C H A P T E R III

RESULTS AND DISCUSSION

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Section A

COMPARATIVE STUDIES ON POOR CHILDREN IN RAIPURA VILLAGE AND UPPER CLASS CHILDREN IN URBAN BARODA

Physical stature:

As mentioned earlier, comparative studies were undertaken on the nutritional status of children in Raipura and upper class children in Baroda whose intakes of critical foodstuffs such as milk and legumes differ because of economic reasons.

The two groups were found to differ appreciably in physical stature as can be seen from Table 21. The weights of Raipura children were generally about 15% less than those of upper class children. Heights were less by about 5 cm or 4%. Thus, consistent with general observations (Wilson et al.,1937; Mitra, 1941; Currimbhoy, 1963a; Rowlands et al.,1968) the differences in weight are greater than those in height.

The typical meal patterns of the two groups are shown in Table 22. In the case of the Raipura children the typical meal consisted of a main dish based on

Table 21: Height and weight of poor and upper class children

Age (years)	Height (cm)				Weight (kg)			
	Raipura	Upper class	Baroda norms L.C.	Baroda norms U.C.	Raipura	Upper class	Baroda norms L.C.	Baroda norms U.C.
6	105.6 (103.4-108.0)	112.2 (110.0-114.2)	102	111	14.8 (14.0-15.5)	17.5 (16.0-19.5)	15.0	18.2
7	114.9 (112.4-117.0)	117.1 (114.6-119.6)	107	116	16.9 (16.0-18.5)	21.4 (17.5-25.0)	16.4	20.0
8	119.3 (115.9-124.7)	125.7 (123.0-128.4)	112	121	18.2 (16.5-21.6)	22.3 (20.0-25.5)	17.3	21.4
9	124.2 (116.2-129.0)	130.0 (128.0-132.0)	114	125	19.9 (18.0-22.5)	23.5 (21.5-26.0)	19.1	23.2
10	127.6 (123.0-134.0)	131.5 (130.0-134.5)	119	132	22.2 (20.0-28.5)	25.6 (24.0-27.0)	21.4	25.0
11	131.0 (125.5-139.2)	136.2 (132.0-140.0)	125	135	24.0 (22.5-25.5)	26.9 (24.0-28.0)	22.8	27.5
12	134.3 (129.0-139.0)	136.4 (134.0-141.6)	130	140	25.1 (63.5-28.0)	26.9 (25.0-28.5)	24.6	29.8

Values are means with range in parentheses.

L.C. = Lower class; U.C. = Upper class.

Table 22: Typical meals consumed by the groups studied.

	Raipura children	Upper class
Morning	Tea Left over roti if available	Milk Bread or roti
Noon	Roti or rice or khichari with liquid dal or vegetable	Chapati, rice, vegetable, liquid dal or cooked whole legumes, curd and fruit
After noon	Tea and roti	Tea, bread or biscuit or parched grains or snacks made of pulses and cereals
Night	As for lunch	As for lunch with milk in place of curd.

cereals and a side dish made of either pulses or vegetables. The upper class differed mainly in that it included more milk and curd. Further, both wheat and rice, as well as vegetables and dals were included. There was more variety in the menu and fruits were included quite frequently.

The composition of the diets consumed by the two groups is shown in Table 23. The consumption of cereals was about the same in both groups, but that of all other foodstuffs, particularly of milk and legumes, was more in the upper class.

The nutritive value of the diets is shown in Table 24. The differences between two groups with regard to the same are to be expected.

<u>Calories</u>: Even in the upper class calorie intake was less than the relatively conservative estimate of 70-75 Calories per kilogram. According to Aub-Dubois standards, the BMR for this group would be about 49 Calories per sq. meter per hour. Allowing for a 10% decrease in the same due to a warm environmental temperature the BMR requirement would be about 44 Calories per sq. meter per

Table 23: Composition of the diets consumed.

Foodstuff	Approximate amount (g) consumed per day[a]	
	Raipura children	Upper class
Cereals and millets[b]	230	225
Pulses[c]	20	45
Leafy vegetables	5	10
Other vegetables / Root vegetables	50-60	150
Sugar or jaggery	15	30
Milk (buffalo)	50	300
Vegetable oil	15	30
Fruits (mostly bananas)	negligible	50

(a) Values derived from records of food intake using receipe method.
(b) Bajra, wheat, rice and kodri taken in the proportion of (4:2:1:1) in the case of Raipura children and wheat and rice taken in the proportion of 8:1 in the case of upper class.
(c) Mostly redgram.

Table 24: Nutrient content of the diets consumed[@]

	Raipura	Upper class	RDA**	Source
Body weight (kg)	20.8	24.6		
Calories	1150	1720	1800-2100	ICMR (1968)
Calories per kg	55	70	75	Rajalakshmi and Ramakrishnan (1968)
Calories/sqm/hr.	55	75		
Protein (g)	31	46	33-41	ICMR (1968)
Per cent protein calories	10.8	10.7		
Protein/kg	1.5	1.9		
Calcium (mg)	220	800	500-700	FAO (1962)
Iron (mg)	17	23	15-20	ICMR (1968)
Carotene (i.u.)	800	1130		
Vitamin A (i.u.)	50	300		
Vitamin A value*(i.u.)	450	865	1600-2400	ICMR (1968)
Thiamine (mg)	0.7	1.1	0.5 mg per 1000 calories	Rajalakshmi and Ramakrishnan (1968)
Riboflavine (mg)	0.8	1.0		

*Assuming that 2 i.u. of carotene are equivalent to 1 i.u. of vitamin A according to Rajalakshmi and Ramakrishnan (1969).
**RDA - Recommended daily allowances.

[@]as calculated from food table values; no allowance made for cooking losses.

hour. The upper class diet provided about 75 Calories per sq. meter per hour or about 75% over and above the expected basal metabolic rate. According to Mitchell (1962) the activity increment over BMR may be of the order of 75-100%. On this basis, calorie intake in the upper class would not appear to be unsatisfactory.

In the Raipura children, on the other hand, the diet provided only 55 Calories per sq. meter per hour or only 25% over the normally expected BMR. However, studies reviewed by Banerjee (1970) suggest a decrease in BMR with undernutrition. If we assume that atleast 1/3-1/4 of the calories were expended in activity, the BMR in this group would be of the order of 37-41 Calories per sq. meter per hour. A difference in BMR between the two groups cannot be ruled out as the whole day excretion of creatinine in the lower class was found to be of the order of 400 mg as against 600 mg in the upper class. In spite of the low calorie intakes in this group, they continued to grow, albeit slowly. This observation and other similar observations in this laboratory led to the conduct of animal experiments in which a group of animals was fed only half the amount of food consumed by a control group fed *ad libitum*. The data summarized in Table 25 showed some weight gain in the undernourished group in spite of gross restriction in food intake. The calories available per 100 sq. cm of surface area was only about 65% of that in the control group. The situation in animals does not seem to be too different from that in the children.

Similar observations have been made in many other investigations in this laboratory using both animal and human subjects. These observations may be accounted for by an appreciable reduction in BMR with chronic undernutrition and underline the need for further investigations on energy metabolism.

The poor calorie intake appeared to be partly due to the restricted availability of food in the family although a poor appetite resulting from a qualitatively inadequate diet might also operate. In many families it was common practice to ration the food among the individual members of the family.

Whatever be the etiology of undernutrition, these results point to the urgent need for improving the

Table 25: Comparison of calorie intake and weight gain in animals and children.

	Children	Animals*
	% of Upper class value	% of control value
Weight	85	56
Surface area	92	68
Calories per day	67	44
Calories/kg body weight	71	79
Calories/sq meter	73	65
Weight gain	67	57

* Rajalakshmi and associates, unpublished

nutrition of school children through school lunch programmes and the like.

Protein: Protein consumption in the upper class seemed quite adequate both in terms of absolute amounts and amount available in relation to body weight. In the case of Raipura children on the other hand, although the diet provided more than 10% protein calories, protein intake was less because of the deficiency in calorie intake. Apart from the difference in the anount of protein, the quality of protein provided by the two diets also differed appreciably as the upper class diet provided more of pulses and milk, and consequently, more of the critical amino acid, lysine as can be seen from the data of Table 26. The pattern with regard to other amino acids was reasonably satisfactory because of the use of bajra which is not lacking seriously in tryptophan, threonine and methionine. This statement is based on mean intakes and does not apply to many subjects who had below average consumption of bajra, legume and milk. Further, when the diets were actually fed to rats the Raipura diet gave a weight gain of 7 g per week as against 12 g for the upper class diet and a 10% casein diet.

Calcium: The upper class diet provided more than enough calcium most of which was derived from milk, an

Table 26: Comparison of amino acids of the diets consumed by Raipura children and upper class children.

	Nitrogen (g)	Approximate amount per g of nitrogen in the diet			
		Lysine	Tryptophan	Methionine	Threonine
Raipura children	5.0	0.23	0.07	0.12	0.18
Upper class children	7.2	0.30	0.07	0.12	0.20
FAO reference pattern		0.27	0.09	0.14	0.18

Calculated from values given for raw ingredients by Aykroyed, Gopalan and Balsubramanian (1966).

excellent source of the same. In the case of poor children, the diet provided less than half the amount recommended by the FAO (1962) derived from plant sources. Data obtained in other investigations showed a fair agreement between analysed and calculated values (Rajalakshmi and Ramakrishnan, 1968). However, there is a consensus that the utilization of calcium is much more efficient than was assumed earlier in population groups subsisting mainly on plant foods (Leitch, 1964). Even so, the average amount deposited in the skeleton is of the order of 100-200 mg per day in the age group studied (Mitchell, 1962) so that unless the efficiency of utilization is indeed very high, some calcium deficiency may be expected.

