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## **Chapter**

# **8**

### **IODINE DEFICIENCY DISORDERS ASSESSMENT IN URBAN AFFLUENT POPULATION (CHILDREN AND ADULTS) SHOWED INCREASED THYROID SIZE DESPITE SUFFICIENT IODINE AND NUTRITION INTAKE POINTING TO POSSIBLE AETIOLOGICAL ROLE OF DIETARY GOITROGENS**

#### **8.1. SUMMARY**

Previous studies (chapters 5 - 7) have highlighted that endemic goitre is highly prevalent in rural and tribal population of Gujarat. The causes of endemic goitre appear to be only partially explained by iodine deficiency as well as by malnutrition in general. Other dietary goitrogens also may play a role. The aetiological role of PEM as a confounding factor is avoidable by selecting study group that is on a sufficient quantity of well-balanced food rich in minerals. The affluent class population has access to both; good diet and iodised salt as a vehicle for iodine supplementation.

The purpose of the present study was to determine the role of goitrogens in the causation of endemic goitre by establishing anthropometric and thyroid volume reference data in iodine replete and well nourished preschool age children (4 - 6 year), schoolchildren (6 - 15) and adults (16 - 61) from the same province of Gujarat.

We studied 128 pre-schoolchildren aged 4 and 5 years (Male to female ratio was 1.5: 1.0), 1541 schoolchildren aged 6-15 years (Male to female ratio was 1.4: 1.0) and 575 adults (Male to female ratio was 1.7: 1.0) in the age range of 16 - 61 years. As the age range for adults was great, they were subdivided in to four groups: adolescents, young adults, middle aged and old. These children and adults were selected from Private Schools and various educational institutes in Baroda (Gujarat).

All subjects were palpated for goitre and the thyroid volume (TV) was measured by ultrasonography using a 7.5MHz probe. The median and 97<sup>th</sup> percentiles for TV were estimated for age and BSA by gender for schoolchildren. Urinary iodine (UI) was measured in all subjects by method L (Hitachi). Z- score deficits (-2 SD) were calculated for height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ) for all children (preschool, schoolchildren, and adults in 16-18 year age group) by Epi-info software program.

Based on WHO classification for assessing the severity of malnutrition by %prevalence ranges of three indicators among children under 5 years of age; stunting (< - 2 HAZ) was seen in 13% and wasting (< - 2 WHZ) was seen in 11% of preschool aged children. Waterlow classification showed that none of the preschool aged children had stunting and wasting together but few children were either stunted or wasted. The nutritional status assessment for 6 - 15 year schoolchildren when compared with WHO standard (1995), showed low prevalence (8%) of stunting, undernutrition (5%) and wasting (8%). Compared to an Indian Standard (Agrawal D et al, 1998) from affluent children residing in metro cities; the growth pattern of these present study children was better. Z-score deficits

(- 2 SD) were also calculated for *adolescent subjects* in the range of 16 - 18 years for HAZ, WAZ and WHZ. The males had high prevalence for wasting but medium prevalence of undernutrition and no prevalence of stunting (< 8%) when compared to WHO reference but when compared to Indian reference they had similar height and less weight.

More than 80% of the schoolchildren, preschool aged children and adults were vegetarian and consumed thiocyanate, goitrin, aliphatic-disulfides and flavonoids (> 10 gms/ day). The median urinary iodine was 222.5  $\mu\text{g/l}$  in 6-15 year and 279  $\mu\text{g/l}$  in 4-5 year old children. Goitre prevalence by palpation was below 1% in 6 - 15 and 0% in 4 - 5 year children. The percentage of adult subjects (> 16 years) affected by goitre increased with age. Thyroid volumes were increased in 85% of schoolchildren (6 - 15) for BSA and 81% for age when compared to the WHO reference (1997). The median and 97<sup>th</sup> percentiles of TV based on BSA and age for these children were 2 - 3 times greater than European schoolchildren in WHO 1997 reference.

Thyroid volumes (TV) for 4 and 5 year old children (both boys and girls) were much larger compared to a 6 year old European child in 1997 WHO normative reference. The normative WHO thyroid volume reference for 4 to 5 year old children is not available. (Median and 97<sup>th</sup> percentile TV in boys was 3.2 ml and 5.4 ml).

Thyroid volume (BSA and age) in the present study for these affluent urban schoolchildren (6 - 15) was much lower than that found in tribal and rural iodine deficient children reported in chapter 5.

The present data indicate that thyroid size is increased in well-nourished iodine-sufficient preschool aged children, schoolchildren (6 - 15 year old) and adults thereby supporting the aetiological role of the only one remaining confounding factor in the pathogenesis of goitre that is dietary goitrogens.

## 8.2. INTRODUCTION

Previous studies (chapters 5 - 7) have highlighted that endemic goitre is highly prevalent in children and adults of Gujarat. The causes of endemic goitre appear to be only partially explained by iodine deficiency as well as by malnutrition in general. Other dietary goitrogens also may play a role.

The overall purpose of the present study was to determine the role of goitrogens in the causation of endemic goitre by establishing anthropometric and thyroid volume reference data in iodine replete and well-nourished preschool age, schoolchildren and adults from Baroda city.

Normative reference standards by nationality are essential for epidemiological surveys to ensure accurate estimates of the severity of any public health disorder. Many reports from various countries like USA, Switzerland, Malaysia have suggested that the WHO/ICCIDD reference values for thyroid size may be too high for accurate comparisons (Xu, 1999). In addition, where reference standards are present these do not exist for some age groups, for example in preschool children (age < 5).

The first aim was to develop standard reference values for internationally accepted indices; weight-for-age, height-for-age, weight-for-height; to define malnutrition based on WHO classification. The other aim was to develop normative (standard reference) values for biochemical and clinical indicators to measure thyroid size (palpation and ultrasonography) of IDD in iodine replete and well nourished affluent urban preschool-age children (4 and 5 years), schoolchildren and adults in India. WHO normative data for these indicators in these age groups is lacking to date.

### 8.3. SUBJECTS

Schoolchildren from Private Schools (those collecting huge fees) were selected for the determination of thyroid volume reference standards. Good to high parental income generally ensures good nutrition and affordability of iodized salt for children. Subject sampling involved a stratified selection of five private schools from each corner and Centre of Baroda City. A representative national sample of 128 preschool aged children (4 - 5 years), 1541 Indian schoolchildren aged 6 - 15 years and 575 adults in the age range of 16 - 69 years was obtained. The adult subjects in the age group 16 - 19 years were studying for their higher secondary studies in private schools. The subjects aged >19 years were the various administration staff members and teachers in schools. The adult sample was also collected from nursing hostels and institutes for medicine and physiotherapy (aged >19 years). As the age range for adult sample was big, we divided the subjects into four groups: I: Adolescents (16 - 19 years) II: young adults (20 - 29 years) III: middle-aged (30 - 49 years) and IV: old-aged (50 - 61 years).

Schools principals were contacted and written consent was taken from the parents. Finally teachers selected 10 students from each class. The male to female ratio was 1.4 - 1.5: 1. Exact age was calculated from the date of birth and date of survey. The rounding up or down of age was done as per decimal criteria ie > 0.5 or < 0.5 respectively.

The frequency distribution for each age group is shown in Figure 8.1. - 8.3.

**FIGURE 8.1. AGE DISTRIBUTION 6-15 YEAR  
SCHOOLCHILDREN**

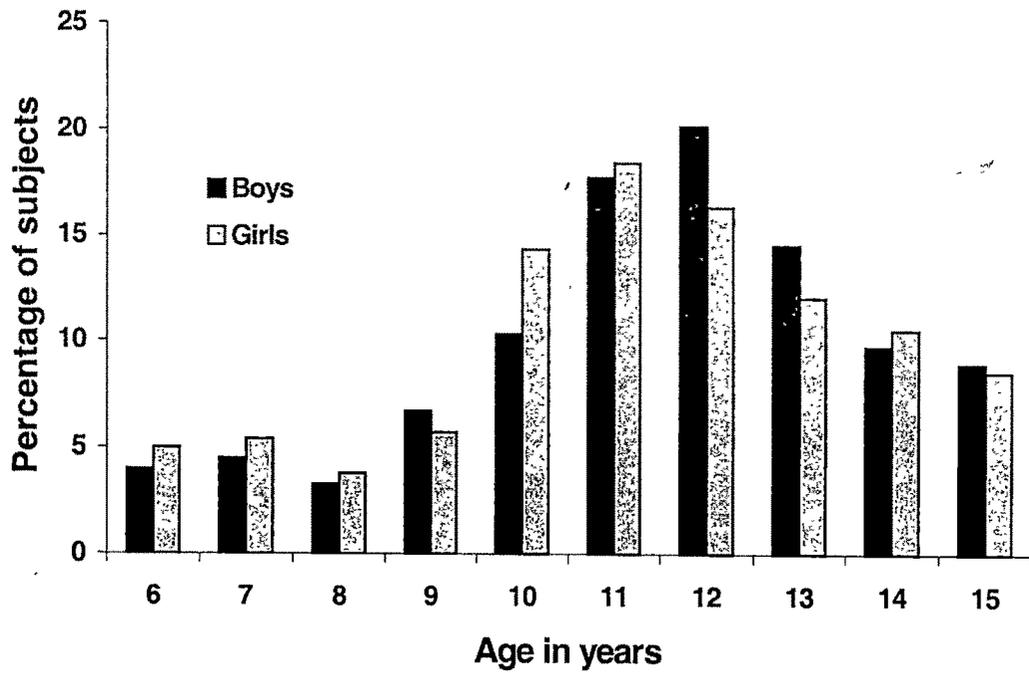
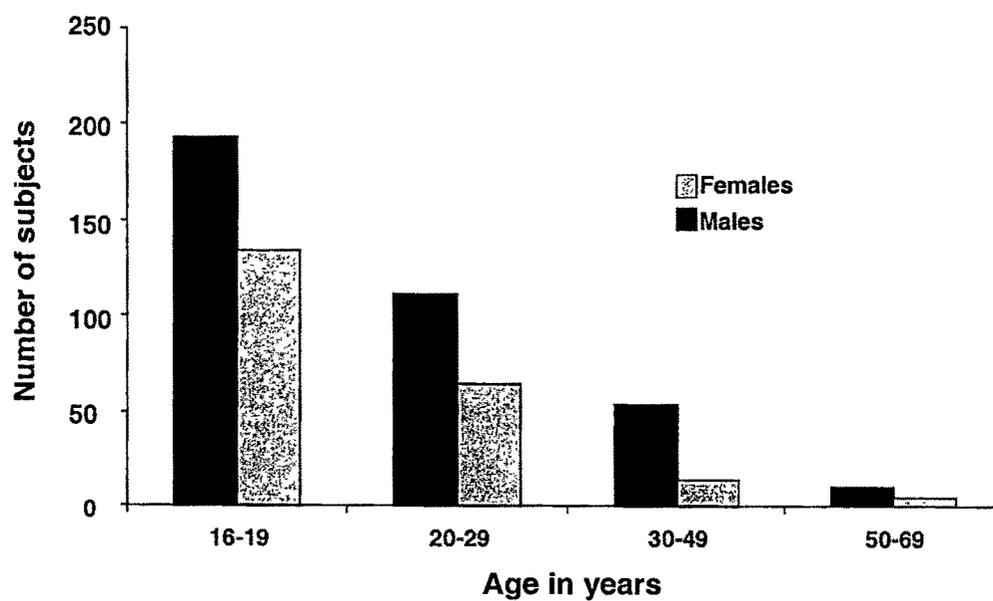


FIGURE 8.2. AGE DISTRIBUTION FOR PRESCHOOL CHILDREN



FIGURE 8.3. AGE DISTRIBUTION FOR ADULTS



## 8.4. DIET

Most of the subjects (>95%) were vegetarian and consumed three main meals per day (chapter 3.3). Tea was the most common beverage. Flavonoid consumption was greater than 10 gms per day (chapter 3.3). Flavonoids from tea and onion are clearly absorbed (chapter 2). The ratio of non-vegetarian to vegetarians was 1: 13 - 19 in preschool and schoolchildren and 1: 8 in adults because > 15 years eat non-vegetarian diet outside their homes. Some vegetables are exclusive to Gujarat and are not available in other far away States of India. Mustard seeds fried in oil are used for decorating almost every cooked vegetable. It is a common trend to eat fried snacks like samosa, pettis and bhajia in between meals. Thus almost all the known goitrogens like thiocyanate, isothiocyanates, aliphatic disulfides, goitrin and flavonoids are ingested in bulk. This urban population consumed iodized salt.

