Chapter 6

ASSESSMENT OF IODINE DEFICIENCY DISORDERS BY CLINICAL AND BIOCHEMICAL INDICATORS IN ADULTS

6.1. SUMMARY

Iodine Deficiency Disorders (IDD) is a global problem with goitre as a compensatory adaptation to iodine deficiency. The epidemiological assessment of the severity of iodine deficiency largely rests with determination of urinary iodine status and of thyroid size in specified population groups.

Assessment of IDD is difficult since it combines indirect measures of current iodine intake, urinary iodine, with indirect measures of past iodine intake, specifically thyroid size. The currency of later appears to diminish with age, but there has been no definitive study demonstrating the lack of utility of measuring thyroid size in an endemic goitre population.

We determined the aetiology and severity of IDD in Gujarat (India) with thyroid ultrasound as a prevalence indicator. The aim was to determine the

utility of thyroid ultrasonography to detect goitre in adults from an iodine population of Gujarat.

The study-group comprised 472 adults selected through household surveys. Data was collected on height, body-weight, mid upper arm circumference, thigh circumference and triceps skin fold thickness, thyroid size (palpation and ultrasonography) and diet. Casual urine samples for iodine (UI) and blood-spots for TSH estimation were obtained.

As criteria in adult populations are not available for IDD status and its elimination, cut-off points recommended by World Health Organization (WHO) applicable to school-aged-children/neonates were used to provide IDD status.

The median-UI for the study-group was 72 μg/l (interquartile-range = 40 – 117 μg/l), mean TSH was 1.96 mU/L (SD $\pm$ 3.2mU/L) and Total goitre rate (TGR) by palpation in 10% indicate mild IDD prevalence. Ultrasonography detected enlarged thyroid volume in 82% suggesting severe IDD. Malnutrition was prevalent. Water iodine concentration varied from 0 - 32 PPM.

IDD is a National health problem in India and a major public health problem in Gujarat State affecting adults especially women (90%) of childbearing age group below 50 years. Goitre prevalence of 82% by ultrasound is very high compared to the degree of iodine-deficiency that is mild. This points to a probable multifactorial involvement of iodine deficiency, dietary flavonoids and malnutrition for the development of goitre. Thyroid palpation was of limited value as grade 0 and 1 goitre predominated whereas thyroid volume measurement by ultrasound is a more sensitive and an important prevalence indicator for the past history of IDD in adults over the age of 30 years. The results indicate that thyroid ultrasonography consistently identifies goitre in adults despite a diminished thyroidal response with aging of the thyroid gland to variable goitrogenic stimuli.

6.2. INTRODUCTION

Iodine Deficiency Disorders (IDD) is a global problem affecting two billion people worldwide (International Council for Control of IDD (ICCIDD), 1999). Its effects are being reflected at all ages in the whole population varying from brain damage (cretinism in fetus) to goitre, thyroid deficiency and impaired mental function in an adult (Hetzel BS, 1994). Goitre is a compensatory adaptation of the thyroid gland to iodine deficiency. World Health Organization (WHO) and ICCIDD have stated (1994) that: (a) goitre rates are no longer reliable indicators of current iodine intake after the age of 30 years (b) the size of the thyroid gland changes inversely in response to alteration in iodine intake, with a lag of 6 to 12 months in children and young adults. This may lead to an interpretation that goitre rate is not important in adults greater than 30 years of age as a prevalence indicator for assessment of IDD.

Assessment of IDD is difficult since it combines indirect measures of current iodine intake, urinary iodine, with indirect measures of past iodine intake, specifically thyroid size. The currency of later appears to diminish with age, but there has been no definitive study demonstrating the lack of utility of measuring thyroid size in an endemic goitre population.

IDD, especially endemic goitre, is national health problem in India following reports of "Extra Himalayan Foci" in addition to sub Himalayan belt since antiquity (Pandav, 1990). Recently in the year 2000, Ministry of Health and Family Welfare lifted a two-year-old ban on the sale of noniodized salt.