Iron: The diets were apparently adequate in iron inspite of which the children were found to suffer from anemia. As anemia found in this region is of the microcytic hypochromic type it would appear that the utilization of dietary iron is poor. The high incidence of intestinal infestation such as hook-worm could be a contributory factor.

Vitamin A: The calculated value does not take into account cooking losses which will reduce the values still further by about 30%. Even the upper class diet failed to provide the amount recommended by FAO although a more efficient conversion of carotene to vitamin A was assumed than has been done by the FAO committee.

Thiamine and Riboflavine: The amounts provided appeared to be adequate in terms of calories consumed. However, some inadequacy is to be expected if cooking losses are taken into account.

Clinical and Biochemical Investigations:

The subjects were examined clinically by Dr. Bagchi using the ICMR assessment schedule. The results are presented in Table 27. The symptoms found most frequently in the village children were xerosis of conjunctiva, pigmentation of conjunctiva and pale and fissured tongue, suggesting deficiencies of vitamin A, protein and riboflavine. These symptoms were found much less frequently in the upper class. None of the Raipura children were altogether free from symptoms whereas about half the subjects in the upper class had no symptoms.

The results of the biochemical investigations are presented in Table 28. The upper class had satisfactory values for all the parameters other than blood hemoglobin.

Table 27: Incidence of clinical symptoms of nutritional deficiency

	Number showing symptoms	
	Raipura children	Upper class
No. of cases	52	21
Xerosis of conjunctiva	26(50)	3(14)
Bitot's spots	2(4)	0
Pigmentation of conjunctiva	23(44)	2(10)
Xerosis of cornea	1(2)	
Pale tongue	32(62)	6(29)
Fissured tongue	24(46)	2(10)
Deficiency of adipose tissue	16(31)	-
<u>Clinical assessment score (ICMR 1948)</u>		
0	0	10(48)
1-3	38(78)	7(33)
4-6	14(27)	4(19)

Percentage incidence shown in parentheses.

Table 28: Composition of blood and urine of Raipura children and upper class children

	Raipura children	Upper class
Blood		
hemoglobin (g)	8.7 ±0.32	11.9 ±0.25
Serum (per 100 ml)		
total protein (g)	6.0 ±0.15	6.6 ±0.10
albumin (g)	3.4 ±0.08	3.9 ±0.09
carotene (μg)	38 ±5.5	60 ±9.4
vitamin C (mg)	0.21±0.04	0.66±0.05
Urine		
creatinine (mg/100 ml)	46 ±3.4	62 ±10.0
Urinary excretion (per g of creatinine)		
thiamine (μg)	1030±56	1600±60
riboflavine (μg)	630±49	1680±72
nitrogen (g)	9.7±0.47	11.6 ±0.31

Values are means ± S.E.'s

In this connection, hemoglobin values have generally been found to be lower than western values in the case of several groups belonging to the upper class. The values for the lower class were found to be even less as may be seen from the comparisons made below:-

	Lower class	Upper class	Western norms (Hawkins,1964)
Pre-school children	9.6	11.4	11.8-13.0
School children	10.4	11.9	12.5-13.5
Adult women	10.1	11.3	13.5
Adult men	12.8	14.0	15.2

In the Raipura group only about 14% of the children had either acceptable or high values (Table 29).

Although mean values for serum protein were not deficient many individual values fell in the deficient range. In contrast, none of the upper class values fell in this range. In the case of serum albumin many of the values for the Raipura children were in the low range.

In the case of thiamine and riboflavine none of the values obtained for urinary excretion were found to be

Table 29: Biochemical status of Raipura children and upper class children on the basis of ICNND (1963) standards*

Constituents	Groups	No.of subjects	Percentage of children			
			D	L	A	H
Blood						
hemoglobin	Raipura children	41	71	15	12	2
	Upper class	20	10	10	55	25
Serum						
total protein	Raipura children	38	42	37	18	3
	Upper class	20	0	10	70	20
albumin	Raipura children	27	11	41	41	7
	Upper class	20	0	25	63	12
carotene	Raipura children	27	7	48	45	-
	Upper class	20	0	10	70	20
vitamin C	Raipura children	25	0	72	16	12
	Upper class	20	0	5	25	75

*ICNND Laboratory Manual for Nutrition Survey (1963).
D = Deficient; L = Low; A = Acceptable; H = High.

low when considered in terms of ICNND standards which use the amount excreted relative to the amount of creatinine excreted. Similar observations were made in other studies on pre-school children and pregnant and lactating women in spite of the presence of clinical symptoms of riboflavine deficiency in all the groups. This would appear to be because of the relatively low rates of creatinine excretion among poorly nourished subjects. When the ICNND norms were modified and the values taken as amount excreted per 2 g of creatinine, a more satisfactory classification appeared to result as can be seen from Table 30. The amount of vitamin excreted per day might be a more reasonable criterion. In any case, the validity of using urinary excretion as a criterion of nutritional status would itself appear to be limited as a low level of excretion may not necessarily indicate a deficiency state.

In summary the diets of school boys in the upper class were reasonably adequate except for vitamin A in spite of which the subjects had relatively low hemoglobin levels and deficiency symptoms were not entirely absent. This might be due to the presence of amoebic infections

Table 30: Thiamine and riboflavine excretion on the basis of ICNND standards and modified standards

	Criterion	No. of subjects	Percentage of children			
			Deficient	Low	Acceptable	High
Thiamine	Per g of creatinine	50	-	-	4	96
	Per 2 g of creatinine	50	-	8	42	50
Riboflavine	Per g of creatinine	48	-	8	31	61
	Per 2 g of creatinine	48	8	29	51	12

which are common in Gujarat. Dietary intakes of the poor children in Raipura were grossly inadequate and many of them were found to have a poor nutritional status particularly with regard to protein, vitamin A and riboflavine. In studies to be described later, many of them were also found to show retarded skeletal development.

The impact of the school lunch programme:

As mentioned earlier investigations were undertaken to ascertain whether the nutritional status of poor children can be improved by a school lunch based on cheap and locally available foods. Forty of the children in Raipura were given a school lunch consisting of cereals, legumes, greens, other vegetables, buttermilk and fruits for a period of 6 months. Twelve children served as controls. The composition of the lunch has been described earlier (Table 18). The fed children received a main dish including wheat and peas either in the proportion 4:1 or 8:1. The two groups of fed children and the controls were roughly matched for age, height, weight and most other parameters measured as can be seen from Table 31. The lower value for serum carotene in the 'B' group is believed to be due to chance and the smaller number of determinations. In interpreting the results, however, only increments were considered and the 'A' and 'B' values were pooled together and analysed according to attendance.

Table 31: Age, height, weight, and nutritional status of the fed and control children at the start of investigations.

	Experimentals 8:1* A	Experimentals 4:1* B	Controls
No. of subjects	20	20	12
Age (years)	9.3	9.3	9.6
Height (cm)	123.9±1.98	123.9±1.99	125.9±3.28
Weight (kg)	20.7±0.76	20.7±0.80	21.0±0.90
<u>Blood</u>			
hemoglobin (g per 100 ml)	8.5±0.60	8.9±0.79	9.5±0.71
<u>Values per 100 ml of serum</u>			
total protein(g)	5.9±0.12	5.9±0.15	6.2±0.15
albumin (g)	3.5±0.09	3.4±0.11	3.6±0.15
carotene (μg)	43.0±5.2	25.0±3.44	45.0±6.8
vitamin C (mg)	0.18±0.11	0.17±0.03	0.27±0.18
<u>Urine</u>			
creatinine (mg per 100 ml)	52.0±7.31	38.0±2.50	45.0±6.00
<u>per g of creatinine</u>			
thiamine (μg)	1020±67	1070±78	1050±168
riboflavine(μg)	630±57	710±63	670±105
nitrogen (g)	9.7±0.59	9.7±0.61	9.7±0.74

Values are means ± S.E.'s.
*Wheat-pea ratio in the lunch provided.

The lunch was provided on all school days. The main dish or dishes providing cereals and legumes were provided *ad libitum*, and the other items, in the quantities specified. A known quantity of the main dish was served in the first instance and the boys allowed to help themselves to additional servings. Records were kept of attendance at lunch as well as the quantities of cereals and legumes consumed.

The school lunch served to increase total food consumption substantially as can be seen from Table 32. The lunch improved the overall nutritive quality of the diet and more or less made up for deficiencies in the home diet as can be seen from Table 33.

The interesting observation was made that food consumption was slightly more in the group for which more pulses were included (Table 34). In animal studies cited earlier (page 65) addition of bengalgram to wheat was found to increase food intake, but no differences were found when the two were used in the proportion 8:1 or 4:1.

Food intake also varied slightly with the recipe used. Fermented foods were consumed in greater amounts (Table 34).