## 8.5. METHODS

### ***8.5.1. Nutrition***

The nutritional status was established from direct and derived indices anthropometric measurements of parameters using standard techniques (chapter 3.4.3.2.). Z-scores for height-for-age (HAZ), weight-for-age (WAZ) and BMI (BMIZ) and the centiles for height, weight and BMI were calculated with the help of software programme based on WHO growth reference. Weight-for-height (WHZ) was calculated from the formula (chapter 3.4.3.1.).

### **8.5.1.1. WORLD HEALTH ORGANIZATION (WHO) CLASSIFICATION FOR PEM**

Z-score deficits ( $- 2$  SD) as calculated for HAZ, WAZ and WHZ for all children and adults in the age group of 16 - 19 years (chapter 3.4.3.1.). These deficits gave rise to three indicators of PEM, stunting, underweight and wasting respectively. These deficits classify the severity of PEM by the percentage prevalence ranges as shown in table 3.5. These reference ranges, however, are only for children less than 5 years of age (WHO, 1995).

### **8.5.1.2. WATERLOW CLASSIFICATION FOR THRESHOLD OF PEM**

This scheme uses plots to combine variables where index weight-for-height is the abscissa and height-for-age index is plotted on the ordinate (chapter 3.4.3.3.).

## ***8.5.2. Iodine Intake***

As it is difficult to measure iodine intake directly from the ingested food, indirect estimation was obtained from the iodine excreted in urine.

### **8.5.2.1. URINARY IODINE**

Spot urine samples were collected from all children and stored at  $- 20$  C until analysis. Method L (Hitachi) (chapter 3.4.1.2.1.) was used to measure urinary iodine. A single iodine laboratory was responsible for all urinary iodine determinations.

### **8.5.3. Thyroid size**

#### **8.5.3.1. PALPATION**

All subjects were palpated for goitre and classified in to three simplified goitre grades (chapter 3.4.1.1.1.).

#### **8.5.3.2. THYROID VOLUME**

Thyroid ultrasonography was performed using a portable thyroid ultrasound machine with a 7.5 MHz linear transducer. Volume of each lobe was calculated (chapter 3.4.1.1.2.). The volumes of both lobes were summed.

## **8.6. RESULTS**

### **8.6.1. Nutrition:**

#### **ANTHROPOMETRY:**

#### **PRESCHOOL AGED CHILDREN**

The detailed results of anthropometry are shown in Table 8.1.

**TABLE 8.1. ANTHROPOMETRIC PARAMETERS  
IN PRESCHOOL AGED CHILDREN**

|               | <i>Girls</i>     |                     | <i>Boys</i>      |                     |
|---------------|------------------|---------------------|------------------|---------------------|
|               | <i>Mean ± SD</i> | <i>Median (IQR)</i> | <i>Mean ± SD</i> | <i>Median (IQR)</i> |
| <b>Weight</b> | 17.4 ± 2.8       | 17 (15.5-19.0)      | 17.3 ± 2.8       | 17 (16.0-19.0)      |
| <b>Height</b> | 104 ± 9.1        | 105 (100-110)       | 105 ± 8.0        | 105 (102-110)       |
| <b>MUAC</b>   | 16.4 ± 2.0       | 16 (15-17)          | 15.9 ± 1.7       | 16 (15-17)          |
| <b>TC</b>     | 28.1 ± 3.1       | 28 (26-30)          | 28.6 ± 3.1       | 28 (27-30)          |
| <b>TSF</b>    | 11.4 ± 4.1       | 12 (8-14)           | 11.1 ± 4.0       | 12 (7-14)           |
| <b>HAZ</b>    | - 0.5 ± 2.1      | - 0.1 (- 1.1-0.7)   | - 0.6 ± 1.7      | - 0.5 (-1.5 - 0.5)  |
| <b>WAZ</b>    | -0.1 ± 1.4       | 0.0 (-0.9 – 0.5)    | - 0.4 ± 1.2      | -0.4 (-1.3 – 0.2)   |
| <b>WHZ</b>    | 0.5 ± 2.2        | 0.5 (-0.8 – 1.5)    | - 0.4 ± 1.2      | - 0.4 (-1.3 – 0.2)  |

MUAC (cm) Mid-upper-arm-circumference

TC (cm) Thigh circumference

TSF (mm) Triceps skin fold thickness

WAZ Z score weight-for-age

HAZ Z score height-for-age

WHZ Z score weight-for-height

**SCHOOLCHILDREN 6-15 YEARS**

The detailed results of anthropometry are shown in Table 8.2.

**TABLE 8.2. ANTHROPOMETRIC PARAMETERS  
6-15 YEARS OLD SCHOOLAGE CHILDREN**

|               | <i>GIRLS</i> |                   | <i>BOYS</i> |                  |
|---------------|--------------|-------------------|-------------|------------------|
|               | Mean ± SD    | Median (IQR)      | Mean ± SD   | Median (IQR)     |
| <b>Weight</b> | 36.7 ± 11.2  | 36 (28-44)        | 37.5 ± 11.9 | 36 (29 - 45)     |
| <b>Height</b> | 143 ± 14     | 145 (134-152)     | 145 ± 15    | 144 (135-154)    |
| <b>BSA</b>    | 1.2 ± 0.2    | 1.2 (1.0-1.4)     | 1.3 ± 0.9   | 1.2 (1.1-1.4)    |
| <b>BMI</b>    | 17.7 ± 3.4   | 17.1 (15.4-19.5)  | 17.5 ± 3.5  | 16.9 (15.4-19)   |
| <b>MUAC</b>   | 20.5 ± 5.2   | 20 (18-22)        | 20.4 ± 3.5  | 20 (18-22.5)     |
| <b>TC</b>     | 36.9 ± 6.3   | 37 (32-41)        | 38.9 ± 6.2  | 39 (34-43)       |
| <b>TSF</b>    | 16.9 ± 5.0   | 17 (13-20)        | 15.9 ± 5.8  | 12 (7-14)        |
| <b>HAZ</b>    | -0.4 ± 1.0   | -0.3 (-1.1-0.3)   | -0.3 ± 1.2  | -0.3 (-1.0-0.4)  |
| <b>WAZ</b>    | -0.6 ± 1.1   | -0.4 (-1.1 - 0.3) | -0.5 ± 2.8  | -0.3 (-1.1 -0.4) |
| <b>WHZ</b>    | 0.06 ± 1.8   | 0.1 (-1.0 - 0.9)  | 0.08 ± 2.2  | 0.0 (-1.1 -0.9)  |

MUAC (cm) Mid-upper-arm-circumference

TC (cm) Thigh circumference

TSF (mm) Triceps skin fold thickness

WAZ Z score weight-for-age

HAZ Z score height-for-age

WHZ Z score weight-for-height

## ADULTS IN THE AGE RANGE OF 16 - 18 YEAR

The detailed results of anthropometry are shown in Table 8.3.

**TABLE 8.3. ANTHROPOMETRIC AND OTHER PARAMETERS 16-18 YEAR ADOLESCENTS**

|               | <i>FEMALE</i> <i>Z &lt; -2.0</i> |    | <i>MALE</i> <i>Z &lt; -2.0</i> |    |
|---------------|----------------------------------|----|--------------------------------|----|
|               | Median (IQR)                     | %  | Median (IQR)                   | %  |
| <b>Weight</b> | 45 (41-54)                       |    | 55 (50-61)                     |    |
| <b>Height</b> | 155 (151-160)                    |    | 170 (165-174)                  |    |
| <b>TSF</b>    | 12 (8-20)                        |    | 21 (16-23)                     |    |
| <b>TC</b>     | 42 (39-44)                       |    | 45 (42-48)                     |    |
| <b>MUAC</b>   | 23 (21-24)                       |    | 25 (23-27)                     |    |
| <b>WAZ</b>    | -1.5 (-2.2 to -0.4)              | 30 | -1.2 (-1.7 to -0.5)            | 16 |
| <b>HAZ</b>    | -1.3 (-2.0 to -0.5)              | 30 | -0.8 (-1.6 to -0.1)            | 8  |
| <b>WHZ</b>    | -0.2 (-1.2 to 0.5)               | 12 | 0.8 (-1.8 to 0.6)              | 21 |
| <b>BMIZ</b>   | -1.0 (-1.5 to 0)                 | 17 | -1.1 (-1.8 to -0.1)            | 18 |
| <b>BMI</b>    | 18.8 (17.5-21.0)                 |    | 19 (17.5-21.0)                 |    |
| <b>BSA</b>    | 1.4 (1.3-1.5)                    |    | 1.6 (1.6-1.7)                  |    |
| <b>TV</b>     | 18 (16-21)                       |    | 20 (17-26)                     |    |
| <b>UI</b>     | 101 (98-210)                     |    | 319 (200-508)                  |    |

|           |                             |
|-----------|-----------------------------|
| BSA       | Body surface area           |
| MUAC (cm) | Mid-upper-arm-circumference |
| TC (cm)   | Thigh circumference         |
| TSF (mm)  | Triceps skin fold thickness |
| WAZ       | Z score weight-for-age      |
| HAZ       | Z score height-for-age      |
| WHZ       | Z score weight-for-height   |
| BMIZ      | Z score body mass index     |
| TV        | Thyroid volume              |
| UI        | Urinary iodine              |

### 8.6.1.1. NUTRITIONAL STATUS

#### **WHO CLASSIFICATION (chapter 3.4.3.1)**

##### ***Preschool aged children:***

Stunting in 13% of children

Wasting in 11% of children

Undernutrition in 10% of children

##### ***Schoolchildren 6-15 year:***

Stunting in 8% of females and 7% of males

Wasting in 9% of females and 8% of males

Undernutrition in 5% of females and 7% of males

Z- score deficit for BMI in 10% of females and 14% of males.

##### ***Adults In The Age Range 16-18 Years***

Stunting in 30% of females and 8% of males

Undernutrition in 30% of females and 16% of males

Wasting in 12% of females and 21% of males.

The height and weight of the present studies boys and girls was compared to NCHS Standard as shown in Tables 8.4. and 8.5.

