and BMI. No association was found between BMI and serum T3 and T4 levels, but there was an association between obesity (BMI >30 kg/m2) and serum TSH levels. Thus results suggest that thyroid function even within normal range could be a factor which determines body weight in a population.
Keywords: TSH (Thyroid Stimulating Hormone), T3 (Tri-iodothyronine), T4 (Thyroxine), BMI (Body Mass Index).

Introduction

The thyroid (Greek - "thureos" meaning a shield refers to its shape) was first described by VESAL I 1543 [1]. The function of the thyroid gland is due to the secretion of L – thyroxine (T4) and 3, 5, 3 – tri – iodo – L – thyronine (T3), the two active thyroid hormones which are secreted by functional unit of thyroid gland i.e. the "thyroid follicle". More then 99% of thyroxine and tri – iodothyronine is bound to plasma proteins, mainly to thyroxine – binding globulin (TBG) and much less to thyroxine binding pre – albumin and albumin [2-3]. Only a small protein of the total T4 and T3 is free i.e. 0.003% of T4 and 0.3% of T3 [4].

The thyroid function is regulated by thyrotropin (TSH) secreted from the pituitary gland. TSH secretion is in turn regulated by two opposing forces;

i) By thyrotropin releasing hormone (TRH) from the hypothalamus which stimulates TSH secretion and synthesis.
ii) By thyroid hormones which inhibit the TSH secretary mechanism directly and also antagonizes the action of TRH. Thus, homeostatic control of TSH secretion is exerted in a negative feedback manner by thyroid hormones and the threshold for feedback inhibition is apparently set by TRH [5].

The thyroid gland maintains the level of metabolism in the tissues that is optimal for normal functioning. Thyroid hormone stimulates the O2 consumption of most of the body cells, helps regulate lipid and carbohydrate metabolism and are necessary for normal growth and maturation. Conversely excess thyroid secretion leads to body wasting, nervousness, tachycardia, tremor and excess heat production which gives rise to various clinical conditions [6].

Important relationship exists between thyroidal and gonadal function. The primary effect of estrogen is to induce an increase in the binding activity of the thyroxine binding globulin (TBG) [7]. The effects of methyltestosterone on thyroid function are opposite to that of estrogen. It induces a striking fall in the thyroxine binding capacity of the thyroxine binding globulin of serum [8]. The sub clinical and clinical form of hypo and hyper- thyroidism are emerging as potential contributors to morbidity from osteoporosis, hyperlipidemia, hypercholesteremia and cardiovascular and neuropsychiatric diseases [9-12] which has resulted in routine investigations of thyroid functions in almost all the patients seen by clinicians. Variations in thyroid function are seen between individuals, documented by relatively small individual variation in serum levels of thyroid hormones and TSH [13] and can be explained by a contribution of genetic and environmental factors [14]. The environmental factors, of which iodine intake levels seems to be of a major importance [15]. The effects on cardiovascular system has been reported for suppressed and particularly elevated serum levels of TSH [16]. It has been documented that patients on T4 therapy are associated with measurable differences in resting energy expenditure (REE), but impact on body mass index (BMI) remains unsettled [17].

The present study has been done in normal kashmiri adult population (both males and females). Kashmir also forms a part of "Himalaya Goiter Belt" which stretches from Kashmir to Naga hills in the east, extending about 2400 km and considered to be the biggest goiter belt [18, 10-12]. The aim of the study was to investigate the association between thyroid function and body mass index in normal population.

Material and Methods

The present study was designed to measure the serum levels of T3, T4 and TSH in normal kashmiri Adult population. The study of population consisted of a sample of four hundred healthy Kashmiri subjects aged 20 – 60 yrs of both sexes. The subjects included students of Govt. Medical College, and Govt. Dental College, Srinagar, Technical and non technical staff of physiology department and Hospital employees. A detailed history was taken and general physical examination and systemic clinical examination was done to exclude the subjects known to suffer from any significant non – thyroidal illness or any thyroid related illness. On detailed clinical examination, only those subjects were selected who were ambulatory, in apparently normal nutritional state and without any abnormality.

Blood Sampling:

After obtaining there consent, blood samples were taken from selected subjects in non – fasting state because fasting causes a rapid fall in serum T3 concentration [19]. To collect blood sample cubital fossa has been selected and after all aseptic precautions, about 4 ml of blood was drawn from anterior cubital vein and collected in a vaccutainer. Then the sample were auto analyzed by the "Elecys 1010 auto analyzer". The principle applied for estimation of serum T3, T4 and TSH levels in "Roche Elecys 1010 Analyzer" is called as "sandwich principle". The electro chemiluminescence immuno assay "ECLIA" is considered to be highly sensitive method for estimation of serum T3, T4 and TSH levels [20].