Table 32: Dietary intake of fed and the control children during experimental period

Foodstuff (g)	Amount (g) consumed during*								
	Lunch			Breakfast & dinner			Whole day		
	A	B	C	A	B	C	A	B	C
Cereals and millets	150	150	110	110	110	130	260	260	240
Pulses	19	38	10	10	11	10	29	49	20
Leafy vegetables	30	30	3	2	2	2	32	32	5
Other vegetables	30	30	20	22	22	30	52	52	50
Milk	30**	30**	Nil	50	50	50	80	80	50
Fats and oil	20	20	5	10	10	10	30	30	15
Sugar and jaggery	-	-	-	15	15	15	15	15	15
Fruits	30	30	Nil	Nil	Nil	Nil	30	30	Nil

A and B - Fed children given less and more of peas in the school lunch.
C - Controls.

*Values derived from records of food intake using the receipe method.

**Equivalent to 100 g of butter milk prepared from 3 g of skim-milk powder.

Table 33: Nutrient intake of fed and control children during the experimental period.

Nutrient	Nutrient intake per day								
	Lunch			Breakfast & dinner			Whole day		
	A	B	C	A	B	C	A	B	C
Calories	850	920	470	620	620	680	1470	1540	1150
Protein (g)	24	28	15	16	16	17	40	44	32
Calcium (mg)	220	230	55	160	160	160	380	390	215
Iron (mg)	16	17	8	8	8	9	24	25	17
Vitamin A:									
Pre-formed (i.u.)	180	180	-	50	50	50	230	230	50
Carotene (i.u.)	2620	2640	370	300	300	310	2920	2940	680
Vitamin A value*	1490	1500	185	200	200	205	1690	1700	390
Thiamine (mg)	0.9	1.0	0.4	0.4	0.4	0.4	1.3	1.4	0.8
Riboflavine (mg)	0.6	0.6	0.3	0.3	0.3	0.3	0.9	0.9	0.6

A and B - fed children given less and more of peas in the school lunch. C - controls.

Calculated from values given for raw ingredients by Aykroyd, Gopalan and Balsubramanian (1966).

*Assuming that 2 i.u. of carotene are equivalent to 1 i.u. of vitamin A.

Table 34: Food intakes of school children with fermented and unfermented foods based on wheat plus peas.

Preparation	Intake of wheat + peas* (grams) Rates of wheat to peas	
	8:1	4:1
Roti	130	130
Dhokla	180	200
Puda	150	150
Debra	140	140

*raw weight basis.

The lunch had the expected effect on weight gain (Tables 35a-b). The controls gained only 0.6 kg as against 1.8 kg. gained by the fed children. The weight gain was somewhat more in the group fed a greater amount of peas and this was consistent with the differences in food intake but the difference was not statistically significant. The weight gain also appeared to vary with percentage attendance as may be expected.

The effects on height were less evident, although there was a difference of 0.6 cm in height gained and this difference was not statistically significant. This is consistent with the general finding that height is less influenced by undernutrition than weight and that children may achieve an increase in height even when there is no increase in weight (Robertson, 1966).

When the weight gain was considered in relation to initial weight and age, the percentage increment in the fed group was found to be more than twice that in the control group. The differences were more obvious at the ages of 7 and 8 (Table 36). These were also the ages at which percentage increments in weight were greater. A similar pattern is found in other reports (Table 37). It is intriguing to find that in the controls the percentage

Table 35(a): Weight gains of fed and control children during experimental period.

Attendance	Weight gain (kg)		
	Experimentals		
	A (8:1)*	B (4:1)*	A+B
90%	1.60±0.21	2.00±0.21	1.80±0.14
50%	1.15±0.21	1.50±0.20	1.32±0.14
total	1.38±0.17	1.75±0.17	1.56±0.08
controls			0.60±0.17

*Wheat pea ratio in the lunch provided.

Table 35(b): Height increments of fed and control children during experimental period.

Attendance	Increment in height (cm)		
	Experimentals		
	A (8:1)	B (4:1)	A+B)
90%	3.6 ±0.23	4.0±0.33	3.8±0.19
50%	3.7 ±0.19	3.6±0.35	3.6±0.19
total	3.6 ±0.14	3.8±0.20	3.7±0.12
controls			3.1±0.24

Values are means ± S.E.'s.

Table 36: Weight gain in relation to age.

Age group	Fed children			Controls		
	Initial weight (kg)	Increase in weight (kg)	% increase	Initial weight (kg)	Increase in weight (kg)	% increase
7-8	17.7	1.8	10.2	16.7	0.2	1.2
9-10	21.6	1.6	7.4	21.1	0.6	2.8
11-12	24.9	1.7	8.6	25.8	0.8	3.1

Table 37: Growth rate of upper class boys in Baroda as compared to that derived from data on western subjects*

Age (years)	Percentage increment in body weight per year		
	Western subjects		Baroda norms (upper class)
	Mitchell (1964)	Hawkins (1964)	
5-8	15	15	11
8-10	10	8	8
10-12	9	10	10

*Rajalakshmi and Ramakrishnan (1968).

increment in weight gain was the least at these ages. Except perhaps in the case of weight, the cereal pulse ratio in the main dish provided did not appear to make any difference in the case of other parameters. The values for groups 'A' and 'B' are therefore combined for the same.

An improvement in the clinical status of the fed children is evident from the data of Table 38. It must be emphasized in this connection that the clinical examination was done by Dr. K. Bagchi and he was not aware to which groups the subjects belonged. Nine subjects were found to be free from clinical deficiency symptoms as against none initially. The number of subjects with a high deficiency score changed from 10 to 4. However, a substantial number of subjects were still found to show symptoms of mild deficiency. This might be because the lunch was provided only on 150 out of 180 days and the average attendance was 120 days. In the case of many subjects irregular attendance might have contributed to the persistence of clinical symptoms. The final survey was done in the summer month of April when deficiency symptoms are found to increase as can be seen from the control data. Further

Table 38: Change in the clinical status of the fed and control children (1965-66)

Symptoms	number showing symptoms of			
	Experimentals		Control	
	Initial	Final	Initial	Final
Xerosis of conjunctiva	25	16	5	6
Bitot's spot	1	1	2	2
Pigmentation of conjunctiva	18	12	5	6
Xerosis of cornea	1	-	-	1
Pale tongue	25	13	7	7
Fissured tongue	20	10	4	7
Deficiency of adipose tissue	12	7	4	5

there was an increase in absenteeism towards the end because of the intervention of the marriage season.

The incidence of intestinal infections and the ambiguity of the criteria used for clinical assessment might have been other factors. The persistence of clinical symptoms of vitamin A deficiency suggests the need for a greater intake of carotene. The lunch provided , on the basis of raw food values, 2600 i.u. of carotene of which 2100 i.u. were contributed by leafy vegetables. If cooking losses and absenteeism are taken into account, the amount provided would be, on an average, about 1500 i.u. and this would be far less than 2100 i.u. required on the basis of about 100 i.u. per kilogram (Rajalakshmi and Ramakrishnan, 1968). In subjects with irregular attendance this gap would be greater. On the basis of animal experiments carried out subsequently in this department, and studies on adult men to be described later, it would seem, in retrospect, more reasonable to have included 50-60 g. This would also have contributed more riboflavine.

The lunch was also found to result in a significant improvement in biochemical status as can be seen from Table 39. In contrast the controls showed no such improvement.

Although the changes in mean values were not marked, in the case of many subjects, the values shifted from 'deficient' to 'low' or 'acceptable' ranges according to ICNND standards (Table 40). The least response was found in the case of hemoglobin and 85% of the values remained in the low or acceptable range even after treatment. A similar persistence of low hemoglobin levels was found in children subjected to nutritional improvement (Dumm et al., 1966, 1966a; Devadas et al., 1967, 1968). This could partly be due to the presence of hookworm and other parasites as many of the children were found to have intestinal parasites. In contrast, animals fed either the home diet or the improved diet were found to have satisfactory levels. In spite of the poor response in hemoglobin levels, these studies point to the feasibility of improving the nutritional status of children at low cost with the help of foods locally available or producible.

Table 39: Comparative data on the biochemical status of fed and control children.

		Fed children with attendence 90%	50%	Controls
No. of subjects		20	20	12
Blood:				
Hemoglobin (g per 100 ml)	Initil	8.0±0.40(15)	8.6±0.59(12)	9.5±0.71 (8)
	Final	8.8±0.31(15)	9.3±0.50(12)	9.1±0.73 (8)
	Increment	0.8±0.23	0.7±0.23	-0.4±0.30
Serum (per 100 ml):				
Total protein (g)	Initial	5.8±0.09(12)	6.2±0.13(12)	6.2±0.15 (8)
	Final	6.4±0.39(12)	6.4±0.30(12)	6.2±0.15 (8)
	Increment	0.6±0.11	0.2±0.15	0.0±0.12
Albumin (g)	Initial	3.3±0.38 (8)	3.4±0.48(10)	3.5±0.15 (8)
	Final	3.6±0.42 (8)	3.6±0.48(10)	3.5±0.15 (8)
	Increment	0.3±0.12	0.2±0.13	0.0±0.10
Carotene(µg)	Initial	31±4.1 (13)	42±7.8 (7)	45±6.8 (8)
	Final	46±4.6 (13)	50±8.2 (7)	33±5.4 (8)
	Increment	13±1.7	8±1.8	-12±3.6
Urinary excretion (per g of creatinine):				
Thiamine(µg)	Initial	830±66 (17)	1190±81 (15)	1050±168 (11)
	Final	1050±127 (17)	1330±91 (15)	840±77 (11)
	Increment	220±119	140±129	-210±220
Riboflavine (µg)	Initial	580±47 (17)	710±83 (16)	670±105 (10)
	Final	1000±100 (17)	1000±120 (16)	640±85 (10)
	Increment	420±113	290±169	-30±79
Nitrogen(g)	Initial	9.4±0.86(17)	9.9±0.42(16)	9.7±0.74(11)
	Final	11.1±0.74(17)	10.3±0.95(16)	9.9±0.63(11)
	Increment	1.7±0.36	0.4±0.15	0.2±0.10

Values are means ± S.E.'s. No. of subjects shown in parentheses. Only subjects for whom both initial and terminal values are available are included in this table. Some subjects refused to give blood samples at the end because of parental objection. In some cases blood was not available for all the estimations.