TABLE 8.4. NCHS AND PRESENT STUDY (PS) WEIGHT PERCENTILES FOR GIRLS

| Age | 3    |          | 5    |           | 10   |           | 50   |           | 97   |           |
|-----|------|----------|------|-----------|------|-----------|------|-----------|------|-----------|
|     | NCHS | PS       | NCHS | PS        | NCHS | PS        | NCHS | PS        | NCHS | PS        |
| 6   | 15.3 | 14.9 (4) | 15.8 | 15.6 (6)  | 16.6 | 16.1 (8)  | 19.5 | 19.0 (43) | 25.8 | 26.0 (95) |
| 7   | 16.7 | 18.0 (7) | 17.3 | 18.7 (10) | 18.3 | 19.0 (15) | 21.8 | 21.5 (41) | 29.7 | 27.0 (91) |
| 8   | 18.3 | 18.4 (5) | 19.1 | 19.2 (7)  | 20.4 | 20.0 (9)  | 24.8 | 25.0 (44) | 35.0 | 42 (100)  |
| 9   | 20.2 | 20.1 (4) | 21.3 | 21.5 (5)  | 22.9 | 23.0 (10) | 28.5 | 27.0 (35) | 41.3 | 43 (98)   |
| 10  | 22.5 | 23.7 (5) | 23.8 | 24.5 (6)  | 25.7 | 26.0 (10) | 32.5 | 32.0 (46) | 48.2 | 44 (89)   |
| 11  | 25.2 | 23.9 (2) | 26.7 | 25.0 (4)  | 28.9 | 26.0 (5)  | 37.0 | 35.0 (38) | 55.3 | 55 (96)   |
| 12  | 28.3 | 27.0 (3) | 29.9 | 28.0 (3)  | 32.5 | 30.0 (5)  | 41.5 | 39.0 (36) | 62.0 | 57 (90)   |
| 13  | 31.7 | 30.5 (3) | 33.5 | 32.0 (4)  | 36.3 | 32.5 (5)  | 46.1 | 42.0 (30) | 68.0 | 56.5 (82) |
| 14  | 35.2 | 33.9 (3) | 37.1 | 34.0 (3)  | 40.0 | 35.5 (4)  | 50.3 | 45.0 (28) | 73.0 | 66.4 (89) |
| 15  | 38.3 | 32.4 (2) | 40.3 | 35.3 (2)  | 43.2 | 37.3 (3)  | 53.7 | 47.0 (21) | 76.8 | 73.2 (93) |

Note: Figures in the parentheses depict percentiles in comparison to the NCHS

**TABLE 8. 5. NCHS AND PRESENT STUDY (PS) WEIGHT PERCENTILES FOR BOYS**

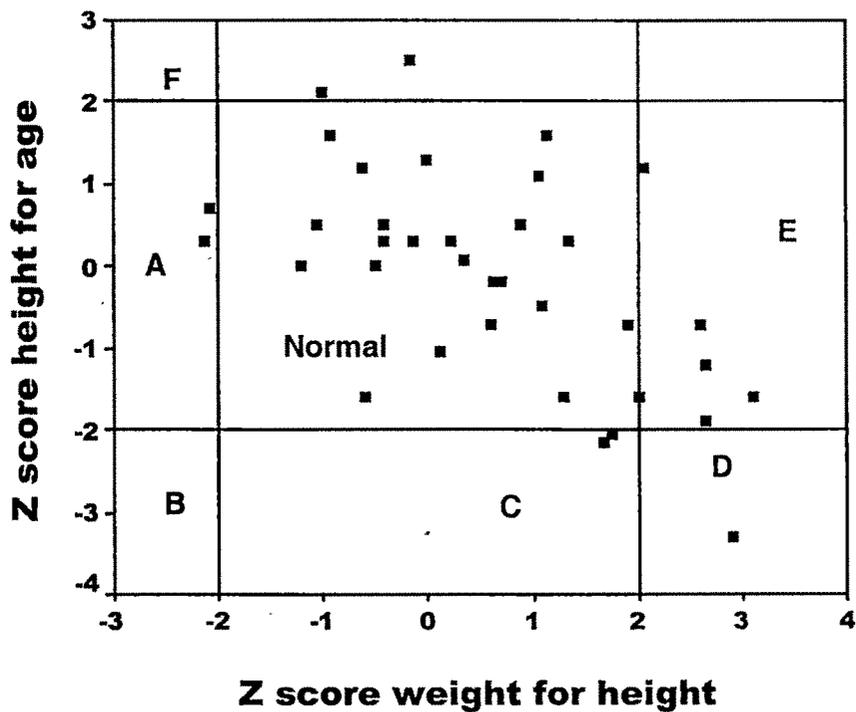
| Age | 3    |        | 5    |        | 10   |          | 50   |         | 97   |           |
|-----|------|--------|------|--------|------|----------|------|---------|------|-----------|
|     | NCHS | PS     | NCHS | PS     | NCHS | PS       | NCHS | PS      | NCHS | PS        |
| 6   | 16.3 | 15 (1) | 16.8 | 16 (3) | 17.7 | 16.0 (5) | 20.7 | 19 (23) | 26.2 | 26.0 (97) |
| 7   | 17.9 | 17 (2) | 18.5 | 19 (8) | 19.5 | 19.0 (8) | 22.9 | 24 (37) | 29.8 | 33.6(100) |
| 8   | 19.5 | 18 (1) | 20.2 | 18 (1) | 21.3 | 19.8 (5) | 25.3 | 25 (47) | 34.1 | 29.0 (73) |
| 9   | 21.0 | 22 (6) | 21.9 | 23 (9) | 23.3 | 24 (15)  | 28.1 | 28 (49) | 39.2 | 46.2(100) |
| 10  | 22.7 | 23 (4) | 23.8 | 24 (5) | 25.5 | 25.0 (7) | 31.4 | 31 (47) | 45.2 | 44.6 (97) |
| 11  | 24.8 | 24.(3) | 26.1 | 25 (4) | 28.1 | 27.0 (7) | 35.3 | 35 (41) | 51.7 | 54.2 (99) |
| 12  | 27.6 | 26 (2) | 29.1 | 27 (3) | 31.5 | 29.0 (5) | 39.8 | 37 (34) | 58.7 | 57.0 (96) |
| 13  | 31.2 | 30 (2) | 32.9 | 30 (2) | 35.6 | 31.0 (3) | 45.0 | 42 (35) | 65.9 | 62.2 (94) |
| 14  | 35.9 | 32 (1) | 37.7 | 33 (1) | 40.6 | 35.8 (4) | 50.8 | 47 (32) | 73.2 | 73.4 (97) |
| 15  | 40.9 | 32 (1) | 42.9 | 34 (1) | 46.0 | 38.0 (2) | 56.7 | 51 (25) | 80.1 | 75.0 (93) |

Note: Figures in the parentheses depict percentiles in comparison to the NCHS

**WATERLOW CLASSIFICATION (chapter 3.4.3.3.)****Preschool children 4-5 years age**

This classification (Figure 8.4.) showed that most of the preschool children were normal. None of the children was stunted and wasted together (group B). There were few children either wasted or stunted as seen in F, A, and C. Few children were stunted and obese as seen in D whereas few were only obese as seen in E.

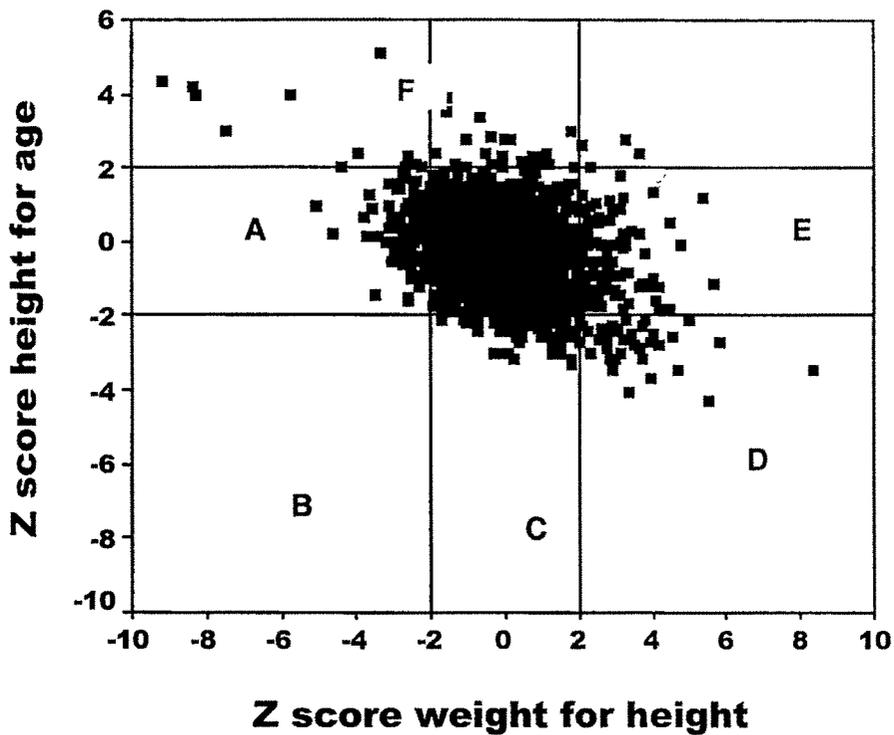
**FIGURE 8.4. WATERLOW CLASSIFICATION  
PRESCHOOL CHILDREN (4 - 5 YEARS)**



**Schoolchildren 6-15 year:**

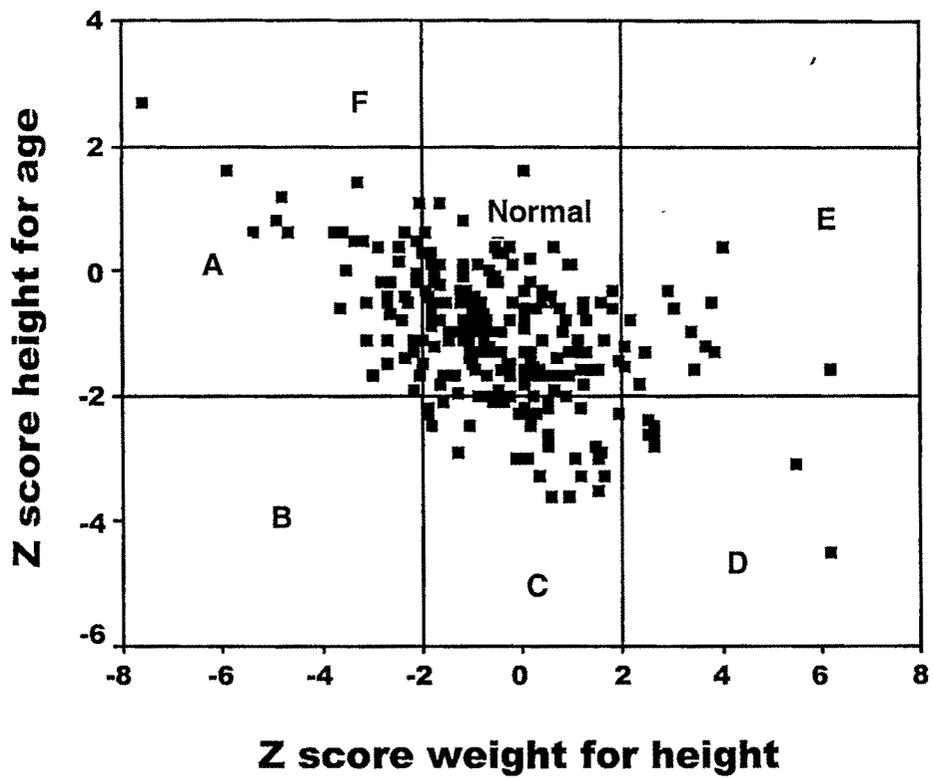
Most of the children were normal according to Waterlow classification (figure 8.5.).

**FIGURE 8.5. WATERLOW CLASSIFICATION FOR 6-15 YEAR SCHOOLCHILDREN**



None was Stunted and wasted together as seen in section B. few children are either stunted or wasted as seen in sections A, C, D, and F. Obese children can be seen in section E.

FIGURE 8.6. WATERLOW CLASSIFICATION FOR ADULT SCHOOLCHILDREN IN THE AGE RANGE 16-18 YEARS



**COMPARISON WITH INDIAN NORMATIVE REFERENCE  
(AGRAWAL 1998)**

***Preschool children 4 and 5 years***

Gujarati 5-year-old children were at par to an Indian reference standard developed for the same age children from affluent class belonging to Metro cities of India. This normative affluent children reference did not include cities of Gujarat because none of the cities are included in the list of metro cities of India. This reference does not include children aged 4 years. The Indian standard for mid upper arm circumference (MUAC), thigh circumference and triceps skin fold (TSF) thickness was not available for the 4 or 5-year-old child.

***6-15 year schoolchildren***

The height and weight of affluent schoolchildren from Baroda in present study was compared to an Indian Standard developed from affluent children in metro cities (Agarwal DK) as shown in Tables 8.6. to 8.9.

