Chapter 9

A SURVEY OF IODINE DEFICIENCY DISORDERS IN HIMACHAL PRADESH PRESENTS NORMATIVE THYROID VOLUME REFERENCE DATA FOR SCHOOLCHILDREN

9.1. SUMMARY

Urban schoolchildren (85%) in Gujarat State, Western India, showed increased thyroid volume (chapter 9), mainly due to the consumption of goitrogens mainly flavonoids. As there is regional dietary variation in all the States of India, a state other than Gujarat from North India was selected. Himachal Pradesh State (HP) was a goitre endemia for 40 years and the Government introduced mandatory salt iodisation in 1970. This State was declared as iodine sufficient in 1999.

Present study was conducted to establish normative thyroid volume reference data in iodine sufficient and well-nourished schoolchildren from Shimla, the Capital City of HP.

The vegetables and cooking-oils consumed in this mountainous area are different to those used in Gujarat. The study was performed on affluent students of two schools in Shimla. The 6 - 15 and 16 - 19 years aged

schoolchildren were 626 (M: F = 2) and 116 (M: F = 9) in number respectively. The subjects were on a mixed diet. All were palpated first for goitre and the thyroid volume (TV) was measured ultrasonographically using a 7.5 MHz probe. Urine samples were collected for iodine (UI) measurement (Method L). Anthropometric measurements were performed. BSA, BMI and Z score for weight-for-age, height-for-age, and weight-for-height and BMI were derived. Medians and 97th percentiles thyroid volumes of 6 - 15 year children were compared to both WHO references of 1997 and 2001.

We found that the nutritional status of children was comparable to Indian normative reference developed from metro cities affluent schoolchildren. WHO based classification showed 4% of boys were either stunted or undernourished. Their thyroid size was not enlarged. Goitre prevalence by palpation was 1% and by ultrasound 0%. The median and 97th percentiles for TV estimated for age and BSA by gender were much smaller (almost one third to one half) than European schoolchildren of WHO 1997 or the corrected 2001 reference. By comparison thyroid size for BSA and age was greater in iodine sufficient children from Gujarat (Table 1). The median UI for 6 - 15 year schoolchildren and > 15 year subjects was 201.5 μg/l and 209 μg/l respectively.

The present study of thyroid volume normative data from Indian iodine-replete and well nourished (nutritionally at par with WHO reference) children residing in mountainous sub- Himalayan belt shows that their thyroid size was almost one third to one half in comparison to corrected WHO reference (2001). This may be due to the mandatory salt iodisation policy imposed by the State Government or due to hypoxia prevailing in hilly regions. This study establishes the normative data for thyroid size in India.

9.2. INTRODUCTION

The normative thyroid volume reference adopted by World Health Organization is based on the European children. The various scientists all over the world have developed their own normative thyroid volume references and compared them to WHO international reference. The thyroid volumes of schoolchildren from USA, Malaysia and Switzerland were much smaller compared to WHO international reference. Zimmerman et al suggested a correction factor in 2001 for the original WHO 1997 reference that brought these values down. The scientists from most of the developing countries have not yet established normative thyroid volume reference values for their respective countries and still rely on the WHO reference values for comparison. WHO/UNICEF/ICCIDD (1994) have anticipated smaller thyroid volumes in developing countries because of relatively smaller body frame and weight of these children compared to their western counterparts as the thyroid size depends upon the human body size. But the question *" What would be the thyroid size of schoolchildren in the developing country if children's height and weight is not too different from European children and they are nutritionally at par with European children?"* remains unanswered.

India has endemic goitre and cretinism as a major wide spread public health problem over the broad region of Himalayan and sub-Himalayan belt. One survey estimated that 200 million people in India were exposed to the risk of iodine deficiency, and 70 million suffered from goitre and other IDD (IDD & Nutrition Cell, 1998).

Himachal Pradesh (HP) is a hilly and mountainous State located on the northwest of the country (Figure 3.3. in chapter 3). State is wrapped in snow most of the time as it is nestled in the Himalayas, and constitutes 10.54% of the Himalayan landmass. The State is known as Fruit Bowl (Apple stone and citrus fruits) of India. Himachal Pradesh State (HP) was a goitre endemia for last 40 years and the Government introduced

mandatory salt iodisation in 1970. Recently this State is declared as iodine sufficient.

Prevalence of goitre, which was quite high previously in Shimla (41.6% in 1974) came down to 2 - 13% in 1996 for various age groups as per Nutritional Survey carried out by Department of Women and Social Welfare in HP. During 1999 - 2000, 1,17,699 samples of salt were analyzed out of which only 78 samples were found to be without Iodine.