Goitre surveys conducted so far in Gujarat State districts have been by palpation alone that defines constitution of a goiter inexactly (Stanbury, 1988). We performed biochemical assessment (urinary iodine and thyroid related hormones) of IDD in adults and children (chapter 4) that showed the magnitude of the problem of iodine deficiency in Gujarat. The fact that thyroid size can be measured more precisely and quantitatively by ultrasonography was derived from earlier study in children and this led to the extended study of IDD assessment in the adult population by all clinical and biochemical indicators.

'Pearl' millet pancakes contained three flavonoids, viz., apigenin, vitexin and glycosyl-vitexin and were the main constituent of at least one large meal in most adults of this study.

No major survey using all the indicators, especially thyroid ultrasonography has been carried out in the adult populations of Gujarat State to assess the prevalence of IDD to date. Since specific criteria and cut-off points to define the magnitude of the IDD as a public health problem and to monitor progress towards its elimination are still not available with WHO for all prevalence indicators in adult populations, those recommended for and applicable to school-aged children/ neonates (1994) were applied to adults.

6.3. SUBJECTS

6.3.1. DIET

A detailed dietary history was obtained through quantitative and qualitative questionnaire from all the subjects.

The majority of the subjects consumed non-iodized salt because it is cheaper compared to the iodized salt. The most important source of iodine was drinking water with an average daily consumption being two litres due to the hot tropical climate of India.

6.3.2. POPULATION STUDIED

We selected 472 subjects (aged 16 to 83 years; 245 men and 227 women) randomly by carrying out household surveys in several villages of Baroda (n = 392) and Dang (n = 80) districts. Every fifth household from the lane of the village was included in the study and at least one woman and head of the family were included in the study as far as possible. The subjects were evenly distributed in different age groups and nearly equal number of males and females were included with a special emphasis to inclusion of females in the childbearing age group. Fifty eight percent of men and 69% of women were above the age limit of 30 years. The majority of the population was rural (Baroda) and tribal (Dang) and belonged to a low socio-economic stratum. Information on height, weight, triceps skin fold (TSF) thickness, thigh circumference (TC), and mid upper arm circumference (MUAC) was recorded. Body surface area (BSA) (Dubois D and Dubois EF) and body mass index (BMI) was calculated.

6.4. METHODS

6.4.1. THYROID PALPATION

The simplified WHO classification (1994) for goitre grading was used:

Grade 0: No palpable or visible goitre.

Grade 1: Palpable but not visible.

Grade 2: Visible goitre when the neck is in the normal position.

6.4.2. THYROID ULTRASONOGRAPHY

Ultrasound scanning of thyroid gland was carried out as shown in chapter 3.

Thyroid glands were classified as 'normal' when the calculated thyroid volume was below 20 ml and 'enlarged' when it was more than 20 ml (Larsen PR, 1998).

6.4.3. URINARY IODINE (UI)

A modified acid-digestion method (method E), based on the reaction between cerium IV and arsenic III (Sandell-Kolthoff Reaction, 1937) using a Technicon Autoanalyzer II was used (May S et al, 1990). The results were expressed as micrograms of iodine per litre of urine (μg/l).

6.4.4. THYROID STIMULATING HORMONE (TSH)

Blood spot TSH levels were measured by commercially available Bioclone neonatal TSH ELISA kits for the quantitative determination of TSH in human neonatal blood spots, manufactured by Bioclone Australia Private Limited, Australia.

6.5. RESULTS

6.5.1. GENERAL

Statistically significant gender differences ($p = 0.0001$) were noted in body weight, height and BSA in both the districts. Baroda males were malnourished as evidenced from BMI ($p = 0.0001$). UI was lower and TSH was higher in females ($p = 0.05$). The TV did not show any significant gender difference ($p > 0.05$) (Table 6.1.).

6.5.2. BIOCHEMICAL STATUS

6.5.2.1. URINARY IODINE (UI)

Median UI for the study-group was 72 μg/l. Dang subjects had a lower median UI compared to the Baroda subjects. Based on these results the Dang district would be categorized as having moderate iodine deficiency and Baroda as having mild iodine deficiency.

In Dang, 100% males and 90% of females had UI proportion below 100 μg/l, whereas 76% males and 63% females had a UI proportion below 50 μg/l. In Baroda 69% females and 59% males had a UI proportion below 100 μg/l and 30% females and 23% males had a UI proportion below 50 μg/l.