TABLE 8.6. THE HEIGHT PERCENTILES OF PRESENT STUDY (PS) BOYS  
 COMPARED WITH INDIAN AFFLUENT CHILDREN NORMATIVE REFERENCE

| Age | 3      |       | 5      |       | 10     |       | 50     |       | 97     |       |
|-----|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
|     | Indian | PS    |
| 6   | 103.7  | 106.2 | 105.5  | 107.7 | 106.9  | 108.7 | 114.2  | 115.5 | 125.9  | 127.9 |
| 7   | 108.5  | 112.0 | 109.8  | 112.0 | 112.0  | 115.0 | 119.7  | 121.0 | 130.8  | 135.0 |
| 8   | 113.3  | 106.5 | 114.0  | 110.4 | 116.3  | 113.8 | 123.6  | 125.0 | 135.8  | 133.4 |
| 9   | 118.0  | 123.0 | 118.5  | 124.0 | 120.9  | 127.0 | 128.2  | 134.0 | 141.4  | 145.6 |
| 10  | 122.7  | 125.8 | 123.4  | 126.0 | 125.9  | 128.0 | 133.6  | 136.0 | 147.7  | 147.0 |
| 11  | 127.5  | 125.0 | 128.5  | 127.0 | 131.2  | 132.0 | 139.6  | 142.0 | 154.3  | 157.4 |
| 12  | 132.4  | 133.0 | 133.8  | 135.0 | 136.6  | 136.2 | 145.8  | 148.0 | 160.8  | 163.5 |
| 13  | 137.4  | 138.0 | 139.2  | 139.6 | 142.0  | 141.2 | 152.0  | 151.0 | 166.9  | 168.0 |
| 14  | 142.6  | 140.2 | 144.5  | 143.8 | 147.4  | 148.0 | 157.6  | 160.0 | 172.3  | 178.1 |
| 15  | 148.0  | 145.0 | 149.8  | 150.0 | 152.4  | 155.0 | 162.5  | 166.0 | 176.8  | 181.0 |

**TABLE 8.7. THE HEIGHT PERCENTILES OF PRESENT STUDY (PS) GIRLS COMPARED WITH  
INDIAN AFFLUENT CHILDREN NORMATIVE REFERENCE**

| Age | 3      |       | 5      |       | 10     |       | 50     |       | 97     |       |
|-----|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
|     | Indian | PS    |
| 6   | 102.1  | 103.0 | 104.5  | 103.6 | 106.1  | 105.3 | 112.5  | 113.0 | 123.3  | 122.2 |
| 7   | 107.1  | 110.0 | 109.4  | 110.5 | 110.7  | 111.3 | 117.4  | 119.5 | 129.3  | 130.0 |
| 8   | 112.3  | 115.7 | 113.9  | 116.2 | 115.5  | 117.6 | 123.2  | 127.0 | 136.4  | 144.6 |
| 9   | 117.8  | 124.0 | 118.8  | 124.0 | 120.9  | 125.0 | 129.2  | 133.0 | 143.1  | 148.0 |
| 10  | 123.4  | 125.7 | 124.1  | 126.5 | 126.5  | 130.0 | 135.2  | 137.0 | 149.0  | 150.3 |
| 11  | 128.8  | 125.9 | 129.7  | 127.8 | 132.1  | 131.0 | 140.9  | 144.0 | 154.2  | 157.1 |
| 12  | 133.9  | 132.2 | 135.0  | 135.2 | 137.4  | 139.3 | 146.0  | 149.0 | 158.5  | 163.9 |
| 13  | 138.5  | 138.3 | 139.8  | 140.3 | 142.1  | 142.0 | 150.4  | 152.0 | 162.1  | 168.8 |
| 14  | 142.4  | 139.8 | 143.8  | 144.3 | 145.9  | 149.0 | 153.8  | 155.0 | 164.7  | 170.1 |
| 15  | 145.5  | 144.0 | 146.6  | 146.0 | 148.6  | 148.3 | 156.0  | 155.0 | 166.5  | 170.4 |

**TABLE 8.8. THE WEIGHT PERCENTILES OF PRESENT STUDY (PS) BOYS COMPARED  
WITH INDIAN AFFLUENT CHILDREN NORMATIVE REFERENCE**

| Age | 3      |      | 5      |      | 10     |      | 50     |      | 97     |      |
|-----|--------|------|--------|------|--------|------|--------|------|--------|------|
|     | Indian | PS   |
| 6   | 15.2   | 15.1 | 15.7   | 15.9 | 16.2   | 16.0 | 19.0   | 19.0 | 25.4   | 26.0 |
| 7   | 16.2   | 16.6 | 18.9   | 19.0 | 18.2   | 19.0 | 21.0   | 24.0 | 29.7   | 33.6 |
| 8   | 17.5   | 17.9 | 18.0   | 18.0 | 19.1   | 19.8 | 22.6   | 25.0 | 33.5   | 29.0 |
| 9   | 19.2   | 21.8 | 19.4   | 23.0 | 20.3   | 24.0 | 24.4   | 28.0 | 37.7   | 46.2 |
| 10  | 20.9   | 23.0 | 21.2   | 24.0 | 22.3   | 25.0 | 27.0   | 31.0 | 42.7   | 44.6 |
| 11  | 22.9   | 24.0 | 23.5   | 25.0 | 24.9   | 27.0 | 30.6   | 35.0 | 48.2   | 54.2 |
| 12  | 25.3   | 26.0 | 26.3   | 27.1 | 27.9   | 29.0 | 34.8   | 37.0 | 54.1   | 57.0 |
| 13  | 28.1   | 29.9 | 29.3   | 30.0 | 31.3   | 31.0 | 39.4   | 42.0 | 60.0   | 62.2 |
| 14  | 31.2   | 31.6 | 32.7   | 32.8 | 34.9   | 35.8 | 44.1   | 47.0 | 65.9   | 73.4 |
| 15  | 34.6   | 32.4 | 36.3   | 34.0 | 38.6   | 38.0 | 48.6   | 51.0 | 71.4   | 75.0 |

**TABLE 8.9. THE WEIGHT PERCENTILES OF PRESENT STUDY (PS) GIRLS COMPARED  
WITH INDIAN AFFLUENT CHILDREN NORMATIVE REFERENCE**

| Age | 3      |      | 5      |      | 10     |      | 50     |      | 97     |      |
|-----|--------|------|--------|------|--------|------|--------|------|--------|------|
|     | Indian | PS   |
| 6   | 14.1   | 14.9 | 15.2   | 15.6 | 15.7   | 16.1 | 17.8   | 19.0 | 23.7   | 26.0 |
| 7   | 14.8   | 18.0 | 15.8   | 18.7 | 16.4   | 19.0 | 19.0   | 21.5 | 27.5   | 27.0 |
| 8   | 15.9   | 18.4 | 16.4   | 19.2 | 17.2   | 20.0 | 20.8   | 25.0 | 32.3   | 41.7 |
| 9   | 17.1   | 20.1 | 17.6   | 21.5 | 18.7   | 23.0 | 23.5   | 27.0 | 37.7   | 42.7 |
| 10  | 19.5   | 23.7 | 19.7   | 24.5 | 21.0   | 26.0 | 26.9   | 32.0 | 43.4   | 44.3 |
| 11  | 22.3   | 23.9 | 22.4   | 25.0 | 24.0   | 26.0 | 30.9   | 35.0 | 49.3   | 54.6 |
| 12  | 25.1   | 27.0 | 25.6   | 28.0 | 27.3   | 30.0 | 35.0   | 39.0 | 55.1   | 56.9 |
| 13  | 27.9   | 30.5 | 28.9   | 32.0 | 30.7   | 32.5 | 39.1   | 42.0 | 60.7   | 56.5 |
| 14  | 30.7   | 33.9 | 32.1   | 34.0 | 34.0   | 35.5 | 42.7   | 45.0 | 65.7   | 66.4 |
| 15  | 33.4   | 32.4 | 35.0   | 35.3 | 36.9   | 37.3 | 45.7   | 47.0 | 70.0   | 73.2 |

### 8.6.2. Urinary iodine

#### *Preschool children (4 - 5 years)*

The median urinary iodine was 279  $\mu\text{g/l}$  thereby showing that they are iodine replete.

#### *Schoolchildren (6 - 15 years)*

The median urinary iodine in girls was 225  $\mu\text{g/l}$  (IQR = 100-401  $\mu\text{g/l}$ ) and in boys was 206  $\mu\text{g/l}$  (IQR = 100 - 415).

#### *Adults*

The median urinary iodine for all adults was 100 $\mu\text{g/l}$  but for male subjects only, it was 193  $\mu\text{g/l}$ .

### 8.6.3. Thyroid size

#### *Preschool children (4 - 5 years)*

None had palpable goitre. This shows that measuring thyroid size by palpation is difficult in this age group due to the glands being smaller.

Ultrasonographically measured thyroid volume in ml for age in for preschool *girls* (n = 51) and *boys* (n = 78) of < 5 years is shown in Tables 8.10. and 8.11.

**TABLE 8.10. THYROID VOLUME FOR AGE (ml)  
PRESCHOOL GIRLS < 5 YEARS**

| Age (n) | Mean $\pm$ SD | Median (IQR)  | 3 <sup>rd</sup> percentile | 97 <sup>th</sup> percentile |
|---------|---------------|---------------|----------------------------|-----------------------------|
| 4 (17)  | 6.9 $\pm$ 1.9 | 6.9 (5.7-8.0) | 4.5                        | 10.7                        |
| 5 (34)  | 8.0 $\pm$ 2.3 | 7.4 (5.6-9.3) | 4.5                        | 13.7                        |

**TABLE 8.11. THYROID VOLUME FOR AGE (ml)  
PRESCHOOL BOYS < 5 YEARS**

| Age (n) | Mean± SD  | Median (IQR)    | 3 <sup>rd</sup> percentile | 97 <sup>th</sup> percentile |
|---------|-----------|-----------------|----------------------------|-----------------------------|
| 4 (19)  | 6.0 ± 2.1 | 5.5 (4.3 - 7.7) | 3.1                        | 10.3                        |
| 5 (58)  | 7.9 ± 2.3 | 7.4 (5.7 - 9.5) | 4.2                        | 16.0                        |

Thyroid volumes of 4 and 5 year old children (both boys and girls) from Gujarat were much larger as compared to a 6 year old child in 1997 WHO normative reference that was a median thyroid volume of 3.2 ml in male and 2.9 ml in female. Even the 97<sup>th</sup> percentile TV in this WHO normative reference was 5.4 ml for male and 5.0 ml for girl. Thus one could conclude that very few children had no thyroid enlargement as three percent were having thyroid size below 4.5 ml.

The median and 97<sup>th</sup> percentile of TV for BSA was calculated and is shown in Table 8.12.

**TABLE 8.12. THYROID VOLUME FOR BSA  
PRESCHOOL CHILDREN**

| <b>BSA</b> | <b>FEMALES</b>      | <b>MALES</b>        |
|------------|---------------------|---------------------|
|            | <b>Median (IQR)</b> | <b>Median (IQR)</b> |
| 0.6        | 8.0 (6.8 - 8.3)     | 6.1 (4.9 - 9.3)     |
| 0.7        | 6.1 (5.4 - 7.8)     | 6.5 (5.3 - 8.4)     |
| 0.8        | 7.5 (6.9 - 9.8)     | 8.0 (6.6 - 10.0)    |
| 0.9        | 5.7 (5.2 - 6.1)     | 10.4 (7.8 - 12.7)   |

**Schoolchildren (6-15 years)**

Goitre prevalence by palpation was below 1% and by ultrasound was 85% when compared to WHO 1997 reference.

Ultrasonographic thyroid volumes percentiles for the age and BSA in a representative national sample of iodine sufficient and well-nourished affluent schoolchildren in Baroda have been described in Table 8.13., 8.14., 8.15. and 8.16. by gender.