Table 40: Biochemical status of fed and control children at the start and termination of the study on the basis of ICNND standards

Constituents	Groups		No.of subjects	Percentage of children D	L	A	H
Blood	Fed	I	32	75	12.5	12.5	0
		F	32	65.5	19	12.5	3
	Control	I	8	50	25	12.5	12.5
		F	8	75	12.5	12.5	0
Serum							
total protein	Fed	I	25	52	28	20	0
		F	25	12	24	52	12
	Control	I	8	25	65.5	12.5	0
		F	8	37.5	37.5	25	0
carotene	Fed	I	24	8	69	33	0
		F	24	4	46	42	8
	Control	I	7	-	28	72	-
		F	7	14	72	14	-

I = Initial; F = Final; D = Deficient; L = Low; A = Acceptable; H = High.

Section B

<u>Field trials during 1966-67</u>:

As mentioned earlier the lunch programme was resumed after a lapse of five months and was in operation for six months in the next academic year. The lunch provided was substantially the same. The number of children fed was less during this year, but they attended more regularly so that the average attendance was 85%.

The height and weight of the subjects included in the study are shown in Table 41. The control group was slightly older, taller and heavier than the experimental group at the start of experiment. This could not be avoided as the study was based on the voluntary co-operation of the subjects.

The lunch given differed from the one given in the preceding year in the following respects: (a) fruits were omitted, (b) lime powder was incorporated in the fermented foods prepared (Dhokla and Poora), (c) bengalgram was used instead of peas and (d) wheat and bengalgram were used only in one proportion, namely 4:1. These changes were introduced for reasons given earlier.

Table 41: Age, height and weight of different groups at the start of the investigation in 1966-67.

	Fed children[a] (1966 Oct.)	Controls[b]
Age (years)	8.4	9.6
No. of subjects	25	12
Height (cm)	122.5±1.63	125.9±3.09
Weight (kg)	20.0±0.51	21.5±1.35

(a) Including 11 subjects from the fed group of the previous year.

(b) Including four subjects from the fed group of the previous year.

(a) and (b): The lunch programme was resumed after an interval of five months during which period the fed children had apparently lost their edge over others (Tables 51 and 52, pages 133 and 134).

The composition and nutritive value of the lunch as compared to the lunch previously provided are shown in Table 42.

The main dish was provided *ad libitum* as in the previous year. The intake varied according to age as might be expected and was also somewhat more in the case of dhokla (Table 43). Four subjects in the 10 and 11 year old groups were found to take enormous quantities of the main dish whenever dhokla was prepared. Food consumption at home of the controls as well as the fed children was similar to that in the previous year.

The change in height and weight are shown in Table 44. Again the fed children showed greater increments in weight although the differences were less than in the previous year presumably because of the difference in age. In the previous series, there were eight 12 year olds nearing the prepubertal spurt in growth as against none in this series.

The clinical status of the different groups at the beginning and termination of the study is shown in Table 45. There was no great difference between the clinical status of the subjects at the start of the

Table 42: The consumption and nutritive value of the lunch compared with the previous year.

Foodstuff (g)	1965-'66	1966-'67
Cereals	150	140
Pulses	38	35
Leafy vegetables	30	30
Other vegetables	30	30
Milk	30	30
Oil	20	20
Fruits	30	-
Nutritive value		
Calories	920	870
Proteins (g)	28	28
Calcium (mg)	230	400
Iron (mg)	17	17
Carotene (i.u.)	2640	2430
Vitamin A (i.u.)	180	180
Vitamin A value (i.u.) *	1500	1395
Thiamine (mg)	1.0	0.9
Riboflavine (mg)	0.6	0.6

*assuming 2 i.u. of carotene are equivalent to 1 i.u. vitamin A.

Table 43: Cereal and pulse intake of subjects studied.

		Age (years)						
		6	7	8	9	10	11	12
Dhokla	1965-66	100	125	175	225	200	225	200
	1966-67	125	138	175	200	262*	300*	-
Poora	1965-66	91	104	178	169	178	208	234
	1966-67	104	104	130	156	156	178	
Debra	1965-66	96	127	154	173	192	192	208
	1966-67	116	116	173	192	212	212	-
Average	1965-66	96	119	170	185	190	208	214
	1966-67	115	119	159	182	210	230	-

Average Age 1965-66 9.3 (years)
1966-67 8.4 (")

*Four subjects in these ages had a marked preference for dhokla.

Table 44: Change in height and weight of fed and control children during experimental period.

	Fed			Control		
	Initial	Final	Increment	Initial	Final	Increment
Weight (kg)	20.0±0.51	21.3±0.60	1.3±0.11	21.5±1.35	22.2±1.43	0.7±0.10
Height (cm)	122.5±1.63	125.9±1.62	3.4±0.13	125.9±3.04	129.4±3.25	3.5±0.12

Table 45: Change in clinical status of fed and control children during 1966 Oct. to 1967 Feb.

Symptoms	number showing symptoms			
	Fed children		Control	
	Initial	Final	Initial	Final
No. of subjects	25	25	12	12
Xerosis of conjunctiva	12	8	8	8
Bitot's spot	0	0	1	1
Pigmentation of conjunctiva	8	5	4	6
Xerosis of cornea	1	0	1	1
Pale tongue	13	7	8	8
Fissured tongue	10	5	6	5
Deficiency of adipose tissue	9	5	4	4

first session and second session, although the subjects in the latter session included some who were in the experimental group in the previous year. This might have been because of some deterioration during the period 1966 April to 1966 October, when the feeding programme was not in operation. As in the previous year the fed children were found to show some improvement in clinical status although the symptoms persisted in some cases, as in the previous year.

The data on urinary excretion of fed and control children are shown in Table 46. The pattern of changes was similar to that found in the previous year (Table 47). The differences were, however, not statistically significant because of the wide variation in each group.

Skeletal development was assessed radiologically in terms of the appearance of the trabeculae of the wrist, and presence or absence of ossification centres.

To facilitate comparisons the bone age arrived at using the criteria $\frac{\text{Bone age}}{\text{Chronological age}} \times 100$ was converted in to a developmental quotient. Since skeletal development may depend on general growth status, the age appropriate for height was estimated on the basis

Table 46: Composition of urine of fed and control children during 1966 October - 1967 February.

	Amount per g of creatinine			
	Fed children		Control children	
	Initial	Final	Initial	Final
Thiamine (μg)	800 ± 91	1075 ± 97	1070 ± 115	980 ± 128
Riboflavine (μg)	750 ± 46	930 ± 35	950 ± 117	900 ± 131
Nitrogen (g)	9.2 ± 0.46	9.6 ± 0.44	9.6 ± 0.63	9.7 ± 0.57

Table 47: Change in urinary excretion of fed and control children compared with urinary excretion of previous years.

		Values per g of creatinine			
		Fed children		Control children	
		1965-'66	1966-'67	1965-'66	1966-'67
Thiamine	Initial	830 ± 66	800 ± 91	1050 ± 168	1070 ± 115
	Final	1050 ± 127	1075 ± 97	840 ± 77	980 ± 129
	Increment	220 ± 119	275 ± 83	-210 ± 220	-90 ± 125
Riboflavine	Initial	580 ± 47	750 ± 46	670 ± 105	950 ± 117
	Final	1000 ± 100	930 ± 35	640 ± 85	900 ± 131
	Increment	420 ± 113	180 ± 69	-30 ± 79	-50 ± 68
Nitrogen	Initial	9.4 ± 0.86	9.2 ± 0.46	9.7 ± 0.74	9.6 ± 0.63
	Final	11.1 ± 0.74	9.6 ± 0.44	9.9 ± 0.72	9.7 ± 0.57
	Increment	1.7 ± 0.36	0.4 ± 0.20	0.2 ± 0.10	0.1 ± 0.11

Values are means ± S.E.'s.

of norms obtained on upper class subjects. The results are summarized in Table 48 and individual data are shown in Table 49. The differences between the two groups were not statistically significant but the fed children showed some tendency to be superior. Typical radiograph of selected subjects from the fed and control groups are shown in plates 1-4. A greater proportion of cases with severe retardation was found in the control group as can be seen from the following data.