9.3. BACKGROUND

Previous studies of affluent schoolchildren from Baroda in Gujarat State, Western India, showed increased thyroid volume for age in 85% in comparison to WHO adopted international reference. This might be mainly due to the consumption of flavonoids in pearl millet, fruits or vegetables and other goitrogens such as disulfides, goitrin, thiocyanates. As there is regional dietary variation in all States of India, a State other than Gujarat from North India was selected for this study. The dietary habits of the subjects in Himachal Pradesh (HP) were different from that of Gujarat. The availability of many types of vegetables and cereals was restricted due to the place being far away from plain lands.

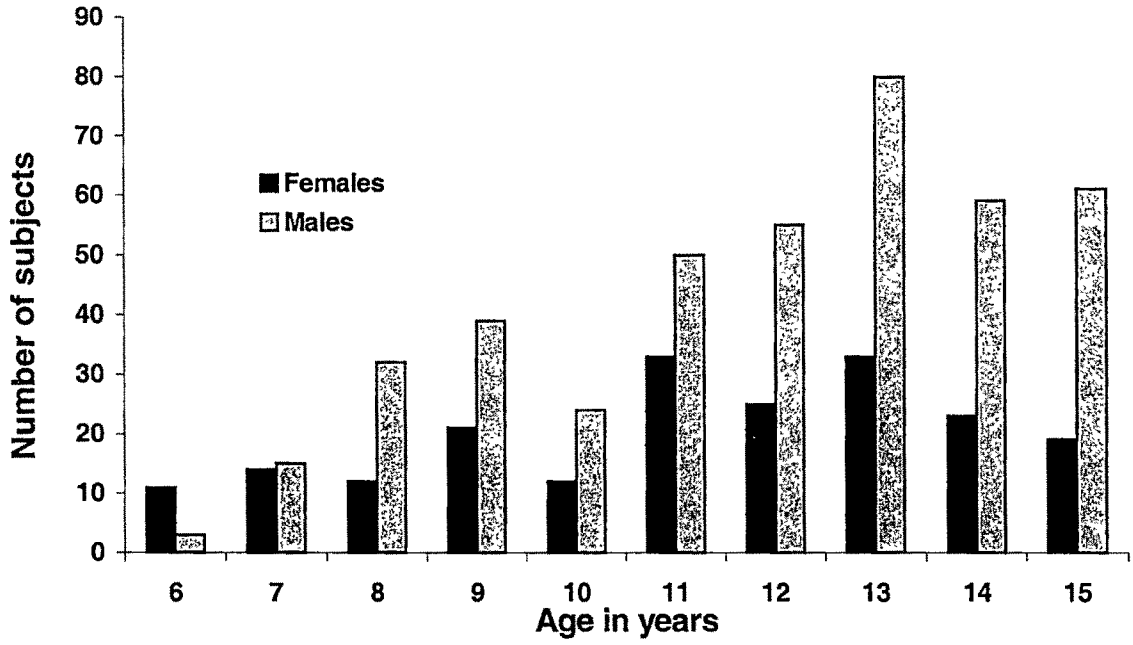
The cooking oils used were different. In Gujarat mainly groundnut oil is used whereas in HP State Sarson and sunflower oils are used for cooking.

As shown in chapter 3, there are 12 districts in HP State and Shimla is the Capital. It was discovered in 1819 on the altitude of 2159 meters and was declared as "summer capital" of India."

9.4. SUBJECTS

The schools selected for study were private boarding schools (Shimla Public School and Cotton Bishop School) for rich and affluent children. SPS charged rupees 50,000-60,000 whereas CBS charged rupees 1,20,000 per year for lodging and boarding the child. These schools had children from most of the States in North India thus providing almost near national sample. The 6 - 15 year old schoolchildren were 621 in number and the male children were more than twice the female children (M: F = 2). Their age distribution is shown in figure 9.1.

FIGURE 9.1. AGE DISTRIBUTION



16 - 19 years aged children belonging to higher secondary section were 116 (M: F = 9) in number. This wide difference in ratio of males to females is mainly due to orthodox parent thinking that gives preference to male's good education in costly private boarding schools.

9.5. DIET

The children were on a mixed diet consuming both vegetarian and nonvegetarian food. The main vegetables consumed were common like okra beans, spinach, cauliflower, eggplant, beans, potato, onion and tomato. The pulses like moong, rajma and udad dal were used frequently. Twice a week one nonvegetarian dish like chicken and goat meat was also provided to the children. The cereals used are mainly wheat and rice. Pearl millet was not consumed at all but maize flour pancakes were consumed by children once a while. The main fruits were apple and litchis.

9.6. RESULTS

The detailed general results of various directly measured anthropometric parameters and the calculated indices (body mass index and body surface area) in 6 - 15 year old schoolchildren are shown in Table 9.1.