According to criteria for monitoring progress towards eliminating IDD, the UI proportion below 100 μg/l should be seen in less than 50% of the population and the UI proportion below 50 μg/l is less than 20% of the population. A good progress towards elimination of IDD goal is not attained from these districts in Gujarat and is far from the ideal that is evident from the results of frequency distribution shown in figure 6.1.

TABLE 6.1. DISTRIBUTION OF CLINICAL, BIOCHEMICAL AND ANTHROPOMETRIC PARAMETERS BY DISTRICT

Baroda (n = 392)	*Females (n = 172)*			*Males (n = 220)*			*P*
	Range	Mean±SD	Median (QR)	Range	Mean±SD	Median (QR)	
Age	16-75	38 ± 14	35 (27-48)	16-83	36 ± 15	33 (24-45)	NS
Height	130-172	151 ± 6	151(148-155)	138-180	163 ± 6.5	163(159-168)	0.0001
Weight	29-79	46 ± 11	45 (39-51)	25-80	50 ± 9	49 (44-55)	0.0001
BSA	1.02-1.8	1.4 ± 0.1	1.36 (1.3-1.5)	1.1-1.9	1.5 ± 0.1	1.5(1.4-1.6)	0.0001
BMI	11.5-34	20 ± 4.6	19.6(17-22.6)	11-31	18.8 ± 3	18 (16-21)	0.0001
UI	0-378	85 ± 60	72 (47-115)	0-425	97 ± 61	90 (54-128)	0.05
TSH	0.1-24.4	1.4 ± 2.4	0.72 (0.2-1.6)	0-7.5	1.0 ± 1.2	0.57(.07-1.3)	NS
TV 1	9.6-102	31 ± 15	28 (20- 39)	7-82	33 ± 15	34 (20-42)	NS
TV 2	10-111	34 ± 16	30 (21-42)	7-89	36 ± 16	36 (21-45)	NS
Dang (n = 80)	**Females (n = 55)**			**Males (n = 25)**			
Age	17 – 50	30 ± 5.5	30 (28-32)	17 - 56	26 ± 11	21 (18 – 32)	0.027
Height	134-166	152 ± 6.4	152(148-156)	147-176	161 ± 6.4	161(158-163)	0.0001
Weight	30 – 60	39 ± 6	39 (34-41)	38 - 62	47 ± 6	46 (42 – 49)	0.0001
BSA	1.1 - 1.6	1.3 ± 0.1	1.3 (1.2-1.4)	1.3 –1.7	1.46 ± 0.1	1.45(1.4 -1.5)	0.0001
BMI	11 – 26	17 ± 2.7	16 (15.6-18)	14 – 23	18 ± 1.9	18 (17 – 19)	NS
UI	0 – 240	50 ± 44	40 (21-74)	0 – 90	35 ± 24	25 (18 – 47)	0.05
TSH	0 – 33	3.2 ± 5.7	0.8 (0.5-3.7)	0 – 3.5	0.5 ± 0.95	0.2 (0.1-0.4)	0.05
TV 1	27– 165	46 ± 23	43 (36-47)	23 – 79	47 ± 14	44 (36 – 56)	NS
TV 2	30– 179	50 ± 25	47 (39-52)	25 – 86	51 ± 15	47 (39 – 60)	NS