**TABLE 8.13. THYROID VOLUME FOR AGE PERCENTILES  
MALE SCHOOLCHILDREN**

| Age<br>(n) |                  |                  |                  |                  |                  |                  | IQR                                 |
|------------|------------------|------------------|------------------|------------------|------------------|------------------|-------------------------------------|
|            | 50 <sup>th</sup> | 60 <sup>th</sup> | 70 <sup>th</sup> | 80 <sup>th</sup> | 90 <sup>th</sup> | 97 <sup>th</sup> | 25 <sup>th</sup> – 75 <sup>th</sup> |
| 6 (37)     | 8.70             | 9.70             | 10.30            | 11.00            | 13.00            | 13.9             | 7.0-10.4                            |
| 7 (41)     | 9.90             | 10.90            | 12.70            | 15.70            | 20.30            | 28.8             | 6.9-14.8                            |
| 8 (30)     | 6.60             | 8.10             | 9.65             | 11.55            | 12.40            | 18.7             | 5.2-10.6                            |
| 9 (61)     | 9.50             | 10.60            | 11.70            | 15.40            | 18.20            | 38.6             | 7.4-14.0                            |
| 10 (94)    | 11.4             | 12.10            | 13.10            | 14.60            | 19.20            | 36.0             | 8.1-13.7                            |
| 11 (161)   | 13.6             | 15.00            | 16.30            | 18.20            | 19.90            | 32.1             | 9.8-17.3                            |
| 12 (183)   | 13.3             | 14.10            | 16.10            | 17.50            | 21.50            | 37.9             | 9.8-16.8                            |
| 13 (132)   | 13.6             | 14.90            | 16.80            | 19.30            | 24.00            | 41.7             | 11.2-17.8                           |
| 14 (89)    | 16.0             | 17.50            | 19.50            | 20.80            | 23.90            | 29.7             | 12.5-19.9                           |
| 15 (81)    | 17.2             | 18.30            | 20.40            | 22.40            | 25.90            | 31.5             | 13.5-21.4                           |

**TABLE 8.14. THYROID VOLUME FOR AGE PERCENTILES  
FEMALE SCHOOLCHILDREN**

| yrs (n)  |                  |                  |                  |                  |                  |                  | IQR                                |
|----------|------------------|------------------|------------------|------------------|------------------|------------------|------------------------------------|
|          | 50 <sup>th</sup> | 60 <sup>th</sup> | 70 <sup>th</sup> | 80 <sup>th</sup> | 90 <sup>th</sup> | 97 <sup>th</sup> | 25 <sup>th</sup> -75 <sup>th</sup> |
| 6 (32)   | 8.80             | 9.60             | 10.20            | 11.80            | 12.20            | 14.7             | 6.9-10.6                           |
| 7 (34)   | 9.20             | 10.6             | 14.00            | 21.60            | 28.40            | 36.4             | 6.7-15.8                           |
| 8 (24)   | 9.65             | 11.0             | 12.50            | 13.90            | 19.20            | 31.7             | 4.8-13.6                           |
| 9 (36)   | 8.80             | 9.60             | 11.20            | 12.20            | 14.80            | 16.5             | 6.9-11.6                           |
| 10 (90)  | 11.9             | 14.0             | 15.70            | 17.85            | 21.05            | 43.2             | 8.8-16.5                           |
| 11 (116) | 13.4             | 15.1             | 15.90            | 18.70            | 26.20            | 45.2             | 9.7-16.8                           |
| 12 (103) | 14.9             | 16.0             | 17.50            | 20.60            | 26.00            | 47.6             | 11.9-18.4                          |
| 13 (76)  | 15.1             | 17.3             | 18.40            | 22.50            | 26.60            | 30.4             | 12.1-19.3                          |
| 14 (66)  | 16.5             | 17.8             | 19.20            | 20.90            | 24.10            | 32.6             | 14.9-19.6                          |
| 15 (54)  | 15.9             | 17.5             | 18.80            | 20.80            | 27.10            | 33.7             | 12.5-19.8                          |

Median TV did not increase gradually by age.

**TABLE 8.15. THYROID VOLUME (TV) FOR BSA  
MALE SCHOOLCHILDREN (6 - 15 YEARS)**

| BSA (n)<br>(m <sup>2</sup> ) | Median | 97 <sup>th</sup> p<br>observed | 97 <sup>th</sup> p |       |
|------------------------------|--------|--------------------------------|--------------------|-------|
|                              |        |                                | Estimated          |       |
|                              |        |                                | 1                  | 2     |
| 0.3 (1)                      | 13.4   | 13.4                           | --                 | --    |
| 0.7 (12)                     | 9.8    | 14.0                           | --                 | --    |
| 0.8 (36)                     | 7.9    | 11.8                           | 14.18              | 22.28 |
| 0.9 (58)                     | 9.0    | 34.7                           | 25.55              | 23.46 |
| 1.0 (105)                    | 9.0    | 19.6                           | 22.9               | 24.63 |
| 1.1 (130)                    | 11.55  | 42.7                           | 28.99              | 25.81 |
| 1.2 (154)                    | 12.0   | 25.3                           | 23.01              | 26.99 |
| 1.3 (134)                    | 14.8   | 46.7                           | 33.1               | 28.18 |
| 1.4 (97)                     | 15.2   | 39.7                           | 31.4               | 29.36 |
| 1.5 (90)                     | 16.1   | 43.5                           | 32.24              | 30.55 |
| 1.6 (42)                     | 18.7   | 30.0                           | 28.12              | 31.73 |
| 1.7 (24)                     | 17.6   | 27.4                           | 27.69              | 32.92 |
| 1.8 (16)                     | 19.55  | 33.1                           | 29.97              | 34.11 |
| 1.9 (4)                      | 17.40  | 29.6                           | --                 | --    |
| 2.0 (4)                      | 29.10  | 32.7                           | --                 | --    |
| 2.1 (2)                      | 18.9   | 20.40                          | --                 | --    |

1. Estimated from normal assumption

2. Estimated from linear model

**TABLE 8.16. THYROID VOLUME (TV) FOR BSA  
FEMALE SCHOOLCHILDREN (6 -15 YEARS)**

| BSA (n)<br>(m <sup>2</sup> ) | Median | 97 <sup>th</sup> p<br>observed | 97 <sup>th</sup> P |       |
|------------------------------|--------|--------------------------------|--------------------|-------|
|                              |        |                                | estimated          |       |
|                              |        |                                | 1                  | 2     |
| 0.7 (10)                     | 6.7    | 12.2                           | --                 | --    |
| 0.8 (35)                     | 8.7    | 14.0                           | 14.04              | 23.8  |
| 0.9 (40)                     | 9.05   | 28.4                           | 23.79              | 25.31 |
| 1.0 (74)                     | 9.25   | 38.5                           | 26.81              | 26.82 |
| 1.1 (80)                     | 11.7   | 35.7                           | 29.13              | 28.33 |
| 1.2(104)                     | 13.4   | 32.0                           | 27.41              | 29.85 |
| 1.3 (94)                     | 15.3   | 46.7                           | 31.88              | 31.37 |
| 1.4 (97)                     | 15.9   | 56.1                           | 39.98              | 32.89 |
| 1.5 (54)                     | 17.5   | 47.8                           | 35.49              | 34.41 |
| 1.6 (30)                     | 17.1   | 38.6                           | 29.64              | 35.94 |
| 1.7 (6)                      | 24.95  | 33.8                           | 40.84              | 37.47 |
| 1.8 (6)                      | 32.15  | 35.7                           | 38.91              | 39.01 |
| 2.0 (1)                      | 14.1   | 14.1                           | --                 | --    |

1. Estimated from normal assumption
2. Estimated from linear model

### 8.6.4. Thyroid volume Comparisons

The thyroid volumes for age and BSA of the present study were compared to WHO normative reference of 1997 and WHO corrected normative reference created in 2001. Eighty five percent and 81% of present study schoolchildren had enlarged thyroid volume for BSA and age, respectively in comparison to WHO normative reference of 1997. The median and upper limits (97<sup>th</sup> percentiles) of thyroid volume based on BSA and age for these children were 2 - 3 times greater than European schoolchildren in WHO reference.

The percentage of goitre-affected children (6 to 15 years) by ultrasound (in comparison to WHO, 1997 reference) is shown in Table 8.17.

**TABLE 8.17. PERCENTAGE OF GOITRE AFFECTED CHILDREN BY ULTRASONOGRAPHIC MEASUREMENT OF THYROID VOLUME**

| <i>Girls</i>  |         |  | <i>Boys</i>   |         |  |
|---------------|---------|--|---------------|---------|--|
| Age years (n) | %Goitre |  | Age years (n) | %Goitre |  |
| 6 (32)        | 97      |  | 6 (37)        | 100     |  |
| 7 (34)        | 85      |  | 7 (41)        | 81      |  |
| 8 (24)        | 67      |  | 8 (30)        | 68      |  |
| 9 (36)        | 64      |  | 9 (61)        | 79      |  |
| 10 (90)       | 69      |  | 10 (94)       | 79      |  |
| 11 (116)      | 70      |  | 11 (161)      | 80      |  |
| 12 (103)      | 75      |  | 12 (183)      | 71      |  |
| 13 (76)       | 75      |  | 13 (132)      | 55      |  |
| 14 (66)       | 76      |  | 14 (89)       | 69      |  |
| 15 (54)       | 48      |  | 15 (81)       | 59      |  |

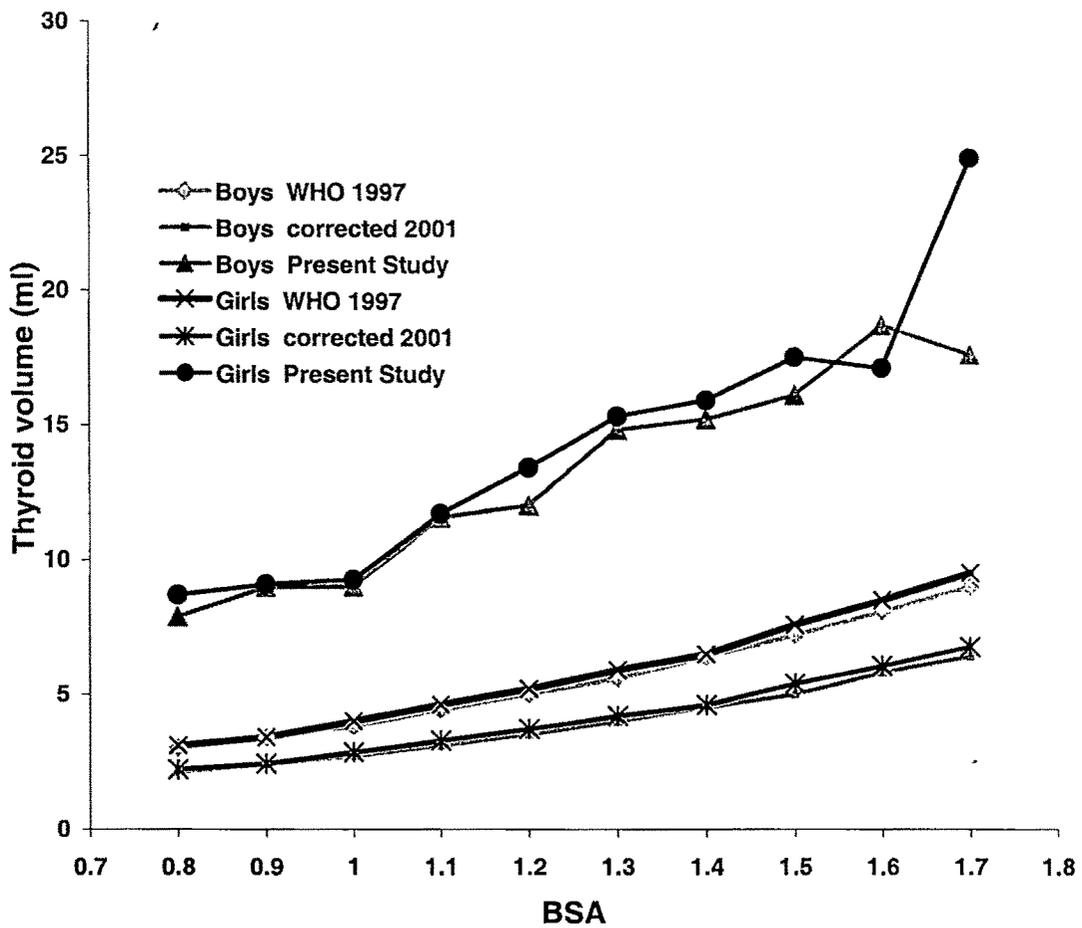
**TABLE 8.19. COMPARISON OF THYROID VOLUME FOR AGE BETWEEN PRESENT (IODINE REPLETE) AND PREVIOUS (IODINE DEplete) STUDY SCHOOLCHILDREN & WHO REFERENCE**