TABLE 9.1. RESULTS (6-15 YEAR SCHOOLCHILDREN)

Parameter	Girls		Boys	
	MEDIAN	IQR	MEDIAN	IQR
Body surface area	1.2	(0.96-1.4)	1.27	(1.1-1.46)
Body mass index	15.8	(13.9-18.1)	17.4	(15.5-19.5)
Triceps skin fold thickness	20	(16-24)	17	(13-20)
Thigh circumference	39.5	(34.5-43.3)	39.8	(36.5-43.5)
Mid upper arm circumference	19.5	(17-21.8)	20.5	(18.5-22.5)

IQR = Interquartile range

9.6.1. WHO classification (chapter 3.4.2.1.)

6 - 15 year

Girls were affected more by malnutrition than the boys. Six percent of the girls and 3% of boys were stunted. Undernutrition (weight for age Z-score was < - 2.0) was seen in 11% of girls and 4% of boys. The wasting in boys and girls was accompanied by 100 percentile WHO HAZ score.

Thus the children were more or less at par with WHO standard data as this standard also has at least 2.5% of children below – 2 Z score.

16 - 19 year

Stunting and undernutrition was seen in 11% (1/ 9) girls. The wasting and undernutrition was not seen in girls of this age range. Only 4% (4/ 104) of the boys were stunted and 4% were undernourished. None of the boys showed wasting.

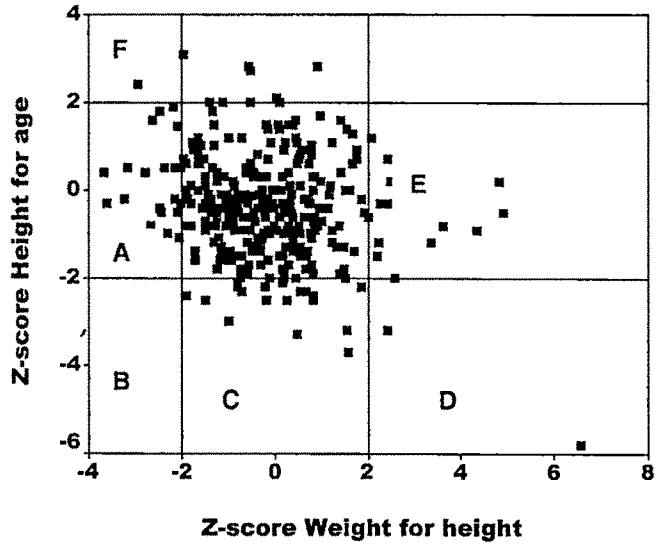
9.6.2. Waterlow classification scheme

Figure 9.2. **A** shows that none of the schoolchildren (6 - 15 years) were stunted and wasted together. Only a small number of children was either stunted or wasted. Seven percent of girls were stunted with low BMI in 6% but high BMI in one percent. None of the stunted boys was obese. The wasted boys had 100 percentile WHO standard for height for age z-score range.

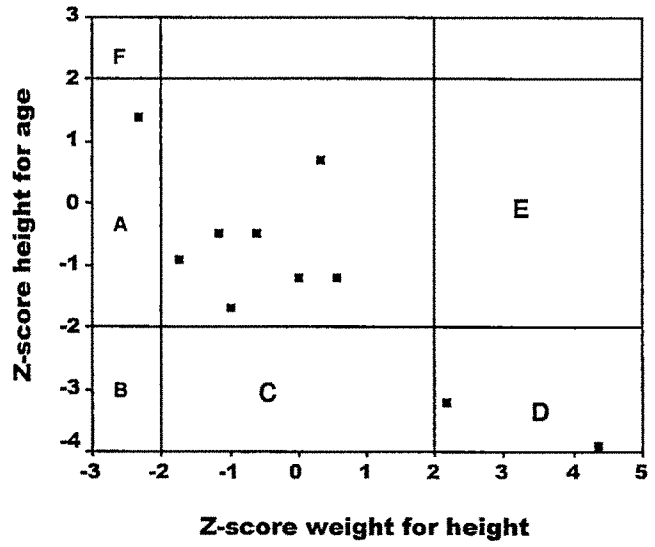
Figure 9.2. **B** shows the threshold of malnutrition in schoolchildren aged 16-19 years. Stunted girls had high BMI > 20.0. Wasting was 0% in both, girls and boys. 4% of stunted or undernourished boys had higher BMI i.e. > 20.0

FIGURE 9.2. WATERLOW CLASSIFICATION

A. 6-15 YEAR SCHOOLCHILDREN



B. 16-19 YEAR SCHOOLCHILDREN



9.6.3. Urinary Iodine (UI)

6 - 15 year old schoolchildren

The mean and the median UI for all the children in this age group was 236 ± 111 µg/l and 204 µg/l respectively.

Girls had a median UI (interquartile range) of 191 (136 - 266) µg/l.
Boys had a median UI (interquartile range) of 212 (172 - 314) µg/l.