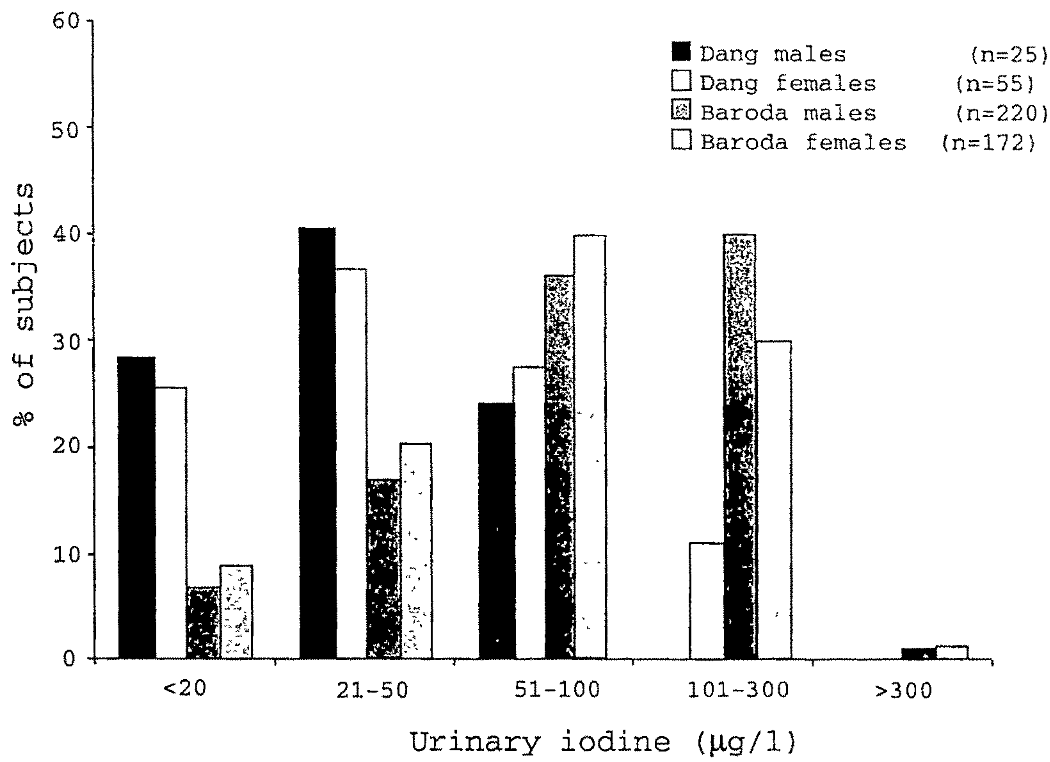
TV 1 derived by WHO formula

TV 2 derived by rotation ellipsoid model formula

IQR = inter quartile range

NS = Not significant

FIGURE 6.1. DEPICTS THE FREQUENCY DISTRIBUTION OF SEVERITY OF IODINE DEFICIENCY (INDICATED BY UI LEVELS) FOR THE STUDIED POPULATION.



< 20	Iodine deficiency (severe)
21-50	Iodine deficiency (moderate)
51-100	Iodine deficiency (mild)
101-300	Adequate iodine intake
> 300	More than Adequate iodine intake

6.5.2.2. BLOOD SPOT THYROID STIMULATING HORMONE (TSH)

The study group had a relatively high mean blood TSH level of 1.96 ± 3.2 mU/L. The mean TSH was higher in Dang (2.4 mU/L; SD ± 4.9 mU/L) compared to that in Baroda (1.7 mU/L; SD ± 1.8mU/L) ($p < 0.01$). There was a statistically significant gender difference in blood TSH levels in Dang ($p = 0.05$).

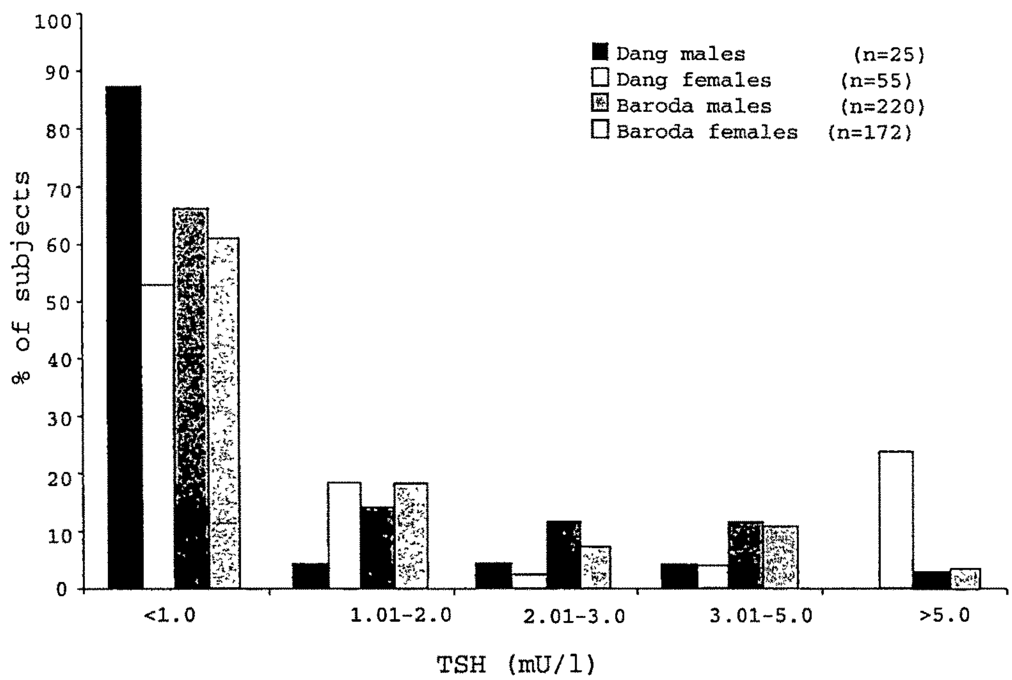
Whole blood TSH > 5mU/L and > 3 mU/L was seen in 5% and 13% of the adult population.