| Age           | Median         |         |                | 97 <sup>th</sup> percentile |         |                |
|---------------|----------------|---------|----------------|-----------------------------|---------|----------------|
|               | Iodine-replete |         | Iodine-deplete | Iodine-replete              |         | Iodine-deplete |
|               | WHO            | Present | Previous       | WHO                         | Present | Previous       |
| 6             | 3.2            | 8.70    | 21.3           | 5.4                         | 13.9    |                |
| 7             | 3.4            | 9.90    | 25.5           | 5.7                         | 28.8    |                |
| 8             | 3.7            | 6.60    | 20.8           | 6.1                         | 18.7    |                |
| 9             | 4.1            | 9.50    | 24.1           | 6.8                         | 38.6    |                |
| 10            | 4.5            | 11.35   | 28.8           | 7.8                         | 36.0    | 53.8           |
| 11            | 5.1            | 13.60   | 27.3           | 9.0                         | 32.1    | 55.8           |
| 12            | 5.7            | 13.30   | 24.6           | 10.4                        | 37.9    | 45.0           |
| 13            | 6.5            | 13.65   | 26.0           | 12.0                        | 41.7    |                |
| 14            | 7.3            | 16.00   | 25.2           | 13.9                        | 29.7    |                |
| 15            | 8.2            | 17.20   | 23.0           | 16.0                        | 31.5    |                |
| <b>Female</b> |                |         |                |                             |         |                |
| 6             | 2.9            | 8.80    | 20.8           | 5.0                         | 14.7    |                |
| 7             | 3.4            | 9.20    | 27.6           | 5.9                         | 36.4    |                |
| 8             | 3.9            | 9.65    | 22.7           | 6.9                         | 31.7    |                |
| 9             | 4.4            | 8.80    | 25.6           | 8.0                         | 16.5    | 40.0           |
| 10            | 5.0            | 11.85   | 26.0           | 9.2                         | 43.2    | 46.8           |
| 11            | 5.7            | 13.40   | 25.0           | 10.4                        | 45.2    | 58.3           |
| 12            | 6.3            | 14.90   | 26.0           | 11.7                        | 47.6    | 69.8           |
| 13            | 7.0            | 15.05   | 28.9           | 13.1                        | 30.4    |                |
| 14            | 7.7            | 16.45   | 31.1           | 14.6                        | 32.6    |                |
| 15            | 8.4            | 15.85   | 20.3           | 16.1                        | 33.7    |                |

**TABLE 8.20. COMPARISON OF THYROID VOLUME FOR BSA BETWEEN IODINE-REPLETE (PRESENT) AND IODINE-DEplete (PREVIOUS STUDY) SCHOOLCHILDREN AND WHO REFERENCE**

| BSA           | 50 <sup>th</sup> Percentiles |         |                | 97 <sup>th</sup> Percentiles |         |                |
|---------------|------------------------------|---------|----------------|------------------------------|---------|----------------|
|               | Iodine Replete               |         | Iodine-deplete | Iodine Replete               |         | Iodine-deplete |
|               | WHO                          | Present | Previous       | WHO                          | Present | Previous       |
| <b>Male</b>   |                              |         |                |                              |         |                |
| 0.8           | 3.0                          | 7.9     | 23.1           | 4.7                          | 11.8    | 44.5           |
| 0.9           | 3.2                          | 9.0     | 27.9           | 5.3                          | 34.7    | 54.7           |
| 1.0           | 3.8                          | 9.0     | 25.8           | 6.0                          | 19.6    | 47.2           |
| 1.1           | 4.2                          | 11.6    | 28.2           | 7.0                          | 42.7    | 56.2           |
| 1.2           | 4.9                          | 12.0    | 23.2           | 8.0                          | 25.3    |                |
| 1.3           | 5.4                          | 14.8    |                | 9.3                          | 46.7    |                |
| 1.4           | 6.1                          | 15.2    |                | 10.7                         | 39.7    |                |
| 1.5           | 7.0                          | 16.1    |                | 12.2                         | 43.5    |                |
| 1.6           | 8.1                          | 18.7    |                | 14.0                         | 30.0    |                |
| 1.7           | 9.0                          | 17.6    |                | 15.8                         | 27.4    |                |
| 1.8           |                              | 19.6    |                |                              | 33.1    |                |
| <b>Female</b> |                              |         |                |                              |         |                |
| 0.8           | 3.1                          | 8.7     | 25.0           | 4.8                          | 14.0    | 40.5           |
| 0.9           | 3.4                          | 9.1     | 24.2           | 5.9                          | 28.4    | 45.5           |
| 1.0           | 4.0                          | 9.25    | 27.2           | 7.1                          | 38.5    | 79.4           |
| 1.1           | 4.6                          | 11.7    | 27.4           | 8.3                          | 35.7    |                |
| 1.2           | 5.2                          | 13.4    | 31.3           | 9.5                          | 32.0    |                |
| 1.3           | 5.9                          | 15.3    |                | 10.7                         | 46.7    |                |
| 1.4           | 6.5                          | 15.9    |                | 11.9                         | 56.1    |                |
| 1.5           | 7.6                          | 17.5    |                | 13.1                         | 47.8    |                |
| 1.6           | 8.5                          | 17.1    |                | 14.3                         | 38.6    |                |
| 1.7           | 9.5                          | 24.9    |                | 15.6                         | 33.8    |                |
| 1.8           |                              | 32.2    |                |                              | 35.7    |                |

**FIGURE 8.7. COMPARISON OF THYROID VOLUME FOR BSA BETWEEN PRESENT STUDY CHILDREN (6-15 YEARS) WITH 1997 WHO INTERNATIONAL REFERENCE AND CORRECTED 2001 ZIMMERMAN REFERENCE.**



**ADULTS**

Total Goitre Rate (TGR) by palpation was 4% (14/ 358) in women and 0% in men. TGR by thyroid ultrasound was 37% in women and 60% in men (considering TV 20.0 ml as upper limit of normal). Thus the prevalence of goitre by ultrasound is very high. The detailed results are shown in table 8.21. and 8.22.

**TABLE 8.21. GOITRE BY PALPATION AND ULTRASOUND IN ALL ADULT AGE GROUPS WITH PERCENTAGE OF AFFECTED SUBJECTS IN PARENTHESES**

| Group | Males |           |            | Females |           |            |
|-------|-------|-----------|------------|---------|-----------|------------|
|       | No.   | Palpation | Ultrasound | No.     | Palpation | Ultrasound |
| I     | 133   | 0         | 70 (53%)   | 183     | 9 (5%)    | 30 (16%)   |
| II    | 64    | 0         | 51 (80%)   | 112     | 5 (5%)    | 50 (45%)   |
| III   | 14    | 0         | 8 (57%)    | 53      | 0         | 28 (53%)   |
| IV    | 04    | 0         | 4 (100%)   | 10      | 0         | 7 (70)     |

The percentage of subjects affected by goitre goes on increasing from age group one to age group IV (table 8.21.). This pointed to long exposure to goitrogens with age that has lead to the more and more people being affected. Underestimation of goitre-prevalence by palpation and inadvertently wrong declarations of no goitre endemia may affect the Government IDD control programs. This deficit can be rectified by tacit use of thyroid ultrasound in assessment and success of IDD control programs in Gujarat (India).

**TABLE 8.22. DETAILED GROUP-WISE ANTHROPOMETRIC PARAMETERS,  
URINARY IODINE AND THYROID VOLUME**

|               | I (16-19 yrs)    |                   | II (20-29 yrs)   |                  | III (30-49 yrs)  |                  | IV (50-69 yrs)   |                  |
|---------------|------------------|-------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|               | F                | M                 | F                | M                | F                | M                | F                | M                |
| <b>Weight</b> | 44<br>(40-51)    | 55<br>(50-60)     | 45<br>(40-50)    | 60<br>(53-67)    | 60<br>(51-70)    | 66<br>(55-71)    | 61<br>(58-67)    | 60<br>(55-67)    |
| <b>Height</b> | 155<br>(151-159) | 170<br>(165-174)  | 155<br>(151-160) | 169<br>(164-173) | 154<br>(149-158) | 166<br>(161-170) | 154<br>(151-155) | 163<br>(162-164) |
| <b>MUAC</b>   | 22<br>(21-24)    | 25<br>(23-27)     | 22<br>(21-24)    | 26<br>(24-28)    | 26<br>(24-28)    | 28<br>(25-30)    | 28<br>(27-30)    | 27<br>(25-28)    |
| <b>TSF</b>    | 10<br>(7-17)     | 21<br>(15-23)     | 8<br>(6-10)      | 9<br>(6-12)      | 21<br>(17-26)    | 15<br>(10-25)    | 27<br>(19-30)    | 6.5<br>(6-8)     |
| <b>TC</b>     | 41<br>(38-44)    | 45<br>(42-48)     | 40<br>(38-44)    | 47<br>(43-50)    | 50<br>(46-55)    | 48<br>(45-49)    | 55<br>(54-59)    | 44<br>(44-48)    |
| <b>BMI</b>    | 18.5<br>(17-21)  | 18.9<br>(17.5-21) | 18.5<br>(17-21)  | 21<br>(19-24)    | 25<br>(23-29)    | 24<br>(21-25)    | 26<br>(25-30)    | 22<br>(21-25)    |
| <b>BSA</b>    | 1.4<br>(1.3-1.5) | 1.6<br>(1.6-1.7)  | 1.4<br>(1.3-1.5) | 1.7<br>(1.6-1.8) | 1.6<br>(1.5-1.7) | 1.7<br>(1.6-1.8) | 1.6<br>(1.5-1.6) | 1.7<br>(1.6-1.8) |
| <b>UI</b>     | 108<br>(100-124) | 290<br>(151-496)  | 110<br>(100-190) | 207<br>(109-281) | 223<br>(100-340) | 141<br>(110-217) | 280<br>(161-370) | 108<br>(82-118)  |
| <b>TV</b>     | 18<br>(16-21)    | 20<br>(17-26)     | 19<br>(16-24)    | 28<br>(22-33)    | 21<br>(17-29)    | 22<br>(18-29)    | 22<br>(19-25)    | 25<br>(23-29)    |

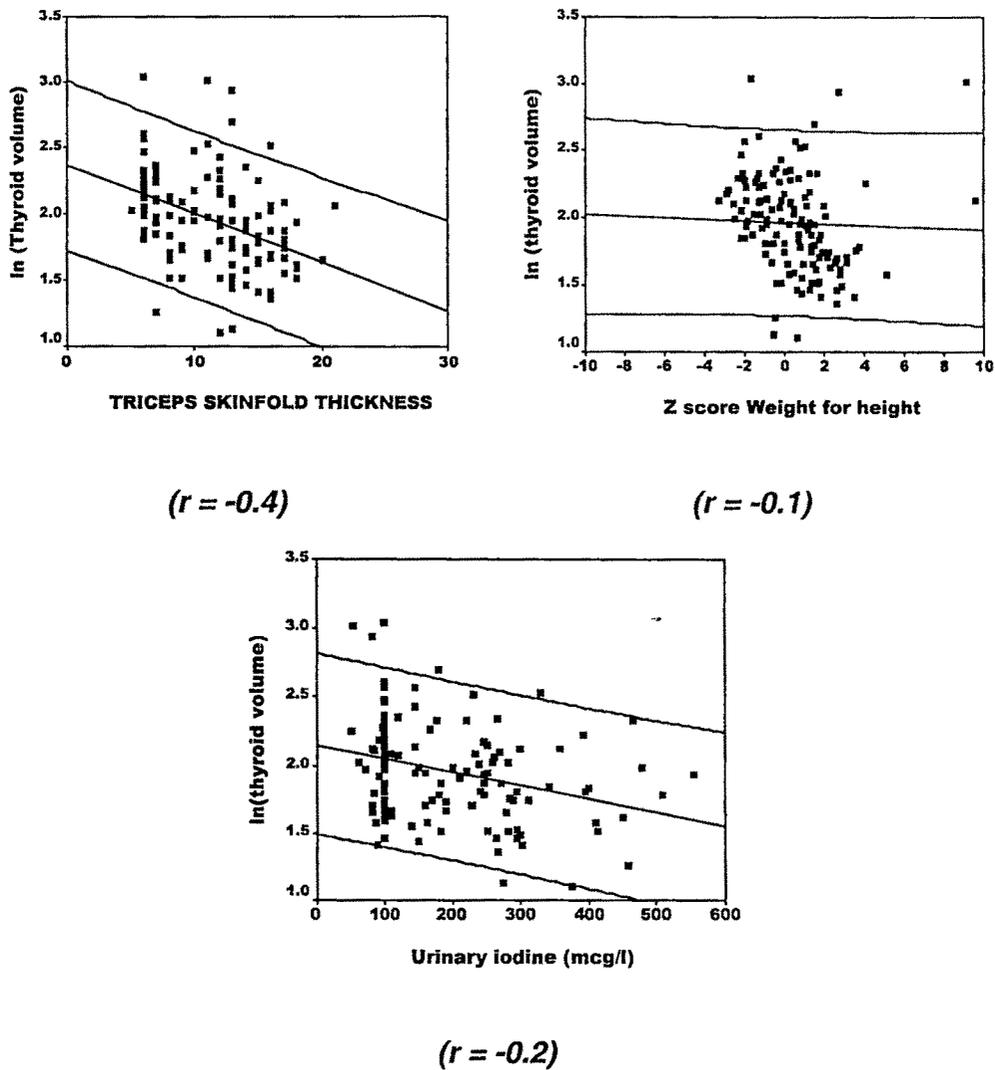
Note: these are median and interquartile values