Bone retardation (years)	Fed	Controls
No. of subjects	16	11
No retardation	3	3
Less than 6 months	5	1
6 months - 1 year	3	-
more than 1 year	5	7
On the basis of height age:		
None	5	4
less than one year	5	3
more than one year	6	4

The lack of an appreciable difference between the fed and control children may be due to a high efficiency of calcium utilization in this age group. The control diet

Table 48: Radiological status of school children

	Experimentals	Controls
No. of subjects	16	11
Bone age X 100 / Chronological age	91 (80-100)	89 (68-100)
Bone age X 100 / Height age	96 (73-110)	93 (84-117)
	Cortical thickness (mm)	
Chronological age		
5-7	2.05 (1.8,2.3)	-
8-9	2.53 (2.1-3.4)	2.46 (2.0-3.0)
10-12	2.83 (2.1-4.0)	2.92 (2.5-3.6)
Height age		
5-7	2.23 (1.8-2.7)	-
8-9	2.79 (2.1-4.0)	2.70 (2.0-3.6)
10-12	2.77 (2.5-3.3)	2.80 (2.2-3.2)

Values are means with range in parentheses.

Table 49: Bone status of Raipura children

Sr. No.	Sub.No.	Chronological Age	Bone Age	Height Age	Trabeculae	Cortical thickness
Experimentals						
1	70	7-0	7-0	7-6	Fine	2.3
2	55	7-0	6-3	7-6	"	1.8
3	1	8-0	8-0	7-3	"	2.3
4	11	8-0	6-9	6-6	"	2.2
5	31	8-0	6-6	7-6	"	2.7
6	34	8-0	7-9	9-3	"	2.3
7	71	8-0	7-9	7-0	"	2.1
8	12	9-0	7-9	9-0	"	2.7
9	33	9-0	8-3	8-9	"	3.0
10	2	10-0	9-6	10-0	"	3.3
11	14	10-0	9-0	9-3	"	2.4
12	69	10-0	9-9	9-6	Coarse	2.1
13	15	11-0	11-0	9-6	Fine	4.0
14	25	11-0	8-9	10-3	Coarse	2.5
15	26	11-0	8-9	12-0	Fine	2.5
16	76	11-0	9-6	9-6	"	3.0
	Controls					
17	72	8-0	6-9	8-0	Fine	2.4
18	75	8-0	7-0	8-0	"	2.0
19	74	9-0	9-0	11-6	Coarse	3.0
20	41	10-0	9-6	8-9	"	2.5
21	42	11-0	11-0	9-3	Fine	3.0
22	43	11-0	9-6	11-3	Coarse	3.1
23	77	11-0	9-6	11-3	Fine	3.0
24	73	12-0	9-9	10-0	Coarse	2.2
25	47	12-0	11-0	11-0	"	2.6
26	48	12-0	11-0	12-0	"	3.2
27	49	12-0	11-3	9-6	"	3.6

Radiological status of fed and control children

1. Control child
(age 8 years)

2. Fed child
(age 8 years)

Radiological status of fed and control children

3. Control child
(age 9 years)

4. Fed child
(age 9 years)

provided 220 mg whereas the amount of calcium expected to be deposited in the skeleton during the ages under study may be of the order of 100-170 mg both according to Shohl (1939) and Mitchell et al. (1945). These amounts would be less in the present subjects because of their smaller physical stature and smaller increments in body weight. With a diet providing 220 mg and assuming 50-70% efficiency of utilization, calcium may not be the most critical deficiency in the diet at least for the younger age groups, but may become critical during adolescence as pointed out by Leitch (1964).

It must also be added that any difference in skeletal development between the experimentals and controls may not be entirely due to differences in calcium intake as the diets also differed with regard to other respects such as protein, lysine, carotene and vitamin C, which have been implicated in calcium utilization.

As mentioned earlier, the possibility of using salivary amylase activity as an index of nutritional status was explored in these studies.

The data on this enzyme are given in Table 50. It is interesting to note from the same that the activity of this enzyme is greater in the fed children. In this connection, as pointed out earlier, since serum amylase is affected by protein nutrition (Brock and Hansan 1962) it is reasonable to expect that salivary amylase may also be similarly influenced. If this assumption is correct the increase in salivary amylase may reflect an improvement either in protein status or overall nutritional status. If further studies confirm this impression, this measure may prove to be a convenient index of nutritional status as the collection of saliva is easier than that of blood.

Table 50: Salivary amylase activity of fed and control children

	Fed children (n = 17)	Controls (n = 11)	't' value
Salivary amylase (mg of maltose liberated/3 minutes/ml)	312±20.5	241±20.5	2.447 $p < 0.02$

It will be recalled that some of the subjects used in the second session also participated in the first session. Table 51 gives comparative data on increments in weight found in different groups during different phases of the investigations. It is interesting to note that the increments were greater when the children were fed, and decreased when the programme was not in operation or if the children switched to the control group. A similar pattern was also found in the case of height and urinary excretion (Table 52) of vitamins.

The present studies confirm the beneficial effects of a school lunch based on locally available foods. It is felt in retrospect that the effects would have been greater with the inclusion of a greater amount of leafy vegetables. Wherever possible, greater quantities of milk or butter milk may also be included. It must be pointed out that the lunch provided was a more generous one than the one stipulated by the Government of India (1961) (Table 53). Perhaps, it would be desirable to modify the latter in view of the present studies. However, the same may be all right as an addition to the home diet.

Table 51: Increment in weight and height of fed and control children during periods of feeding and non-feeding.

(a) Mean increment in weight (kg)

Group affiliation during I	III	No. of subjects	Experimental period I	Control period* II	Experimental period III
Experimental	Experimental	11	1.8 (1.0-3.0)	0.4 (0.0-1.5)	1.2 (0.5-2.0)
Experimental	Control	4	1.3 (0.5-1.5)	0.4 (0.0-1.0)	0.7 (0.0-1.0)
Control	Control	6	0.4 (0.0-0.5)	0.9 (0.0-1.5)	0.8 (0.0-1.0)

(b) Mean increment in height (cm)

Group affiliation during I	III	No. of subjects	Experimental period I	Control period* II	Experimental period III
Experimental	Experimental	11	3.6 (3.1-4.8)	2.1 (0.5-5.3)	2.3 (1.3-3.6)
Experimental	Control	4	3.5 (2.5-4.3)	1.5 (1.0-2.8)	1.8 (1.5-2.2)
Control	Control	6	2.9 (2.0-4.1)	1.7 (0.8-3.1)	1.6 (1.0-2.3)

*Feeding programme was not in operation during period II.
Values are means with range shown in parentheses.

Table 52: Change in the urinary excretion of fed and control children during period of feeding and non-feeding.

Group affiliation duration period 1965/1966 I	1966/1967 III	Nov.'65 to April '66 I	May '66 to Sept. '66* II	Oct. '66 to Feb. '67 III
(a) Mean change in Thiamine (µg/g of creatinine)				
Exptls.	Exptls.	300 (-50-790)	-250 (-700-200)	+200 (-70-600)
Exptls.	Controls	140 (100-380)	-160 (-400- 90)	-100 (-180- -50)
Controls	Controls	-20 (-190- 20)	+30 (-30-240)	-10 (-40-100)
(b) Mean change in Riboflavine (µg/g of creatinine)				
Exptls.	Exptls.	140 (20-700)	-50 (-500-240)	140 (30-540)
Exptls.	Controls	270 (30-800)	-190 (-530-220)	-10 (-240-110)
Controls	Controls	10 (-200-260)	50 (-60-200)	-50 (-300-190)
(c) Mean change in Nitrogen (g/g of creatinine)				
Exptls.	Exptls.	0.9 (0.4-2.5)	0.0 (-0.8-1.0)	0.5 (0.3-1.0)
Exptls.	Controls	0.9 (0.2-1.6)	-0.7 (-0.9-0.2)	-0.1 (-0.3-0.1)
Controls	Controls	0.2 (-0.1-0.4)	-0.3 (-0.8-0.5)	0.3 (0.2-1.1)

*Programme was not in operation.

Table 53: Lunch provided at school and stipulated by the Government of India (1961).

Foodstuff	Amount in (g)	
	Lunch provided at school	Lunch stipulated by Government of India
Cereals	150	60
Pulses	38	28
Leafy vegetables *	30	28
Other vegetables	30	28
Milk	30	-
Oil	15-20	7
Fruits	30	-

*This could be increased to 50 g.

Section C

STUDIES ON THE IMPACT OF THE 'CARE' LUNCH PROGRAMME ON THE NUTRITIONAL STATUS OF SCHOOL BOYS

Subsequent to the conduct of the investigations in Raipura, an opportunity arose to assess the impact of the 'CARE' lunch programme on school children in a tribal area in Gujarat, namely Panchmahal District. The people living in this area are the 'Bhils'. Their food habits are basically similar to those of farmers in Raipura except that they ordinarily consume maize as against a mixture of grains consumed in Raipura and take even less of oils and pulses than in Raipura. As a matter of fact, some families seldom purchased any oil.