Twenty-four percent of women from Dang had blood spot TSH > 5 mU/L whereas 27% women and 4% men had TSH > 3mU/L.

Three percent each of men and women from Baroda had blood spot TSH > 5 mU/L, whereas 14% women and 8% men had TSH > 3 mU/L.

Figure 6.2. shows the frequency distribution of TSH values in the study-group.

FIGURE 6.2. SHOWS THE FREQUENCY DISTRIBUTION OF TSH VALUES



Normative values for TSH from an iodine-replete population from India are not currently available. Nor has WHO/ICCIDD/UNICEF published the cut-off values for blood TSH to be followed as an IDD prevalence indicator for assessing its severity as a public health problem for school-aged children/adult population unlike those available for neonates (WHO, 1994). Hence, we have used arbitrary cut-off values of 3 and 5 mU/L for the present study because it is possible that 5 mU/L as the upper limit may be too high.

6.5.3. THYROID SIZE

6.5.3.1. PALPATION

Total goitre rate (TGR) by palpation was ~10 % (45/ 472) with most of the subjects having grade 0 and 1 goitre according to WHO classification. Goitre grade 2 was seen in two males and five females. TGR by palpation was higher in Dang (31.3%) compared to Baroda (5.1%). Females were more affected in number (32/ 227 = 13.7%) as well as by goitre size as compared to males (13/ 245 = 5.1%) (Table 6.2.).

6.5.3.2. ULTRASONOGRAPHY

Goitre prevalence by ultrasound was found to be much greater, 100% in Dang and 78.6% in Baroda (Table 6.2.). The median thyroid volume for the study group was 36.6 ml (IQR: 23.4 - 47.1 ml). Enlarged thyroid volume (as defined >20 ml) was found in 82.2% subjects (388/ 472). Median thyroid volume was higher in Dang (46.8ml) compared to Baroda (32.7 ml) ($p < 0.001$). There was no significant difference in thyroid volumes by gender ($p = 0.8$).

TABLE 6.2. THYROID SIZE AS DETERMINED BY PALPATION AND ULTRASOUND

Thyroid size	Male n (%)	Female n (%)	Baroda n (%)	Dang n (%)
Thyroid palpation				
Grade 0	232 (94.7)	195 (86.3)	372 (94.9)	55 (68.7)
Grade 1	11 (4.5)	27 (11.5)	17 (4.3)	21 (26.3)
Grade 2	2 (0.8)	5 (2.2)	3 (0.8)	4 (5.0)
Total (n = 472)	**245 (100)**	**227 (100)**	**392 (100)**	**80 (100)**
Thyroid ultrasound				
TV 1 (> 20 ml)	187 (76.3)	179 (78.9)	286 (73)	80 (100)
TV 2 (> 20 ml)	193 (78.8)	195 (85.9)	308 (78.6)	80 (100)
Iodine in water (μg/l)			32	0

To determine the sensitivity of thyroid ultrasound at different age (As the age range was wide from 16 to 83 years), we divided the subjects in to four groups (Table 6.3.). Ratio of thyroid volume (TV) to body weight (Wt), TV to height (Ht) and TV to BSA was calculated. The mean thyroid volume and the ratio of TV: wt and TV: BSA decreased with age up to 70 years. The only exception was in males • 70 years; this may not be statistically significant as the sample size in this group was very small (Table 6.3.). TV: Wt ratio was higher in males in the age-group 30 - 49 years ($p < 0.001$), whereas TV: BSA ratio was higher in females in the same age-group ($p < 0.001$). We found no significant gender difference in TV: Ht ratio in age groups • 69 years (Table 6.3.).