16 - 19 year old schoolchildren

Girls had median UI (interquartile range) of 151 (130 - 223) µg/l.
Boys had median UI (interquartile range) of 199 (152 - 290) µg/l.

All the schoolchildren were iodine replete.

9.6.4. Thyroid size

9.6.4.1. PALPATION

6 - 15 year schoolchildren

Girls:
Only one girl had palpable goitre of grade 1.

Boys:
Four boys were palpable for goitre grade 1. The type of goitre was simple and diffused. One boy had 2 cysts in the left thyroid lobe and one diffuse cyst in the right lobe.

16 - 19 year schoolchildren

None of the girls had palpable goitre but one boy had a palpable goitre that was simple diffused type of the goitre having multiple cysts.

9.6.4.2. ULTRASONOGRAPHY

6 - 15 year schoolchildren

The median and 97th percentile thyroid volume values for BSA and age by gender are shown in Table 9.2. and 9.3. These values were compared to WHO references; 1997 and corrected 2001.

The median thyroid volume values for BSA of our children were less than one half to those of WHO 2001 values as shown in Figure 9.3.

The 97th percentile thyroid volume values for BSA were approximately two thirds to WHO 2001 values as shown in figure 9.4.

The 97th percentile thyroid volume values for age were also approximately two thirds to WHO 2001 values as shown in figure 9.5.

16-19 year schoolchildren

The median thyroid volume for age was 2.5 ml in boys and 2.1 ml in girls whereas 97th percentile thyroid volume for age was 5.0 ml in boys and 3.3 ml in girls.

TABLE 9.2. COMPARISON OF PRESENT STUDY THYROID VOLUME FOR BSA WITH WHO 1997 REFERENCE AND THE CORRECTED 2001 REFERENCE (ZIMMERMAN ET AL)

	Median			97th percentile		
BSA	**Present**	**WHO 1997**	**Corrected 2001**	**Present**	**WHO 1997**	**Corrected 2001**
Male						
0.8	0.9	3.0	2.1	2.1	4.7	3.3
0.9	1.0	3.4	2.4	2.6	5.3	3.8
1.0	1.1	3.8	2.7	2.8	6.0	4.3
1.1	1.3	4.2	3.0	3.1	7.0	5.0
1.2	1.4	4.9	3.5	3.4	8.0	5.7
1.3	1.5	5.4	3.8	3.7	9.3	6.6
1.4	1.7	6.1	4.3	4.2	10.7	7.6
1.5	1.9	7.0	5.0	4.6	12.2	8.7
1.6	2.1	8.1	5.8	5.1	14.0	9.9
1.7	2.3	9.0	6.4	5.6	15.8	11.2
1.8	2.5			6.2		
1.9	2.8			6.8		
Females						
0.8	1.0	3.1	2.2	2.4	4.8	3.4
0.9	1.1	3.4	2.4	2.6	5.9	4.2
1.0	1.2	4.0	2.8	2.9	7.1	5.0
1.1	1.3	4.6	3.3	3.2	8.3	5.9
1.2	1.4	5.2	3.7	3.5	9.5	6.7
1.3	1.6	5.9	4.2	3.9	10.7	7.6
1.4	1.8	6.5	4.6	4.4	11.9	8.4
1.5	1.9	7.6	5.4	4.7	13.1	9.3
1.6	2.2	8.5	6.0	5.4	14.3	10.2
1.7	2.4	9.5	6.7	5.8	15.6	11.1

TABLE 9.3. COMPARISON OF THYROID VOLUME FOR AGE BETWEEN PRESENT (IODINE REPLETE), PREVIOUS (IODINE DEPLETE) STUDY AND WHO (2001 REFERENCE)

Age	Median			97th percentile		
	Present Shimla	Corrected 2001	Previous (Gujarat)	Present Shimla	Corrected 2001	Previous (Gujarat)
Males						
6	**1.0**	2.3	*8.7*	**2.4**	3.8	*14.0*
7	**1.0**	2.4	*9.9*	**2.6**	4.0	*29.0*
8	**1.8**	2.6	*6.6*	**2.8**	4.3	*19.0*
9	**1.5**	2.9	*9.5*	**3.1**	4.8	*39.0*
10	**1.3**	3.2	*11.0*	**3.4**	5.5	*14.0*
11	**1.3**	3.6	*14.0*	**3.5**	6.4	*32.0*
12	**1.4**	4.0	*13.0*	**3.7**	7.4	*38.0*
13	**1.6**	4.6	*14.0*	**4.4**	8.5	*42.0*
14	**2.0**	5.2	*16.0*	**4.9**	9.9	*29.0*
15	**2.8**	5.8	*17.0*	**7.8**	11.4	*32.0*
Females						
6	**1.0**	2.1	*8.8*	**2.3**	3.6	*15*
7	**1.0**	2.4	*9.2*	**2.5**	4.2	*36*
8	**1.0**	2.8	*9.7*	**2.7**	4.9	*32*
9	**1.4**	3.1	*8.8*	**3.0**	5.7	*17*
10	**1.6**	3.6	*11.9*	**3.3**	6.5	*17*
11	**1.4**	4.0	*13.4*	**3.5**	7.4	*45*
12	**1.5**	4.5	*14.9*	**3.9**	8.3	*48*
13	**2.1**	5.0	*15.1*	**4.3**	9.3	*30*
14	**1.8**	5.5	*16.5*	**4.6**	10.4	*32*
15	**1.6**	6.0	*15.9*	**5.1**	11.4	*34*