### 8.6.5. REGRESSION ANALYSIS

#### *Preschool aged children*

Regression analysis (figure 8.8.) shows a statistically significant ( $p < 0.0001$ ) negative correlation between thyroid volume and triceps skinfold thickness ( $r = -0.4$ ) and urinary iodine levels ( $r = -0.2$ ) and weight-for-height ( $r = -0.1$ ) index.

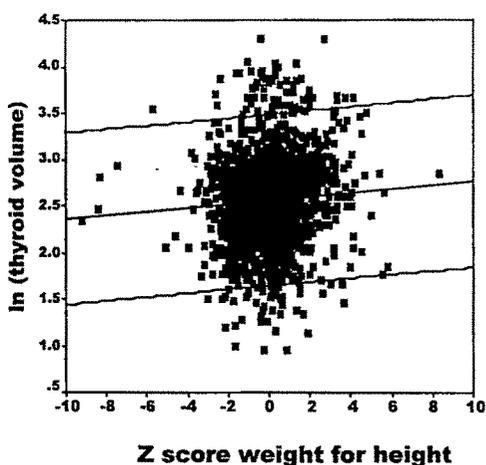
**FIGURES 8.8. REGRESSION ANALYSIS**



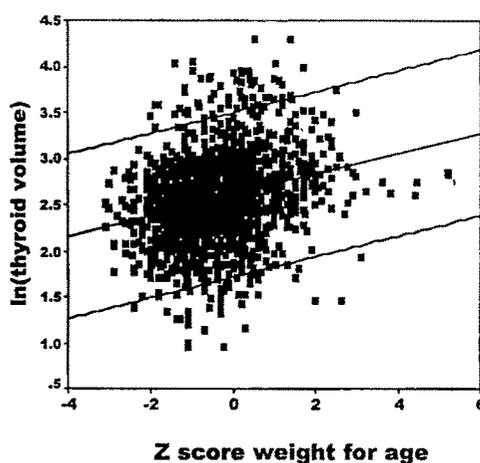
**SCHOOLCHILDREN 6-15 YEARS**

Regression analysis showed a statistically significant ( $p < 0.0001$ ) positive correlation between thyroid volume and most of the anthropometric parameters as shown in figure 8.9.