TABLE 6.3. AGE AND SEX DISTRIBUTION OF THYROID VOLUME (TV), BODY WEIGHT AND RATIO OF TV: WEIGHT, HEIGHT AND BSA

Age (years)	Sex	No.	TV 2 (ml) Mean±SD	TV : weight ratio (ml/kg)	TV: Height ratio (ml/cm)	TV: BSA ratio (ml/m^2)
16 – 29	F	71	40.2 ± 26	1.00 ± 0.65	0.26 ± 0.18	30.4 ±19.8
	M	102	41.7 ±16.3	0.91 ± 0.39	0.26 ± 0.10	28.4 ± 11.5
30 – 49	F	113	35.3 ± 16.5	0.68 ± 0.32	0.25 ± 0.10	27.7 ± 11.1
	M	102	38.1 ± 14.8	0.87 ± 0.38	0.23 ± 0.10	22.7 ± 10.3
50 – 69	F	36	31.0 ± 15.3	0.64 ± 0.28	0.21 ± 0.13	22.0 ± 13.5
	M	32	30.9 ± 20.2	0.66 ± 0.41	0.19 ± 0.09	20.6 ± 9.4
• 70	F	7	24.6 ± 13.4	0.55 ± 0.27	0.23 ± 0.10	28.4 ± 12.7
	M	9	34.1 ± 12.6	0.94 ± 0.46	0.15 ± 0.09	16.2 ± 9.3

6.5.4. RELATIONSHIPS

Simple linear regression analysis showed statistically significant ($p < 0.0001$) correlation between TV and three ratios (TV: weight, TV: height and TV: BSA) in each age group. The best correlation was seen between TV and (TV: height) ratio (Table 6.4.).

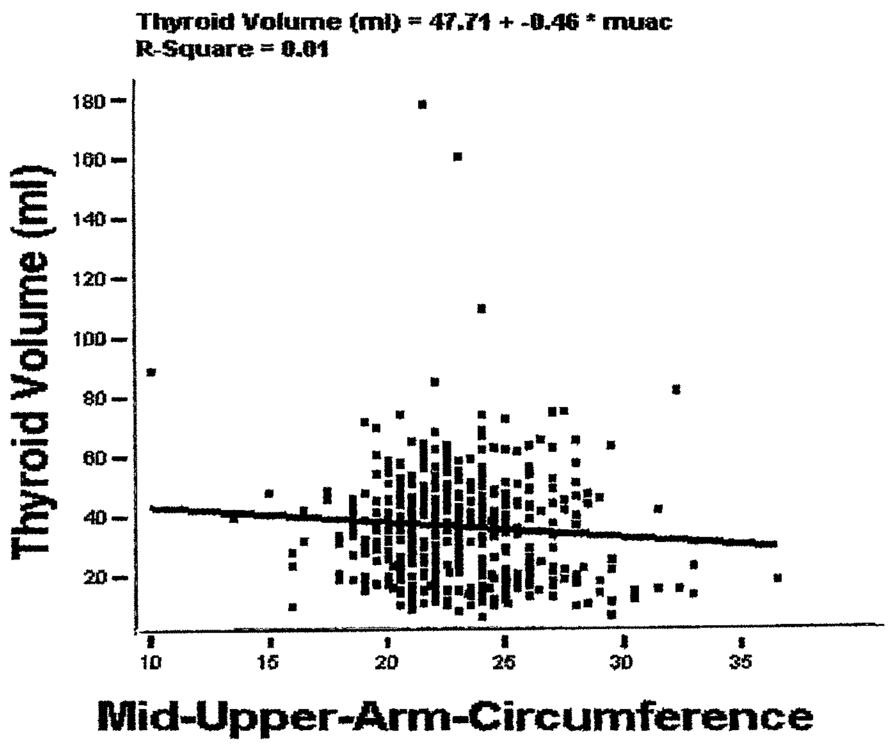
TABLE 6.4. CORRELATION (R-VALUES) BETWEEN THYROID VOLUME AND VARIOUS RATIOS (SIMPLE LINEAR REGRESSION ANALYSIS)