FIGURE 9.3. COMPARISONS OF MEDIAN THYROID VOLUME FOR BSA

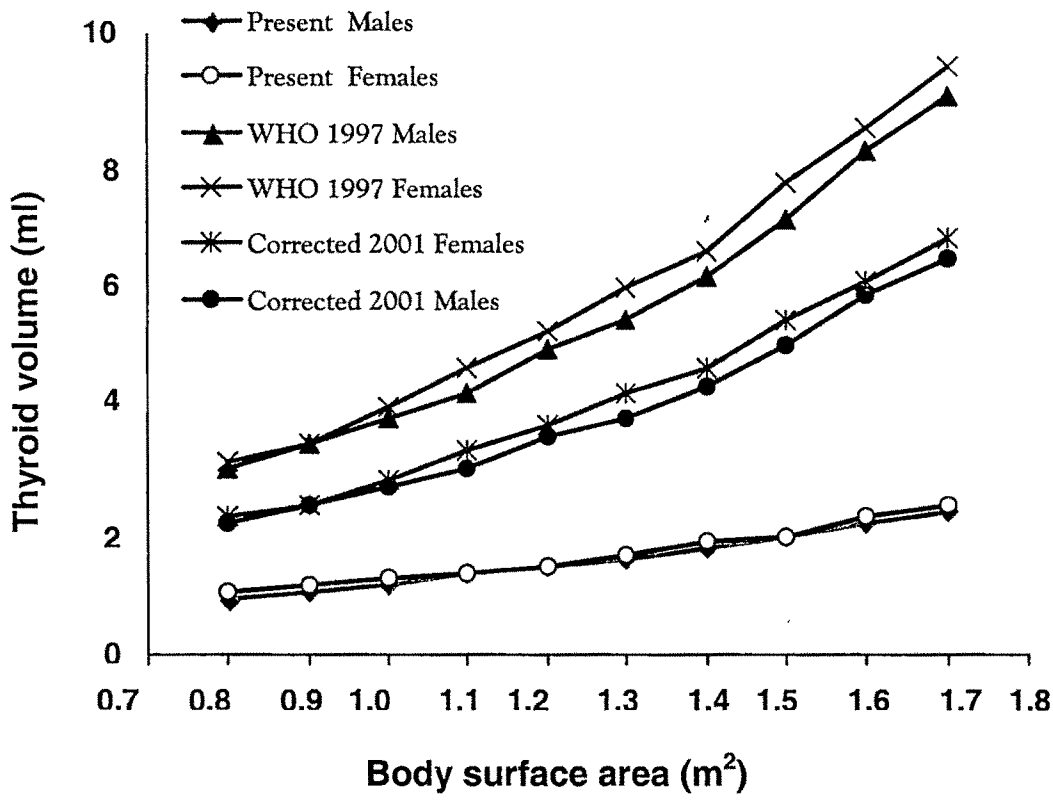


FIGURE 9.4. COMPARISONS OF THYROID VOLUME FOR BSA (97th PERCENTILES)