The typical diet in this area consists of rotis made from maize with a vegetable, mostly chillies and onions, twice a day. In addition, they had rotis with a small cup of tea in the morning. The adult men had a second cup of tea in the afternoon while working in the fields. The region studied is a chronic scarcity area and was subject to acute drought conditions for two years prior to the survey. Two successive harvests had failed and the government had to organize relief measures. This consisted of providing alternate work such as construction of roads etc., making grains available in fair-price shops and sporadic distribution of skim milk powder. However, not much of this found its way into the blood of the school children. During the first year, the families were given milk powder in bulk which found its way to the urban market. During the second year, they were given 20 g per head per day but the villagers could not be bothered to queue up daily for the same and collected it only twice a week.

The Bhils have no inhibitions against eating meat and are fond of hunting and fishing when possible. They also go on a community fishing expedition about once a year and a hunting expedition once in two or three years (The government officials said they hunted more often than this). At the time of survey, the families reported that they did not get any supply of game from the forests because most of the game, animals had been eaten up during the previous drought years. It appears that they may have an occasional catch, about once a year, when they share the meal with neighbours, friends and relatives. However, the average consumption per day may not amount to more than 5-10 g on the basis of the information given .

In some schools, in this area the children had been receiving a school lunch under 'CARE' programme for 2 years prior to the investigations. The lunch consisted of 60 g of cracked wheat, 30 g of skim-milk powder and 15 g of soya-bean oil. There were other schools in nearby villages where no such programme was in operation. 'CARE' assistance was based on the voluntary co-operation of individual villages and in some villages the leaders were not interested in the programme.

It was felt that a study of children in the 'fed' and 'control' villages would provide an opportunity not only to measure the impact of the lunch programme but also compare the same with the experience in Raipura. Further the people in this area consumed maize whereas those in Raipura consumed bajra, wheat, rice and kodri so that the comparison of the control groups alone would be of interest, particularly as maize is considered inferior to other grains.

<u>Subjects</u>:

The group studied ranged in age from 6 years to 16 years and included some older boys in secondary schools. Heights and weights were measured in the case of 750 fed children and 750 control children. In addition, biochemical and radiological investigations were made on a smaller sample of 53 children. Information was also obtained on the dietary intake of these children. Their home diet is shown in Tables 54 and 55. As mentioned earlier, the same consisted mainly of maize or jowar with very little of other foods such as legumes, milk, oil and sugar. At the time of study, because of scarcity conditions they consumed wheat available through fair-price shops. Because of the low sugar and fat content of their diets, protein calories in the diet formed 13% of the total. But in animal experiments the weight gains with this diet corresponded only to those of a 6-7% casein diet.

As mentioned earlier, the lunch included 60 g of cracked wheat, 30 g of skim-milk powder and 15 g of soya-bean oil. However, the supplies were often interrupted and one or other of these commodities were not available for varying intervals so that the actual supply came on an average to about 40 g of cracked wheat,

Table 54: Dietary intake of Devgad Baria children

Foodstuff	Amount consumed (g) per day		
	7-8	9-12	13-16
Cereals	240	280	360
Pulses	13	15	17
Leafy-vegetables	7	8	9
Other vegetables	40	45	60
Milk	25	25	25
Oil	5	6	7
Sugar or jaggery	5	5	5

CARE Lunch (on an average)	
Cracked wheat	40
Skim-milk powder	20
Soya oil	10

Table 55: Nutritive value of the diets consumed by Devgad Baria children

Nutrient	Approximate nutrient intake per day			
	7-8	9-12	13-16	CARE Lunch
Calories	990	1130	1400	300
Protein (g)	31.4	36.8	46.1	12.0
Calcium (mg)	125	140	166	300
Iron (mg)	17	20	25	2.2
Vitamin A				
Carotene (i.u.)	840	960	1150	40
Pre-formed(i.u.)	25	25	25	300
Vitamin A value(i.u.)	445	505	600	320
Riboflavine (mg)	0.34	0.40	0.50	0.38

Assuming that 2 i.u. of β-carotene are equivalent to 1 i.u. of vitamin A as assumed by Rajalakshmi and Ramakrishnan(1968) and ICMR revised allowances.

20 g of skim-milk powder fortified with vitamin A and 10 g of soya-bean oil.

The 'CARE' lunch was generally provided in the form of 'upma', when cracked wheat was available and the milk powder was incorporated in this. When cracked wheat was not available the milk powder was given in the form of milk prepared from the same. As the upma was given as a supplement and not in lieu of a meal, it did not affect food intake at home appreciably.

Although the 'CARE' supplies were not regular, they increased food intake by about 300 Calories. More important, they increased the availability of critical nutrients such as calcium, vitamin A and riboflavine by significant amounts.

The data on the heights and weights of the 'fed' and 'control' boys are shown in Table 56 and the Figure 6. The control values were close to the norms obtained for the lower class in this department except in the case of the oldest age groups. The 'fed' subjects were taller and heavier than the controls at all ages and the difference was as much as 4-5 kg

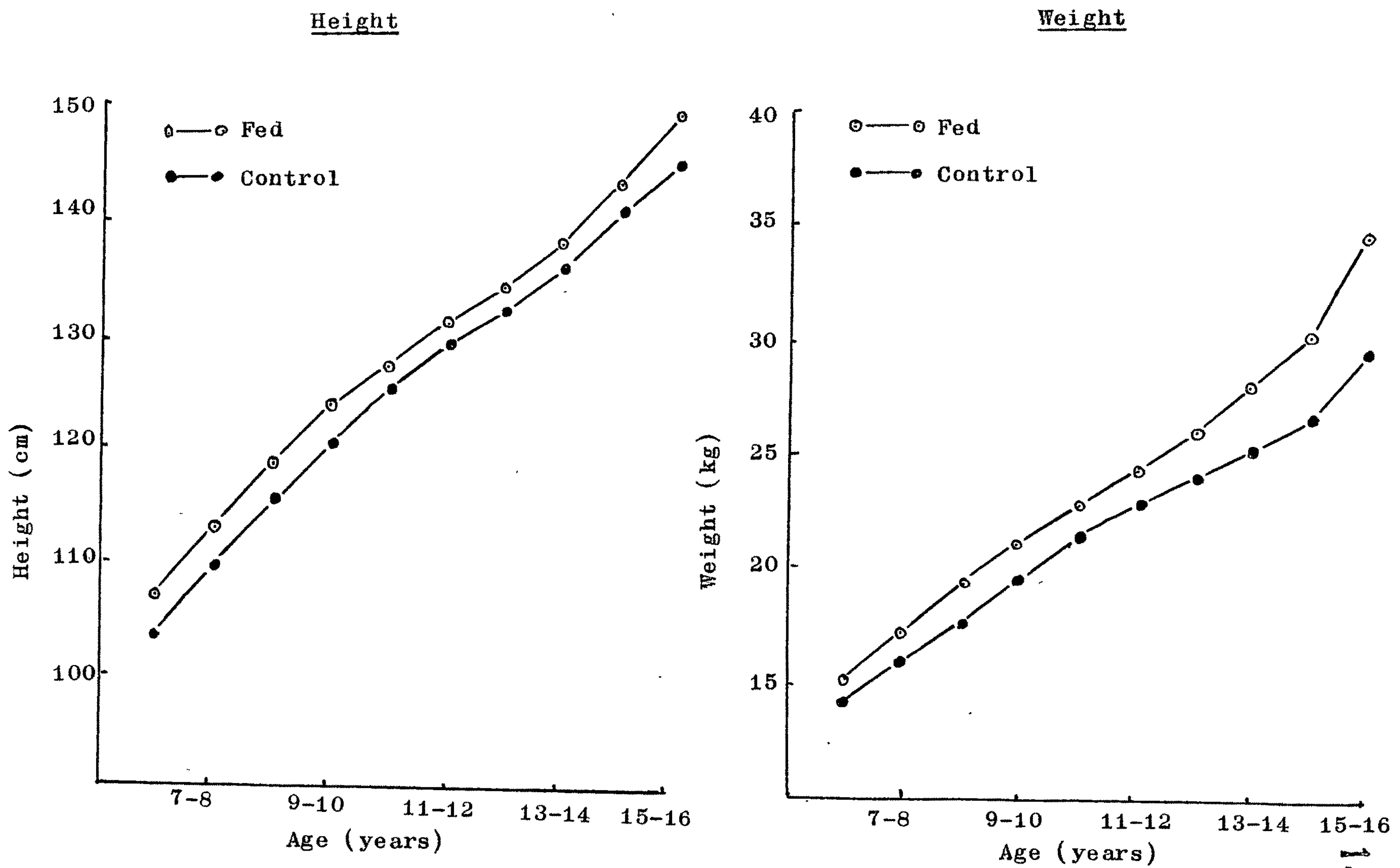
Table 56: Height and weight of fed and control children (boys) in Devgad Baria (Gujarat)*

Age (years)	No. of subjects		Height (cm)		Weight (kg)	
	E	C	E	C	E	C
6-7	50	50	106.5 (98.5-113.0)	103.0 (93.1-110.0)	15.0 (13.5-17.5)	14.4 (11.5-17.5)
7-8	86	89	112.4 (103.0-117.6)	109.1 (102.5-115.5)	17.2 (15.0-20.5)	16.0 (13.5-18.5)
8-9	61	130	117.5 (112.2-119.8)	115.1 (106.2-120.3)	19.2 (16.5-20.5)	17.4 (14.5-21.5)
9-10	68	66	123.1 (115.6-135.3)	120.3 (114.0-125.5)	21.4 (18.5-23.0)	19.6 (17.0-24.5)
10-11	82	61	126.7 (120.0-130.5)	125.6 (116.2-130.3)	22.7 (19.5-27.5)	21.8 (18.0-26.0)
11-12	69	69	130.4 (125.2-135.0)	128.9 (120.8-134.0)	24.5 (22.0-28.5)	22.8 (18.0-29.0)
12-13	103	85	133.8 (126.5-141.3)	132.1 (120.7-139.0)	26.0 (23.0-30.0)	24.0 (18.5-28.0)
13-14	101	95	138.2 (129.4-145.3)	135.8 (124.3-143.6)	28.1 (24.0-31.5)	25.2 (21.0-30.0)
14-15	67	41	142.9 (135.5-149.5)	140.4 (132.3-143.8)	30.2 (25.0-33.5)	26.3 (23.0-32.5)
15-16	48	22	149.0 (136.1-156.5)	145.0 (135.7-151.1)	35.4 (28.5-43.0)	30.4 (27.0-34.0)

*Values are means with ranges in parentheses.