The subjects were classified into three groups according to the BMI: (body mass index was calculated by Quetelet's index i.e. weight (Kg) / height (m) 2 [10].

- Group I – BMI <= 25 (normal weight)
- Group II – BMI 25.1 – 29.9 (over weight)
- Group III – BMI >= 30 (obese)

Results

The present study was conducted on 400 subjects who were in the age of 20 – 60 yrs. All the subjects were ambulatory and in apparently normal health. The minimum age of the volunteers was 20 yrs and the maximum age was 60 yrs with an average age of 37.65 ± 13.97 yrs. The minimum weight of the volunteers was 40 kgs and maximum was 85 kgs with an average weight of 59.36 ± 9.62 kgs. The maximum height of volunteers was 141 cms and maximum was 183 cms with an average height of 163 ± 9.43 cms. Similarly the body mass index (BMI) of the subjects was calculated and the minimum BMI was 16.16 and maximum was 37.22 with an average of 22.51 ± 4.08. In group A i.e. subjects aged 20 – 39 yrs, there were 102 (45.10%) males and 124(54.90%) females. While as in group B i.e. subjects aged 40 – 60 yrs, they were 76 (43.70%) males and 98 (56.30%) females. The distribution of sex with respect to the different age groups was non – significant (Table 1).

Table-1: Comparison of age (yrs) and sex of the studied subjects

Age (yrs)	No. of cases	Male	Female		
20 – 39	226	102(45.10%)	124(54.90%)	X2=0.084 i.d.f	0.772 N/S
40 – 60	174	76(43.70%)	98(56.30%)		
Total	400	178(44.5%)	222(55.5%)		

Comparison of T3, T4 and TSH values with the respect to age i.e. group A (20 – 39 yrs) and group B (40 – 60 yrs). The mean T3 values in group A (20 – 39 yrs) was 0.99 ± 0.19 ng/ml while as the mean T3 value in group B (40 – 60 yrs) was 0.95 ± 0.18 ng/ml. On comparing the mean T3 values in group A and group B, the difference was statistically non – significant (P – 104 i.e. P > 0.05)

The mean T4 value in group A (20 – 39 yrs) was 8.74 ± 1.92U g/dl. On comparing the mean T4 value in group A and group B, the difference was statistically non – significant (P – 0.092 i.e. P > 0.05).

The mean TSH value in group A (20 – 39 yrs) was 2.19 ± 0.93 µIU/ml while as the mean TSH value in group B (40 – 60 yrs) was 2.37 ± 1.00 µIU/ml. On comparing the mean TSH values in group A and group B, the difference was statistically non – significant (P – 0.185 i.e. P > 0.05) (Table 2).

Table-2: Comparing of T3, T4 and TSH values with respect to age (yrs).

Variable	Group A (20 – 39 yrs)	Group B (40 – 60 yrs)	T value	P value	Results
	Mean ± S.D	Mean ± S.D			
T3 (ng/ml)	0.99 ± 0.19	0.95 ± 0.18	1.63	0.104	NS
T4 (µg/dl)	8.74 ± 1.92	8.48 ± 1.51	1.73	0.092	NS
TSH(µ IU/ml)	2.19 ± 0.93	2.37 ± 1.00	1.33	0.185	NS

Among all the 400 studied cases, the serum level of T3 were ranging from 0.50ng/ml to 1.80ng/ml with mean ± S.D as 0.97 ± 0.19ng/ml, serum levels of T4 were ranging from 5.30µg/dl to 13.60µg/dl with mean ± S.D as 8.49 ± 1.77 µg/dl and serum levels of TSH were ranging from 0.27 µIU/ml to 4.20 µIU/ml with mean +- S.D as 2.27 +- 0.96 µIU/ml.

Serum levels of T3, T4 and TSH in males

T3 values: The T3 values in males varied from a minimum of 0.80ng/ml to the maximum of 1.80ng/ml the mean value was 0.94 ± 0.17ng/ml.

T4 values: The T4 values in males varied from a minimum of 5.30µg/dl to the maximum of 13.60 µg/dl. The mean value was 8.55 ± 1.60µg/dl.

TSH values: The TSH values in males varied from a minimum of 0.30 µIU/ml to the maximum of 4.20 µIU/ml. The mean value was 2.34 ± 0.95 µIU/ml.