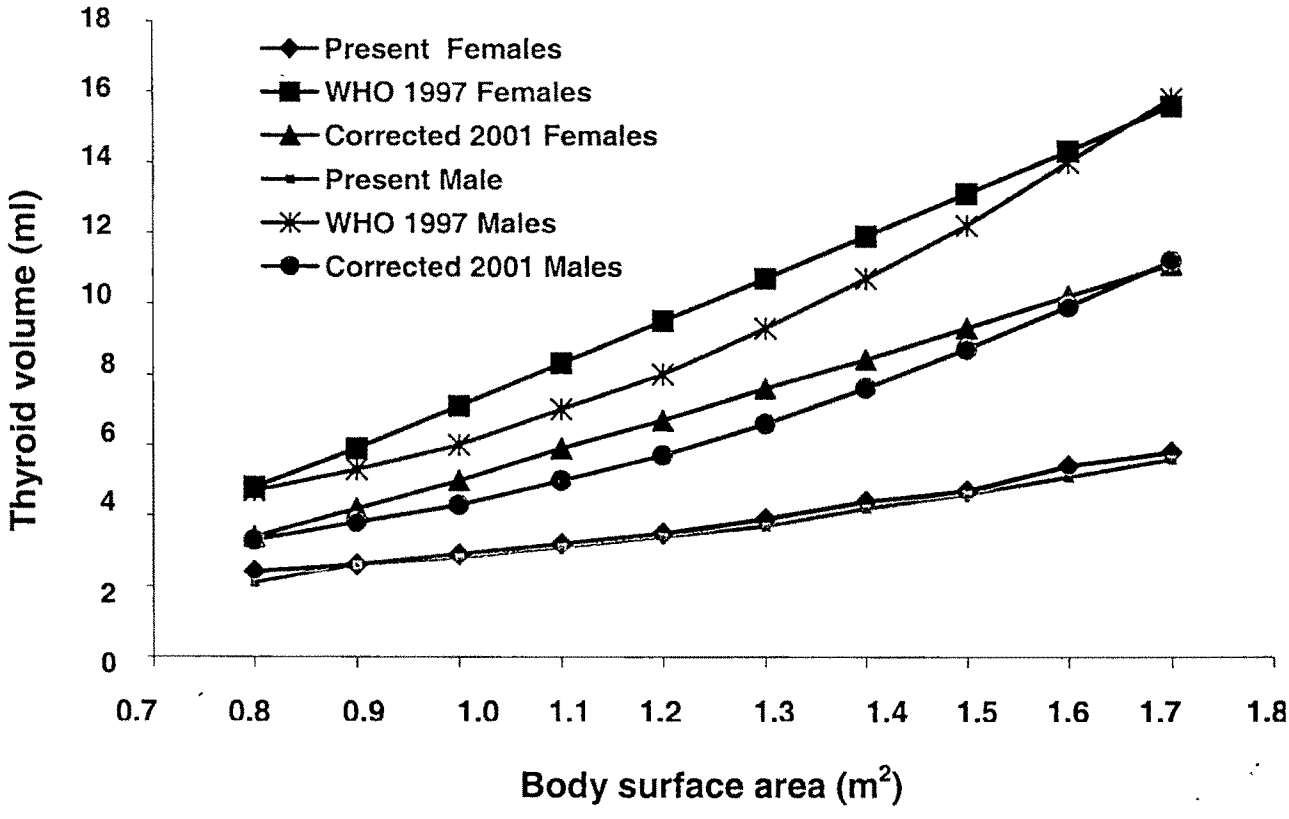
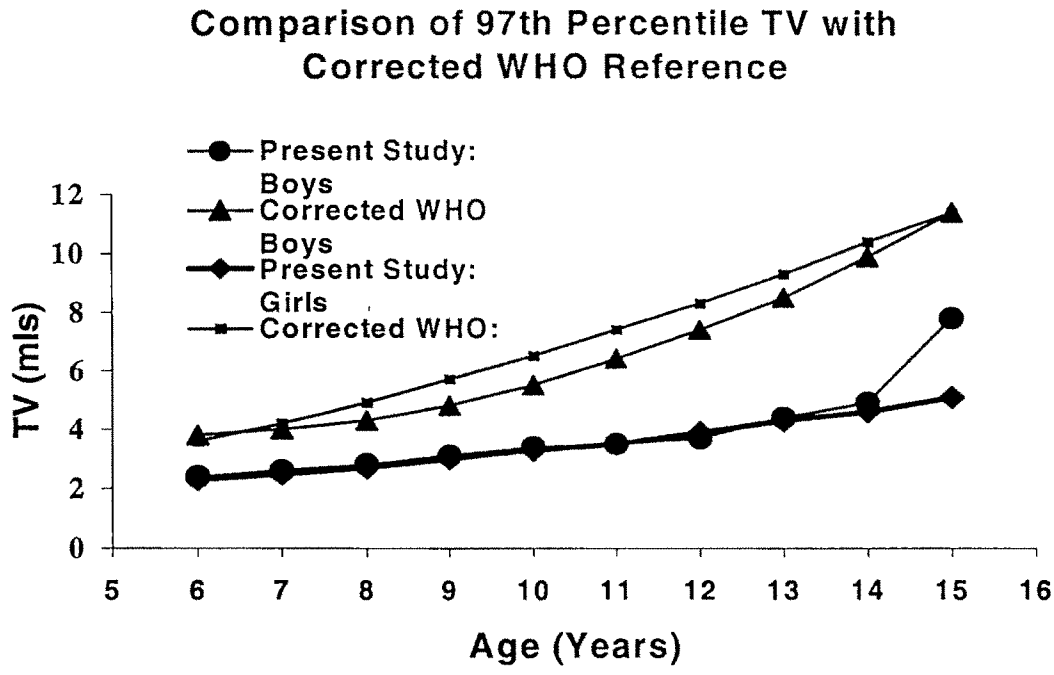