E = Experimentals ; C = Controls

Fig. 6. Height and Weight of fed and control children (Boys) in Devgad Baria (Gujarat)



during adolescence. The six year olds did not show much difference probably because they had just joined school and were less regular in attendance.

The striking difference in the case of older boys is consistent with a similar pattern of differences between low and high income groups in other studies as can be seen from Figs. 1-5. The data suggest that a school lunch may be of crucial importance in preventing serious growth retardation during adolescence.

The data on biochemical status are presented in Table 57. The values obtained for the controls compared with values obtained for poor children in Raipura village. The 'CARE' lunch resulted in a significant increase in the levels of hemoglobin, serum protein, albumin and vitamin A as might be expected. All the differences except that with regard to carotene were statistically significant. The results for carotene are not surprising as the 'CARE' lunch did not provide significant amounts of the same. However, in this as well as in other studies in this laboratory, serum carotene values tended to be slightly

Table 57: Biochemical status of fed and control children in Devgad Baria.

Constituent	Values per 100 ml		
	Fed children	Control children	't' and 'p' values
Blood			
Hemoglobin(g%)	12.3±0.189	10.8±0.147	6.28 $p < 0.001$
Serum			
Total protein(g)	6.7±0.045	6.5±0.05	2.96 $p < 0.01$
Albumin (g)	3.8±0.049	3.6±0.05	2.86 $p < 0.01$
Carotene (µg)	28.6±2.62	22.8±2.34	1.66 n.s.
Vitamin A (µg)	17.9±1.81	12.5±1.55	2.27 $p < 0.05$
Vitamin C (mg)	0.41±0.038	0.43±0.042	0.36 n.s.

Values are means ± S.E.'s

n.s. - Not significant.

higher with a protein supplement which did not include carotene. This may be due to improved absorption.

The data on urinary excretion are presented in Table 58. As in previous studies, the values were in the acceptable or high range in the case of thiamine and riboflavine and the supplements tended to increase these values but the differences were not statistically significant. In the case of N'methylnicotinamide the values were lower as compared to values obtained for other groups in this laboratory (Table 59). However, most of the values were in the normal range. The relatively smaller values might have been because the subjects subsisted mainly on maize. In animal studies in this laboratory the same is associated with low excretion of N' methylnicotinamide although the decrease in tissue levels is of a much smaller magnitude.

As mentioned earlier, the children were subjected to radiological examination of the wrist and hand. The criteria used were bone-age as judged by the number of ossification centres, the appearance of the metaphysis and the cortical thickness of the second metacarpal bone.

Table 58: Composition of urine in fed and control children in Devgad Baria.

	Values per g of creatinine	
	Fed children	Controls
Riboflavine (μg)	790 ± 38	624 ± 34
Thiamine (μg)	1150 ± 99	1190 ± 66
N-Methyl-nicotinemide (mg)	7.2 ± 0.78	6.5 ± 0.65

Values are means ± S.E.'s.

Table 59: Urinary excretion of N'methylnicotinamide in school boys.

Group	N'methylnicotinamide in urine mg per g creatinine
Urban Baroda	12.5
Rural Baroda	10.3
Bhils (Panchmahal Dist.)	6.4
Present Study:	
Experimentals	7.2
Controls	6.5

The shape of the metaphysis was normal and no cupping or cleft was found. But coarse trabeculae were noted in some cases.

Marked retardation of bone development as judged by the number of ossification centres was found. In individual cases, the retardation was as much as four years and was much more than was found in Raipura. This might have been because of the fact that these children lived on maize which is much more deficient in calcium than wheat and bajra consumed by Raipura children. In animal experiments in this department (Annual Report of PL 480 Project FG-In-402 1969-70) rats fed maize had less calcium in the femur (16 mg) than those fed wheat (23 mg).

Similarly, cortical thickness was also less in these children than in Raipura children.

The experimentals and controls were not found to differ appreciably with regard to bone age or the same in relation to chronological age but a significant difference in favour of the experimentals was found in the case of cortical thickness suggesting that the latter responds earlier to dietary improvement. It would appear that it takes a much longer time for skeletal retardation to be reversed. The long period required for reversing skeletal retardation has also been noted by other investigators (Garn, 1966).

In conclusion tribal children in Devgad Baria living on maize were found to compare with Raipura children in most respects. The chief differences were that they were slightly shorter and lighter, showed more of skeletal retardation and less excretion of N' methylnicotinamide in urine. Dietary improvement produced a response comparable to that in the Raipura studies. A greater response was evident in the case of adolescent boys.

Section D

STUDIES ON THE AVAILABILITY OF CAROTENE IN LEAFY VEGETABLES IN ADULT MEN

As mentioned earlier the inclusion of 30 g of leafy vegetables in the school lunch was not found to clear completely symptoms of vitamin A deficiency. This might have been due to factors such as cooking losses and absenteeism and holidays which would have the effect of lowering the amount of carotene available. On the other hand, extrapolation from subsequent animal studies suggested that about 50-60 g of leafy vegetable might provide the equivalent of 2000 i.u. of vitamin A in the form of retinol. Studies were made of adult male volunteers whose home diet was deficient in vitamin A to test this hypothesis.

Subjects: The subjects were moderately active adult males who were employees of the University with a monthly income of about Rs.150/- p.m. Data on their height and weight and home diet are shown in Table 60.

Dietary treatment: The subjects were examined initially for blood hemoglobin, serum protein, albumin, carotene and vitamin A and divided into three groups

Table 60: Subjects used in the investigation.

No. of subjects	23
Height (cm)	160
Weight (kg)	46.0
Food intake (g)	
Cereals	350
Pulses	40
Leafy-vegetables	5
Other vegetables	100
Milk	80
Oil	30
Sugar	30
Flesh foods	5-10
Nutrient	
Calories:	
total	2000
per kg	43
Protein:	
total (g)	35
per kg	1.2
Calcium (mg)	400
Iron (mg)	30
Carotene and vitamin A (i.u.)	1000

matched roughly for weight, and blood and serum values. All the three groups were given a lunch in the laboratory more or less resembling their home lunch. The same consisted of chapaties, dal, rice and vegetables. The vegetables consisted of potatoes and one other vegetable. In the case of one group, the latter consisted of fenugreek, spinach or amaranth. In the case of the other two groups, one or other of vegetables having negligible amounts of carotene such as brinjal, bittergourd etc. were used. One of the latter two groups was given 2000 i.u. of vitamin A in the form of palmitate in one teaspoon of groundnut oil which was served on rice. The other two groups were given the same amount of oil without vitamin A. The lunch was given for six days a week for a period of 3 months.

Repeat analyses of blood and serum were made once a month. In addition to the above three groups an additional control group which did not take the lunch described was also investigated.

Balance studies with regard to β-carotene were carried out for a period of 3 days prior to the termination of treatment on five subjects. During this period, the subjects were provided all their meals including tea in the laboratory and were requested to inform the investigator of anything eaten outside. Nothing was reported to be consumed outside. Fecal markers were used.

The feces were weighed within a few minutes after defecation and a portion of the same taken up immediately for analysis. Both the subjects and investigator stayed in the laboratory during the period to facilitate collection and analysis.

Results and Discussion:

Data on height, weight and normal food intake of the subjects are shown in Table 60. The diet provided about 2000 Calories or 43 Calories per kg. The diet was deficient in vitamin A but was reasonably adequate in other respects. The reliability of the data on the dietary intake was checked by comparing the amount reportedly consumed at lunch with that actually consumed during the experimental period. Similarly, comparisons were made of reported and actual whole day intakes of the five subjects investigated in balance studies.

At the lunch items other than vegetables were provided _ad libitum_ but the amounts consumed were recorded (The subject was not aware of this). On an average 200 g of wheat, 150 g of rice, 35 g of dals and 70 g of potatoes were consumed in addition to either 50-60 g leafy vegetables or other vegetables.

During this period food intake at home was also recorded on the basis of verbal reports. Particular care was taken to record information on vegetables and fruits consumed at home during the experimental period.