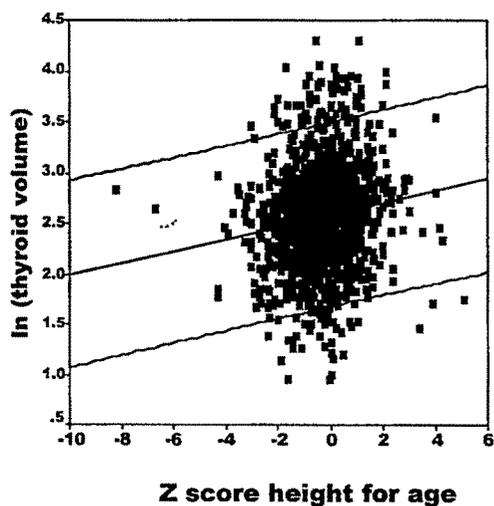
**FIGURES 8.9. REGRESSION ANALYSIS**



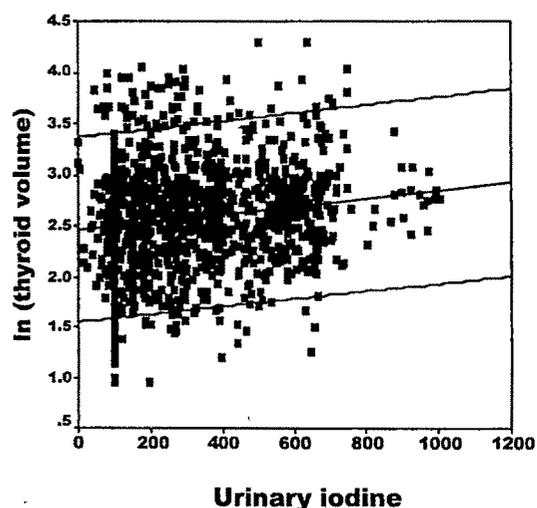
$(r = 0.1)$



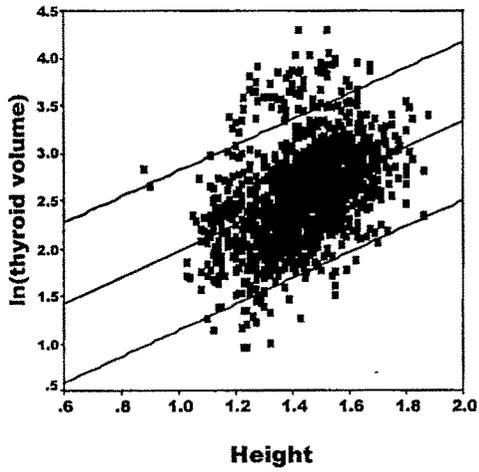
$(r = 0.3)$



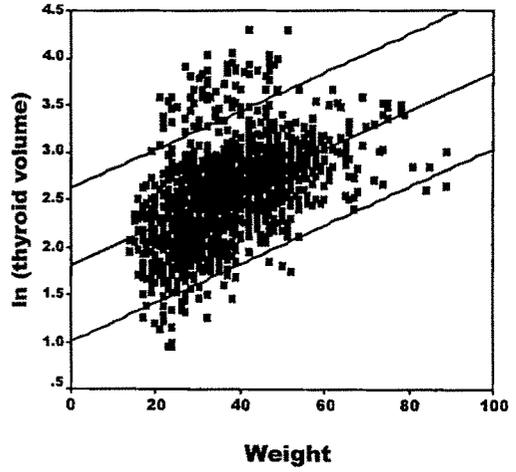
$(r = 0.15)$



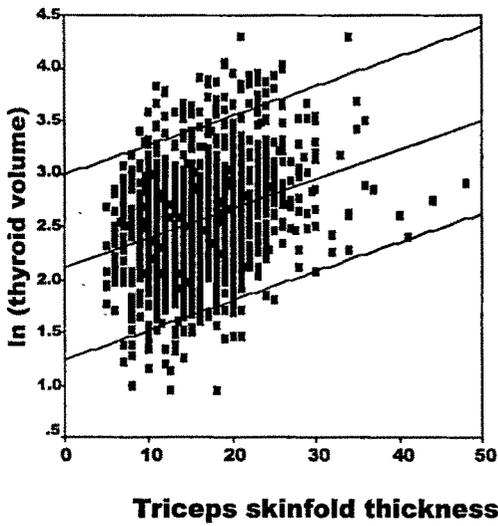
$(r = 0.2)$



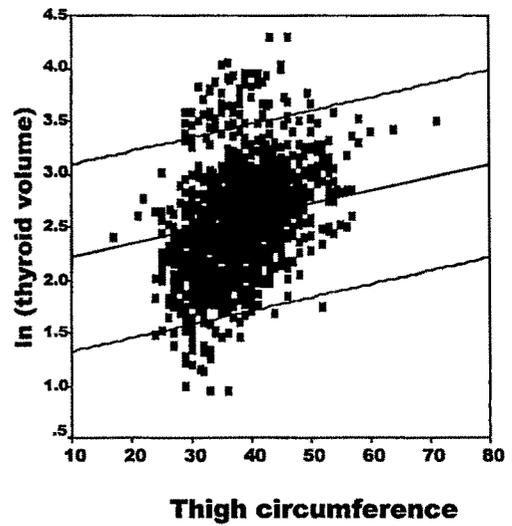
$(r = 0.4)$



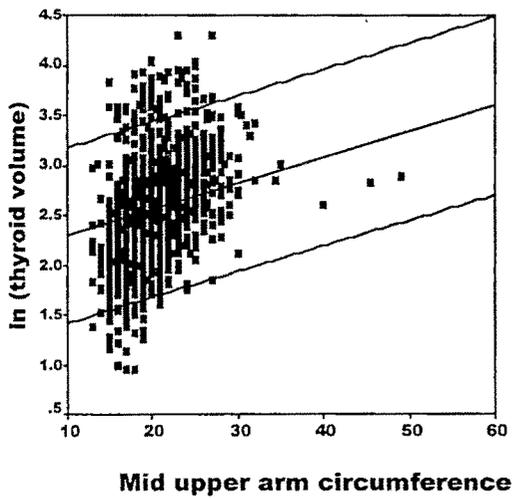
$(r = 0.5)$



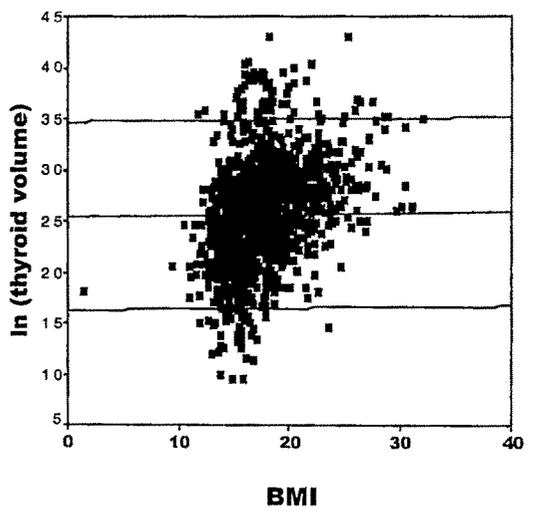
$(r = 0.3)$



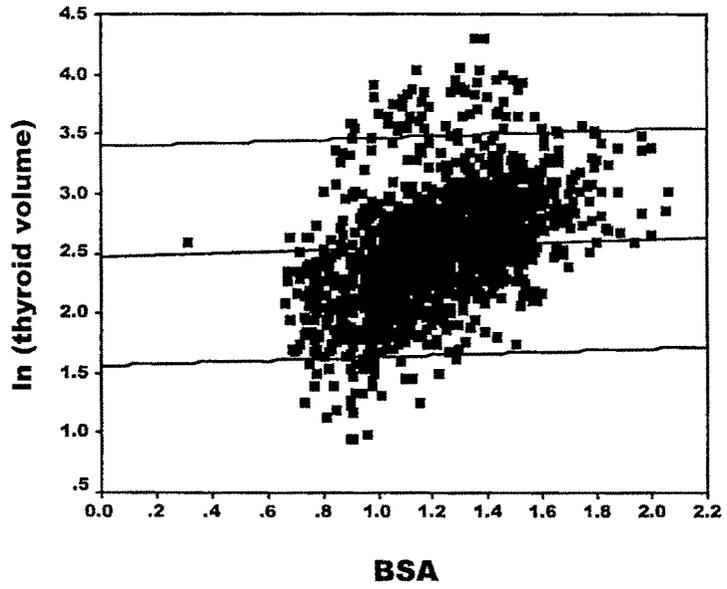
$(r = 0.3)$



$(r = 0.3)$



$(r = 0.1)$

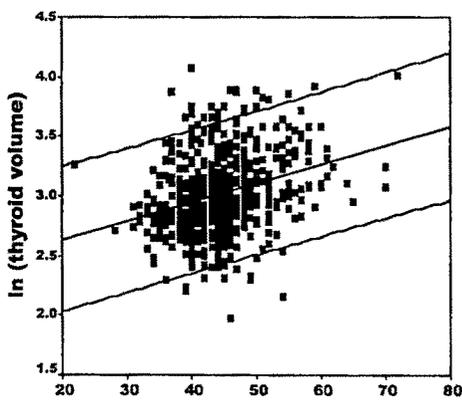


$(r = 0.1)$

**ADULTS**

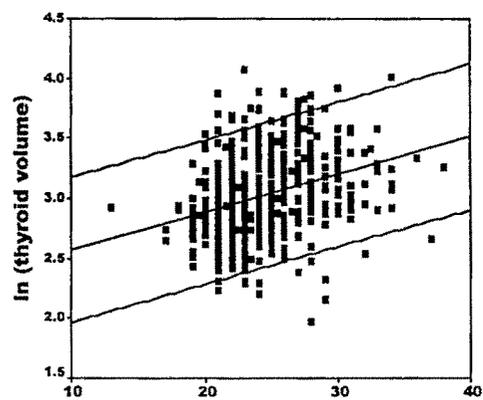
Best correlation was seen between TV and body-weight (figure 8.10.) by linear regression analysis ( $p < 0.0001$  and  $r = 0.4$ ). Thyroid volume also showed a good correlation with other nutritional parameters like TSF, TC and MUAC and BSA ( $r = 0.2 - 0.3$  and  $p < 0.0001$ ). Surprisingly no relation was seen between TV and height ( $r = 0.02$ ) and between TV and BMI ( $r = 0.05$ ) in females. BMI did show a correlation ( $r = 0.3$ ) with thyroid volume in males.

**FIGURES 8.10. REGRESSION ANALYSIS BETWEEN THYROID VOLUME AND ANTHROPOMETRIC PARAMETERS IN ADULTS**



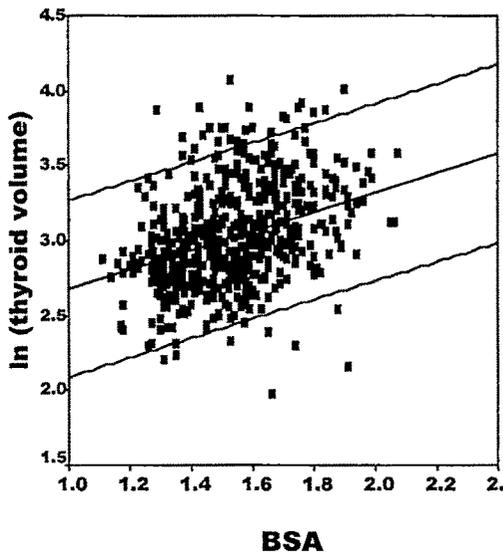
**Thigh circumference**

**( $r = 0.3$ )**

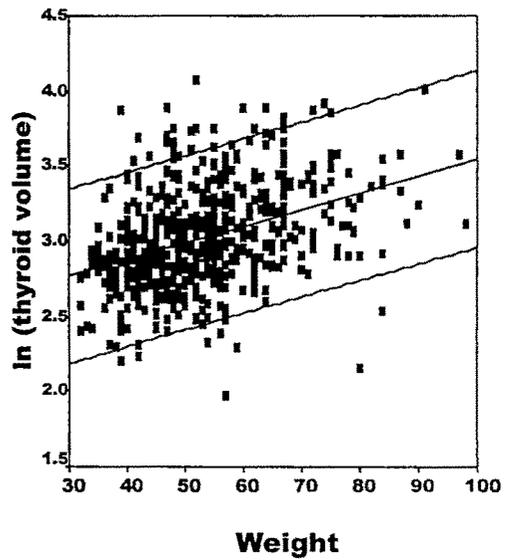


**Mid upper arm circumference**

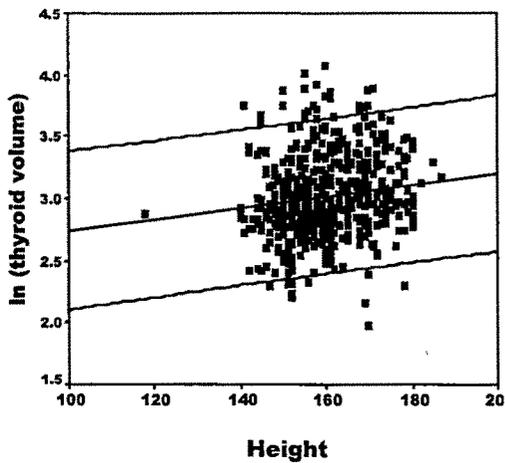
**( $r = 0.32$ )**



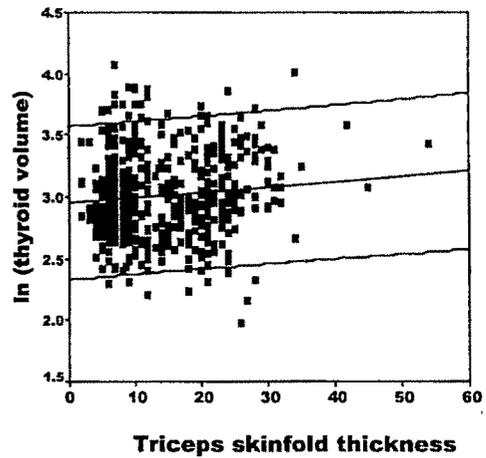
$(r = 0.4)$



$(r = 0.4)$



$(r = 0.15)$



$(r = 0.1)$

The results for the various anthropometric indices (both direct measurements and derived indices) are shown in Table 8.10.

## 8.7. DISCUSSION

The current survey in an urban environment of Gujarat shows that endemic goitre is highly prevalent in children and adults who are iodine replete and well nourished. Thyroid enlargement was however less than found in other areas of Gujarat (Tables 8.20) but above European WHO reference ranges. The most likely cause of goitre in this community is therefore the high ingestion of dietary goitrogens.

The main goitrogens consumed in this population are thiocyanate and goitrin (cruciferae, capparidaceae and resedaceae family vegetables), isothiocyanates (mustard seeds), aliphatic disulfides (onion) and a variety of different flavonoids. These were arachidoside (peanuts and milk), catechin and kaempferol (tea and all vegetables), quercetin (onion), flavenol glycosides (red kidney beans and tomato), anthocyanidin and biflavan (vegetables, cereals, tubers, bulbs, and natural pigments), genistin, daidzin, glycitein, formononetin, biochanin-A and isoflavanone (soy beans, green beans, black beans and in leguminosae family), vitexin and apigenin (pearl millet).

A tremendous gap from a public health point of view persists between the well-documented biochemical knowledge of these goitrogenic compounds and their action in human beings.

The first step in the formation of thyroid hormones (active uptake of inorganic iodide) is not compromised in these children due to competitive inhibition by thiocyanate (SCN) or aliphatic disulfides (major components of onion and garlic). This step is overcome by iodine administration and subjects used iodized salt as also evident from median urinary iodine values. However it is possible that iodine trapping mechanism efficiency was only 10 - 20% due to inverse relationship to serum I<sub>2</sub> concentration.

Isothiocyanates in mustard seeds can react spontaneously with amino acids forming di-substituted thiourea derivative, which produces a thiourea

like antithyroid effect hence these may be one of the possible mechanism responsible for goitre in these otherwise euthyroid subjects.

The second step for thyroid hormone synthesis entails the incorporation of oxidised iodine into the amino acid tyrosine –within the peptide sequence of thyroglobulin- to form mono-iodo-tyrosine (MIT) and di-iodo-tyrosine (DIT). This is organification and the process is mediated by the action of thyroidal peroxidase enzyme (TPO). Flavonoids, aliphatic Disulfides and “Goitrin” inhibit organification.

Progoitrin in Brassicae vegetables may be converted by hydrolysis to goitrin by normal GIT (large intestine and caecum) bacteria such as *Escherichia coli* and *Proteus vulgaris*. Goitrin inhibits TPO. Its action can not usually be antagonised by iodine. Goitrin (L-5 vinyl -2 thiooxazolidone) is acting like thionamide type of goitrogen such as thiourea.

Food preparation does not damage Flavonoids because they are very stable and resistant to heat, oxygen, dryness and acid but destroyed by illumination. Flavonoids present in foods were considered once non-absorbable but recent evidence indicates that may be absorbed in the large intestine after action by intestinal bacteria. It was also recently reported that the human small intestine possesses an ability to liberate the aglycone from quercetin glycosides. Nevertheless, quercetin glucosides are found to be present in human plasma without metabolic conversion (need references for all of these statements).

Acute and chronic administrations of naturally occurring and synthetic flavonoids in animal experiments have demonstrated marked effects on thyroid hormone homeostasis, metabolism and action. Flavonoids (synthetic F 21388) mimic the three-dimensional structure of thyroxine hence there is a competition for binding to transthyretin (TTR); a carrier protein in serum. Thyroxine is displaced from its binding thereby increasing free T4 levels and their transfer to cells that is followed by elimination. Whether TTR interaction with naturally occurring flavonoids or

their metabolites is of relevance in thyroid hormone physiology remains to be elucidated.

Flavonoids are potent antithyroid drugs. Well documented effects include inhibition of TSH secretion, direct inhibition of TSH, inhibition of TPO, competition for thyroid hormone binding to TTR, and potent inhibition of 5' -deiodinase activity. These multifaceted actions might represent the amazing power of active principles of these plant constituents, but also raises problems of identifying the mechanisms of action and characterizing clear pharmacological profiles.

Antithyroid effects of purified flavonoid, quercetin and rutin were investigated (Jeney et al) by oral ingestion of very small amount in water for 5 months. Thyroid weights increased whereas the iodide content of the thyroids was reduced. Histological examination demonstrated typical thyroid hyperplasia. The investigators suggested the role of flavonoids in the aetiology of endemic goitre. If such small amounts of flavonoids can cause goitre then large quantities of almost all different types of flavonoids consumed daily for many years could result in the goitre seen in these iodine sufficient and well nourished children.

The vegetables produced and consumed in Gujarat (Western India) are exclusive to those consumed in all other parts of India (north, south and East India). We are planning to carry out next study in the sub-Himalayan belt where these vegetables are not available. As Indian children weigh substantially lower and are shorter than same-age European children, it is possible that thyroid size if iodine replete, low goitrogen intake, well nourished children should be less than in the present study and below European/WHO reference ranges.

This study signals the importance of identifying all known causes of endemic goitre in population surveys for IDD and for establishing appropriate controls and normative reference data. These principles are further explored in chapter 9 in another part of India where goitrogen

consumption was low. The US data highlight the potential pitfalls of using non-validated reference ranges for thyroid size developed in other environments.

## 8.8. CONCLUSIONS

Though palpation of thyroid suggested no goitre endemia in well-nourished iodine sufficient affluent school age children, sonographic measurement showed the increased thyroid size in comparison to normative WHO reference of 1997 and the corrected recent reference of 2001.

The median thyroid volume of this study can be used for comparisons in endemic goitre area of India.

The median thyroid volume is twice or greater than that of WHO reference value. The school-age children of the present study were iodine replete and well nourished thus pointing to the possibility of consumption of different types of goitrogens (thiocyanate, isothiocyanate, goitrin, aliphatic disulfides and flavonoids) acting together for prolonged period. Quantitative and qualitative use of Flavonoids may be the most important aetiological factor in the pathogenesis of goitre.

Hence the only possible reason for enlarged thyroid in these iodine replete and well-nourished children that remains to be elucidated is the consumption of goitrogens.