Serum levels of T3, T4 and TSH in females

T3 values: The T3 values in females varied from a minimum of 0.50ng/ml to the maximum of 1.80ng/ml. The mean value was 0.99 ± 0.20ng/ml.

T4 values: The T4 values in females varied from a minimum of 5.40 µg/dl to the maximum of 13.60 µg/dl. The mean value was 8.77 ± 1.86 µg/dl.

TSH values: The TSH values in females varied from a minimum of 0.27 µIU/ml to the maximum of 4.20 µIU/ml. The mean value was 2.21 ± 0.98 µIU/ml.

Comparison of T3, T4 and TSH values with respect to sex

The mean T3 values in males was 0.94 ± 0.17ng/ml while as the mean T3 values in females was 0.99 ± 0.20ng/ml. On comparing the mean T3 values in males and females, the difference was statistically non – significant (P – 0.083 i.e. P> 0.05). The mean T4 value in males was 8.55 ± 1.60 µg/dl while as the mean T4 value in females was 8.77 ± 1.86 µg/dl. On comparing the mean T4 values in males and females. The difference was statistically non – significant (P – 0.068 i.e. P > 0.05). The mean TSH values in males was 2.34 ± 0.95 µIU/ml, while as the mean TSH value in females was 2.21 ± 0.98 µIU/ml. On comparing the mean TSH values in males and females, the difference was statistically non – significant (P – 0.329 i.e. P > 0.05). Hence the difference in the mean values of T3, T4 and TSH when compared in males and females was statistically non-significant (Table 3).

Table-3: Comparison of T3, T4 and TSH values with respect to sex.

Variable	Male Mean ± S.D	Female Mean ± S.D	T-value	P-value	Result
T3 (ng/ml)	0.94 ± 0.17	0.99 ± 0.20	1.74	0.083	NS
T4 (µg/dl)	8.55 ± 1.60	8.77 ± 1.86	1.78	0.068	NS
TSH (µIU/ml)	2.34 ± 0.95	2.21 ± 0.98	0.97	0.329	NS

Comparison of T3,T4 and TSH values with respect to body mass index (BMI). The total numbers of cases studied were divided into three groups according to their BMI viz:

- Group I – BMI <= 25 (normal weight)
- Group II – BMI 25.1 – 29.9 (over weight)
- Group III – BMI >= 30 (obese)

The mean T3 values in group I (BMI <= 25) was 0.99 ± 0.19ng/ml, in group II (BMI 25.1 – 29.9) was 0.94 ± 0.13 ng/ml and in group III (BMI >=30) was 0.95 ± 0.15ng/ml. the difference in T3 values in all the three groups with respect to BMI was statistically non – significant(table 4).

Table-4: Comparison of T3 values (ng/ml) with respect to body mass index (BMI).

BMI	No. of cases	Mean ± S.D	T – value	P – value	Result
Group – I (<= 25)	304	0.99 ± 0.19	I vs II =1.82	0.078	NS
Group – II (25.1 – 29.9)	76	0.94 ± 0.13	II vs III =1.14	0.190	NS
Group – III (>= 30)	20	0.95 ± 0.15	I vs III=1.81	0.076	NS

The mean T4 value in group I (BMI <= 25) was 8.57 ± 1.84 µg/dl, in group II (BMI 25.1 – 29.9) was 8.26 ± 1.51 µg/dl and in group III (BMI >= 30) was 8.16 ± 1.68 µg/dl. The difference in T4 values in all the three groups with respect to BMI was statistically non – significant (table – 5).

Table-5: Comparison of T4 values(ug/dl) with respect to body mass index(BMI)

BMI	No. of cases	Mean ± S.D	T – value	P – value	Result
Group – I (<= 25)	304	8.57 ± 1.84	I vs II =0.98	0.330	NS
Group – II (25.1 – 29.9)	76	8.26 ± 1.51	II vs III =0.48	0.659	NS
Group – III (>= 30)	20	8.16 ± 1.68	I vs III=0.69	0.490	NS

The mean TSH value in group I (BMI<= 25) was 2.22 ± 0.96 µIU/ml, in group II (BMI 25.1 – 29.9) was 2.38 ± 0.97 µIU/ml and in group III (BMI>= 30) was 2.67 ± 0.96 µIU/ml. The difference in TSH values in group I and group II was statistically non – significant. Again the difference in TSH values in group II and III was also statistically non – significant. But TSH values when compared between group I and III showed statistically significant difference i.e. TSH values in group III (BMI>=30) were significantly on higher side than the TSH values in group I(BMI<=25) (table 6).