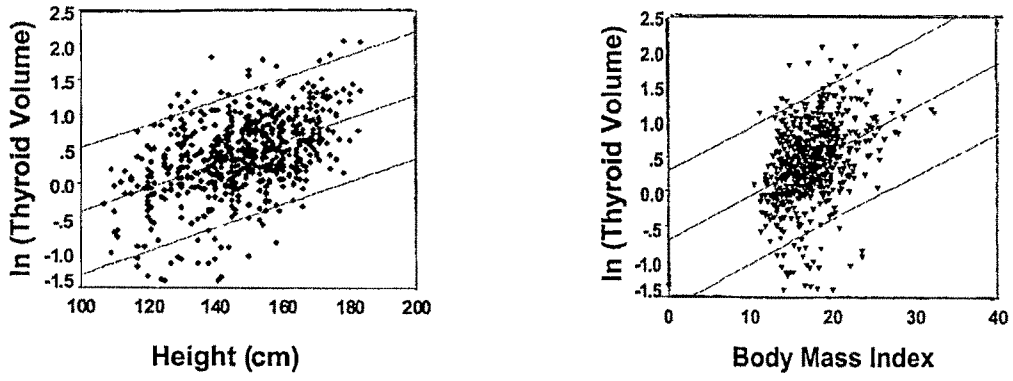
FIGURE 9.5. COMPARISONS OF THYROID VOLUME FOR AGE (97th PERCENTILES)

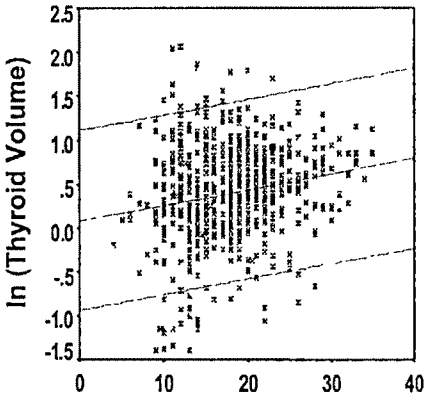


9.6.5. Regression analysis

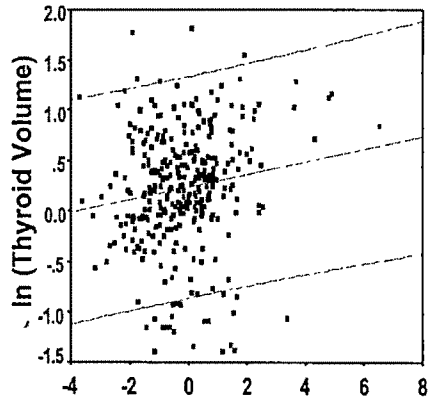
Logarithmic thyroid volume regression showed a good significant ($p < 0.05$) positive correlation ($r = 0.5$) with all the anthropometric parameters like weight, height, BSA, thigh circumference, mid upper arm circumference. It showed a weak but significant correlation ($r = 0.2$) with urinary iodine and z scores for weight for age, height for age and weight for height (Figure 9.6.).