Sex	**Age group**	**TV: (TV: Ht)**	**TV: (TV: Wt)**	**TV: (TV:BSA)**	**Number**
Female	16 - 29	0.997	0.958	0.987	71
Male		0.993	0.927	0.978	102
Female	30 – 49	0.997	0.878	0.969	113
Male		0.996	0.930	0.980	102
Female	50 – 69	0.998	0.998	0.982	36
Male		0.997	0.921	0.984	32
Female	• 70	0.989	0.943	0.977	7
Male		0.996	0.932	0.983	9

Statistical significance as p- value < 0.0001 for all correlation

Simple linear regression between thyroid volume and various anthropometric parameters like weight, height, BMI, BSA, MUAC, TSF and TC was performed. This showed a weak ($r = -0.1$) but statistically significant ($p < 0.05$) negative correlation between TV and MUAC (Figure 6.3.) as well as AMA, in other words the poorer the protein nutrition the larger the thyroid size. There was no correlation between TV and other anthropometric parameters.

FIGURE 6.3. SHOWS NEGATIVE CORRELATION BETWEEN TV AND MUAC



The IDD parameters are measured on a continuous scale but the results do not have the normal Gaussian distribution hence it is desirable to transform some non-normally distributed data into normal distributions by logarithmic means. Thyroid volume values were transformed in to logarithmic values (LN-TV) to study simple linear regression with other parameters like age, sex, height, weight, BMI, district, UI, TSH, TSF thickness, TC, MUAC, BSA and consumption of iodized salt. There was a statistically significant ($p = 0.002$) positive correlation between LN-TV and TSH ($r = 0.36$). A weak but statistically significant ($p < 0.05$) negative correlation existed between LN-TV and age, thigh-circumference, MUAC, and iodized salt (r = -0.20, -0.12, -0.12, -0.20 respectively). We did not see any correlation between thyroid volume and body-weight. There was no significant correlation between TV and consumption of diet constituents known to contain goitrogens (eg cauliflower, cabbage, sweet potato and maize).

The best fitting multivariate linear regression model for LN-TV selected using backward elimination accounted for only 20% (R^2) of the variability in the LN of thyroid volume. In the adults the significant independent predictors of LN-TV are age, geographic location (district), interfering substances (most probably dietary goitrogens), nutritional status parameters (TSF thickness, TC and MUAC) and BSA (Table 6.5.).

TABLE 6.5. BEST MODEL OF LINEAR REGRESSION ANALYSIS RESPONSE: LN OF THYROID VOLUME

Parameter	Coefficient	Standard Error	p value
Constant	2.703	0.240	0.000
Age	-0.005	0.002	0.003
District	0.498	0.060	0.000
IS	0.001	0.000	0.005
TSF	0.021	0.006	0.000
TC	-0.017	0.005	0.002
Arm circumference	-0.025	0.011	0.026
BSA	0.878	0.117	0.000

TSF = Triceps Skin fold thickness

TC = Thigh circumference

IS = Interfering substances

6.5.5. COMPARISONS

Comparison with European iodine-replete subjects from Denmark and Sweden (Lazlo, 1983, Gutekunst, 1988) and iodine-deplete subjects from Germany (Gutekunst, 1988) and Japanese populations (Kyoko, 1989) showed highest values of mean thyroid volume in our study group. Indian *men* had 2-4 times higher *mean* thyroid volumes than their European and Japanese counterparts, whilst Indian women had even larger (2.5-5 times) thyroid glands compared to the women from Europe and Japan.