Table 6: Comparison of TSH values (μIU/ml) with respect to body mass index (BMI).					
BMI	No. of cases	Mean ± S.D	T – value	P – value	Result
Group – I (<= 25)	304	2.22 ± 0.96	I vs II =0.91	0.367	NS
Group – II (25.1 – 29.9)	76	2.38 ± 0.97	II vs III =0.95	0.344	NS
Group – III (>= 30)	20	2.67 ± 0.96	I vs III=2.36	0.021	Significant

Discussion

The primary objective of the present study was to investigate the association between thyroid function and body mass index in normal population. Increasing prevalence of overweight in the population is a major concern worldwide. Few data have been presented regarding the association between variations in thyroid function seen in the normal population and body weight. This study was restricted to subjects of Kashmir region only because of the fact that the iodine intake of the population of a particular region affects the status and nature of thyroid disorder in that area [21]. As Kashmir region falls in the "Himalaya goiter belt" [10-12, 18]. All the 400 volunteers who participated in the present study were healthy, ambulatory and aged between 20 – 60 yrs comprising of 178 males and 222 females. All the subjects who participated in the present study underwent a detailed clinical examination and detailed history was asked to rule out any thyroid disorder. It was also made sure that the subjects were not taking any drugs known or subjected to influence thyroid hormone measurement. After obtaining proper consent the blood samples were obtained from the volunteers in non – fasting state.

The serum levels of T3, T4 and TSH were determined by latest method i.e. non – competitive Immunometric Assay (IMA) method [22]. As a result of conclusion drawn from the present study conducted for healthy volunteers, the normal range of serum T3, T4 and TSH levels for normal kashmiri adult can be established as:

	Normal range
T3 (ng/ml)	0.50 – 1.80
T4 (μg/dl)	5.30 – 13.60
TSH (μ IU/ml)	0.27 – 4.20

While compiling the data obtained from the present study, an attempt was made to compare the mean T3, T4 and TSH values between males and females to see for any significant difference. On comparing the mean T3, values in males and females, the difference was statistically non – significant. Ruskin et al in 1973 reported no significant difference in serum T3 concentration in different age groups suggesting that T3 is probably not influenced by change in either body weight or muscle mass [23]. Lipson et al in 1979 reported that mean T4 values for men were stable throughout life but in females under 60 years T4 values were significantly higher than in older women. Throughout all decades male had stable TSH levels [24].

Gupta et al in 1998 conducted a study in non – hospitalized, health subjects aged 40 – 70 years to assess thyroid function by using radio immuno assays and observed that serum T3, T4 and TSH values were within normal range and the age related changes were statistically insignificant [25]. Similarly when serum T3, T4 and TSH values were compared between males and females, the results shown were non – significant. Oddie, Meade and Fischer in 1996 observed that sex showed no significant effect on thyroxine levels [26, 5]. On comparing the meanT3, T4 and TSH values with respect to two age group (20 – 39 yrs and 40 – 60 yrs), the difference was statistically non – significant (i.e. P value for all the three levels – T3, T4 and TSH was < 0.05), hence suggesting that the serum T3, T4 and TSH levels does not vary significantly from 20 – 60 yrs of age.

On comparing mean T3 and T4 values with respect to body mass index (BMI), among normal weight (BMI<=25), overweight (BMI 25.1 – 29.9) and obese(BMI >=30) subjects, no difference was seen. But a significant statistical difference was observed between the mean TSH values of normal weight (BMI<=25) and obese (BMI>=30) subjects i.e. the individuals with BMI >=30 were having higher TSH values than the normal weight individuals having BMI <=25. Similar findings were represented by the endocrine society of USA in 2005 which conducted a study to investigate the association between thyroid function and the BMI or obesity in a normal population. The results showed a positive association between BMI and TSH levels [27]. A larger proportion of the variation in BMI was explained by age and in general by life style including dietary habits and physical activity. Thus to determine education and life style impact on TSH and BMI needs further study. The thyroid hormone – induces increase in thermogenesis, there is an established association between increase thyroid activity and weight changes because weight loss is a relatively constant phenomenon in hyperthyroidism [17]. It has been speculated that the association between serum TSH and body weight is caused by signals from adipose tissue [28].

Thus a detailed study is required to be carried out with primary emphasis to be laid on establishing a possible relationship between leptin and thyroid functions. The study concluded that even slightly elevated serum TSH levels are associated with an increase in the occurrence of obesity.

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