FIGURE 9.6. REGRESSION ANALYSIS

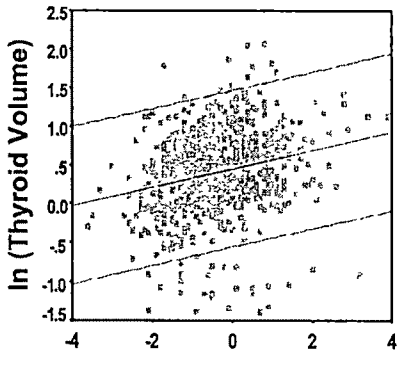




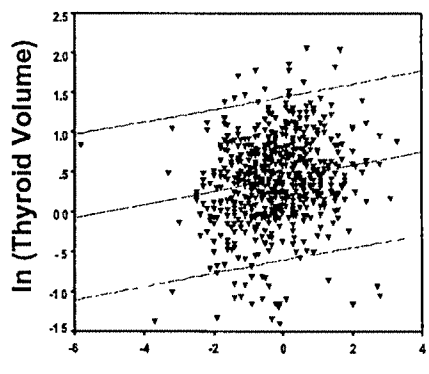
Triceps skin fold thickness



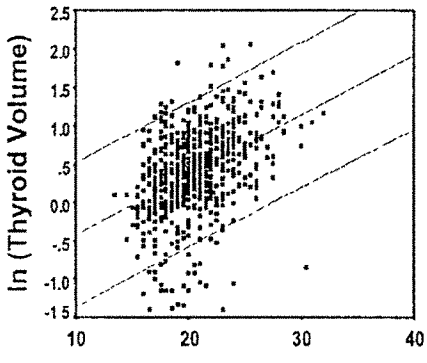
Z-score weight for height

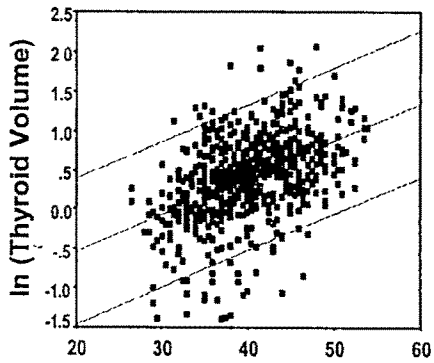


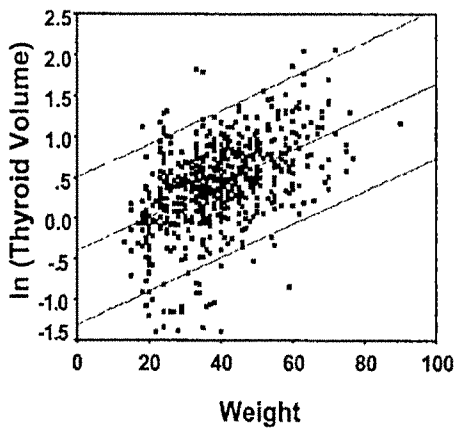
Z-score weight for age



Z-score weight for age


ln (Thyroid Volume)
2.5
2.0
1.5
1.0
.5
0.0
-.5
-1.0
-1.5
10
20
30
40
Mid upper arm circumference


ln (Thyroid Volume)
2.5
2.0
1.5
1.0
.5
0.0
-.5
-1.0
-1.5
20
30
40
50
60
Thigh circumference


ln (Thyroid Volume)
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.5
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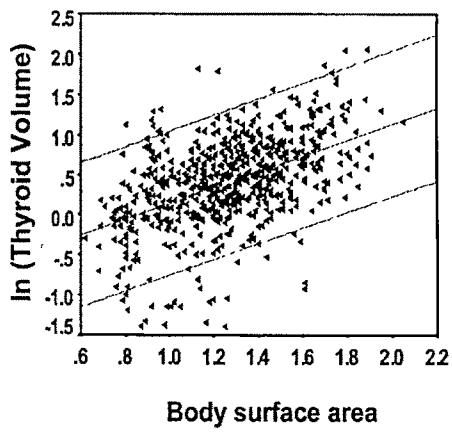
-.5
-1.0
-1.5
0
20
40
60
80
100
Weight


ln (Thyroid Volume)
2.5
2.0
1.5
1.0
.5
0.0
-.5
-1.0
-1.5
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Body surface area

9.7. DISCUSSION

The present study has established the thyroid volume normative data from Indian iodine-replete and well-nourished (nutritionally at par with WHO reference) children. Though these children were residing in mountainous sub- Himalayan belt, their thyroid size was almost one third to one half in comparison to corrected WHO reference (2001) thereby showing that

1. This, once upon a time severe iodine deficient belt, is no more iodine deficient.
2. The children from developing country on par with European children in nutritional status can have small thyroid size (one usually expects that children from developing country would have smaller body size and therefore a smaller thyroid size) and
3. The mandatory salt iodisation helps in controlling and eradicating IDD.

Thus, thyroid size varies always with iodine deficiency and may not vary according to body size always when primary iodine intake is sufficient with no secondary iodine deficiency caused by goitrogens as seen in chapter 8, though there is usually a good correlation between thyroid volume and height and weight.

On the other hand under iodine deficiency circumstances (both primary due to lack of iodine intake in the form of iodine supplementation in the diet and secondary due to non-availability of iodine for incorporation in to thyroid hormones due to goitrogen intake), smaller body size (due to the impact of malnutrition) can have greater thyroid size.

This smaller thyroid size of these children may be due to the mandatory salt iodisation policy imposed by the Himachal Pradesh Government for last 32 years.

There was limited use of flavonoids that form a structural part of coloured vegetables and fruits. The place being on the hilly mountainous area had restrictions on availability of fresh green leafy and other vegetables.

The lower range of normative thyroid volume may also be due to hypobaric hypoxia prevailing in hilly regions. The hypoxia stress produces marked elevation in plasma thyroxine and triiodothyronine that are maintained during the entire exposure on altitude. Plasma TSH does not change significantly at high altitudes thereby suggesting that elevation in thyroid hormones was TSH independent (Sawhney RC et al, 1991). The hypoxic and post hypoxic states can also increase the accumulation of iodine in experimental subjects that is unique with multiple short and sharp duration peaks of iodine uptake by the thyroid gland thus reflecting an increased rate of iodine release from the thyroid (Rawal SB, 1993). Shimla was on the altitude of 2000 meters hence hypoxia may not prevail and this possibility may not be the cause for smaller thyroids.

CONCLUSIONS

This study establishes the normative data for thyroid size in a part of India that was long ago a goitre endemic area.