TABLE 6.6. COMPARISON OF THYROID VOLUME (ml) FROM GUJARAT (INDIA) V/S OTHER COUNTRIES

Parameter	Gujarat	Denmark*	Japan**	Germany***	Sweden***
TV	37.3 ± 18.4	18.6 ± 4.5	12.3 ± 4.6	21.4 ± 15.6	10.1 ± 4.9
TV males	37.0 ± 16.7	19.6 ± 4.7	19.9 ± 1.1	26.9 ± 17.0	11.1 ± 4.7
TV female	37.5 ± 20.1	17.5 ± 4.2	8.9 ± 5.6	16.5 ± 12.2	7.7 ± 4.3

Thyroid volumes expressed as mean ± SD (ml)

* Source: Laszlo, 1983

** Source: Miki Kyoko, 1989

*** Source: Gutenkunst, 1988

6.6. DISCUSSION

We used all prevalence indicators and epidemiological criteria of IDD (WHO/UNICEF/ICCIDD, 1994) to assess the extent and severity of IDD in a target population of adults from Gujarat State. This is the first study of its kind to be carried out in this state so far.

Analysis of the biochemical prevalence indicators for the study group is suggestive of mild IDD in Baroda and moderate IDD in the Dang district.

However, the high prevalence of goitre (82.2%) as measured by ultrasound shows that IDD is a severe public health problem in this state. This justifies public health action, not only to treat and prevent goitre but, more importantly, to address IDD in general. Endemic goitre could be seen as a biological marker and the tip of the IDD-iceberg. It is noteworthy that this tip itself appears to be very wide (imagine the size of the actual iceberg!). This may be due to the consumption of non-iodized salt by the population for most of their life. However, in this study, palpations of the thyroid gland and biochemical parameters both underestimated the severity of the problem as compared to thyroid volume determination by ultrasound. This is, in part, explained by the concomitant impact of goitrogens and malnutrition in the pathogenesis of goitre.

Normative values for TSH from an iodine-replete population in India are not currently available. Nor have WHO/UNICEF/ICCIDD published the cut-off values for blood TSH to be used as an IDD prevalence indicator for assessing its severity as a public health problem for school-aged children/adult population as those available for neonates (1994). According to a recent ICCIDD report "the difference in median serum TSH concentration between iodine deficient and iodine-sufficient populations groups is not great unless the iodine deficiency is moderate or severe. Therefore, the blood TSH concentration in school-age children and adults is not a practical marker for iodine deficiency, and its routine use in school-based surveys is not recommended" (Dunn J, 1999). As our survey was conducted in late 1998 before this report and universal neonatal screening is not a commonplace in India (a developing country), we used blood spots TSH levels for this adult survey to assess IDD. The median TSH values of our population indicate the euthyroid status due to auto-regulation, despite a high prevalence of goitre.

From our study it is apparent that thyroid palpation is of limited value for epidemiological surveys as it underestimates the extent of IDD due to its low sensitivity and specificity in small goitres (grades 0 and 1). The slight increase in thyroid size, which could not be appreciated by palpation, was easily detected by thyroid ultrasound.

Females were more severely affected as almost 10% of women had TSH values greater than 5mU/l. Most of these iodine deficient women were in the child bearing group and thus, likely to pass on their iodine deficiency to their foetuses and infants leading to irreversible neurologic deficits and brain damage (Boyages S, 1993).

Increased thyroid volume after 70 years of age could be due to higher TSH levels and this in turn, could be due to a fall in T3 in old age due to coexisting chronic illnesses (Burrows AW, 1975 and Laurberg P, 1999).

According to the WHO, thyroid size is no longer a reliable indicator of current iodine intake after aging 30 years (WHO/UNICEF/ICCIDD, 1994). This may be debated, as thyroid size is indicator for the past history of IDD as seen from the present study. The populations as seen from these results demonstrate increased thyroid volumes in all age groups beyond 30 years (Table 6.2.).

We have demonstrated the best correlation in adults is between thyroid size and body height (Table 6.2.). Linear regression analysis between thyroid volume and various nutritional anthropometric parameters showed a negative correlation between thyroid volume and thigh-circumference and mid-upper-arm-circumference (that point to prolonged and severe malnutrition) point to the effect of malnutrition on the thyroid volume. Positive correlation between thyroid volume and TSH point to the role-played by TSH in goitre formation. There was no significant correlation between TV and consumption of cauliflower, cabbage, sweet potato and maize for this population and the predictors have been identified in the best model.