Most of the subjects were in apparent energy balance during the period of study as they did not either lose or gain weight, assuming that body composition did not change during the period of study. It must be presumed that their previous calorie intake was adequate as they did not gain weight on the lunch provided _ad libitum._ Two of the subjects in the control group, however showed a gain of 2.5 and 4.5 kg suggesting a previous state of under nutrition.

The absence of weight gain in most of the subjects is not surprising as their calorie intake was consistent with their physical stature and levels of activity. Studies reviewed by Banerjee (1970) suggest that the activity increment in sedentary workers may be of the order of 50%. In the present studies basal metabolism might be expected to have accounted for about 1200-1300 Calories in these subjects so that the activity increment was of a similar order.

The amount of vitamin A and carotene consumed by the subjects during the study period are shown in Table 61. The leafy vegetables were obtained mainly from the kitchen garden maintained by the Department. Samples of the vegetables were analysed for β-carotene as such and after cooking. The analysed values are shown in Table 62.

The results of serial measurements are shown in Table 63 and also Table 63a. Many of the subjects had relatively low levels of hemoglobin but only one of them had a value below 11%. The values of 10% in the case of this subject did not change during the period of study. The subject had chrnnic amoebiasis and low blood pressure.

Table 61: Carotene and vitamin A consumed by the subjects during the experimental period.

Group	Addition to Lunch	Amount in whole day diet	
		Vitamin A (i.u.)	Carotene (i.u.)
I	Leafy-vegetable 60 g	75	5220
II	Vitamin A Palmitate 2000 i.u.	2075	960
III	Controls	75	810

Table 62: β -carotene in raw and cooked leafy-vegetables.

		μg/100 g of leafy vegeable		
		Raw	Cooked	% loss
Spinach sample	1	6025	3475	42
"	2	4800	2600	36
"	3	-	2876	
"	4	-	3594	
Amaranth sample	1	4875	3550	27
"	2	4490	2875	36
"	3	-	3325	
Average		5050	3170	

Table 63: Biochemical status of the subjects at the start and during the experimental period.

	Group	Values per 100 ml			
		at start	1st month	2nd month	3rd month
Blood:					
Hemoglobin	I	12.7±0.28	12.7±0.30	12.8±0.36	12.8±0.37
	II	12.7±0.25	12.8±0.25	12.7±0.21	12.7±0.29
	III	12.9±0.36	12.9±0.47	12.9±0.23	12.9±0.21
	IV	14.1±0.70	14.1±0.67	14.2±0.65	14.2±0.64
Serum:					
Protein(g)	I	6.5±0.10	6.6±0.13	6.6±0.16	6.7±0.16
	II	6.5±0.13	6.5±0.29	6.6±0.11	6.6±0.12
	III	6.6±0.13	6.7±0.15	6.7±0.13	6.8±0.12
	IV	6.8±0.11	6.7±0.14	6.8±0.14	6.8±0.18
Albumin(g)	I	3.8±0.11	3.9±0.08	4.0±0.05	4.0±0.05
	II	2.8±0.11	3.9±0.11	3.9±0.08	3.9±0.08
	III	3.7±0.11	3.8±0.07	3.9±0.06	3.9±0.07
	IV	4.3±0.17	4.2±0.15	4.2±0.15	4.2±0.15
Carotene(µg)	I	23±2.8	39±3.4	53±8.7	59±5.8
	II	30±2.1	30±4.4	29±3.8	28±2.4
	III	30±4.0	30±3.7	29±5.3	28±2.6
	IV	17±1.5	20±0.8	21±1.4	22±1.1
Vitamin A (µg)	I	9±1.0	11±0.9	18±1.8	24±1.9
	II	11±1.2	14±1.8	21±3.8	27±4.0
	III	11±3.0	11±2.7	12±2.9	13±2.9
	IV	15±1.9	15±1.8	15±1.9	15±1.9

Values are means ± S.E.'s.

I = Leafy vegetables 60 g/day; II = Vitamin A palmitate 2000 i.u./day;
III= Controls (without leafy vegetables and vitamin A); [illegible]

IV = Additional control group not given lunch.

Table 63a: Increase in serum carotene and vitamin A levels with consumption of leafy vegetables.

Source of carotene or vitamin A added to lunch*	Micrograms per 100 ml of serum					
	carotene			vitamin A		
	at start	at end	difference	at start	at end	difference
Leafy vegetables(60g)	23	59	36	9	24	15
Vitamin A palmitate in oil (2000 i.u.)	30	28	-2	11	27	16
None	30	28	-2	11	13	2

*Period of treatment, 3 months.

In the case of two subjects hemoglobin values increased by about 1.2% during this period. These subjects also improved their serum protein values. These were also the subjects whose body weights increased during the study period. None of the subjects had deficient values for serum protein though some had low values.

Incidentally, the data on the additional control group provided some idea of the extent of variation in normal subjects living on their customary diets. In these subjects, the values for hemoglobin, serum protein and serum albumin showed very little variation, the maximum change in individual subjects being 0.2% in the case of serum albumin and 0.6% in the case of the other two parameters.

In the case of carotene and vitamin A, the values changed in the expected direction in the case of the two experimental groups. Mean serum carotene values (μg/100 ml) changed from 23 to 59 in the case of the group given leafy vegetables.

Neither the control group fed vegetables poor in carotene nor the vitamin A supplemented group showed any change in serum carotene.

In the case of serum vitamin A both the experimental groups showed an increase of 15-16 µg/100 ml or about 150% increase over the initial levels, suggesting that 50 g of leafy vegetables used were as effective as 2000 i.u. of vitamin A in increasing serum vitamin A levels in addition to which they also increased serum carotene levels.

As mentioned earlier, balance studies were done on selected subjects. The data are presented in Table 64. They suggest about 50% utilization at the suggested levels of intake and a higher utilization at lower levels of intake. This is consistent with other reports (Mitchell, 1964). They are however subject to the limitation that bile pigments may interfere with the estimation and that some of the unabsorbed carotenoids may get oxidised in the intestinal tract. However, they are consistent with observation that 50 g of leafy vegetable containing 3500 i.u. of carotene elicited the same response of serum vitamin A

Table 64: Balance studies with regard to β -carotene in selected subjects.

Subject No.	β -carotene (μg)		
	diet	feces	% utilised
1	2400	1200	50
2	2450	1125	54
3	340	89	74
4	400	180	55
5	406	150	63

levels as 2000 i.u. of vitamin A and with more than 40% and 60% absorption found for spinach and cabbage by Hume and Krebs (1949). Koehn (1948) found that in rats β-carotene can be quantitatively converted to vitamin A in the presence of adequate levels of vitamin E. The fact that about 2400 μg of carotene compared with 600 μg of vitamin A in increasing serum vitamin A levels, and increased in addition serum carotene levels suggests a high efficiency of utilization of β-carotene.

Recent studies suggest the involvement of vitamin A in the utilization of protein (Moore, Sherman and Ward, 1952) and the inclusion of serum protein and albumin levels as parameters was guided by this consideration. However, no change was found in the case of either, except in the case of the two subjects mentioned earlier. Similarly no change in blood hemoglobin was found although the leafy vegetables provided 10 mg of iron. This suggests their initial satisfactory state with regard to protein and iron.

In conclusion, the results suggest a fairly efficient utilization of carotene in leafy vegetables. Similar findings have been made in animal studies in this laboratory (Rajalakshmi and Chari, unpublished) and in human subjects in Vellore (Prof. Mary Dumm, personal communication) and Hyderabad (Annual Report of National Institute of Nutrition, 1968) and in several studies reviewed by Mitchell (1964).

Section E

EFFECT OF VITAMIN B_{12} SUPPLEMENTATION

As mentioned earlier, the response of blood hemoglobin levels to dietary improvement was poor as compared to other blood or serum constituents. As the diets provided only 66 μg of vitamin B_{12} and could have been marginally limiting in the vitamin, the question arises whether better responses could have been obtained by a diet providing more liberal amounts of this vitamin.

In this connection, in spite of the fact that ordinary diets in this country are lacking in animal foods and are therefore likely to be deficient in vitamin B_{12}, megaloblastic anemia arising from vitamin B_{12} deficiency is seldom reported. On the other hand some studies suggest that mental symptoms of vitamin B_{12} deficiency may be found even in the absence of anemia (Vilter _et al_., 1950). Subclinical deficiency of vitamin B_{12} may possibly reduce hemoglobin levels without affecting appreciably the size of red blood cells.

The present studies were carried out on adult male volunteers with low levels of vitamin B_{12} intake with a view to investigate the effects of supplementation with the vitamin on hemoglobin levels and psychological performance.

Twenty subjects belonging to the low income group were studied in these experiments. Most of the subjects took no more than 100 g of milk. Some of the subjects were lactovegetarians and others consumed about 15 g of animal food per day. Data were obtained on blood hemoglobin and serum protein and albumin. The latter were estimated because of the possible role of vitamin B_{12} in the utilization of protein and vice versa.

In addition, performance on a selected psychological task which involves new learning was also investigated. Performance in this task is found to be sensitive to variables such as age and to be improved by administration of certain tranquilizers (Rajalakshmi and Jeeves, 1968; Rajalaksmi and Patel, unpublished). This task was chosen as it was felt that any beneficial effect on mental function should be evident in performance on the same.

All the above measurements were made at the start and conclusion of treatment. The subjects were divided into 3 groups matched for age, body weight and initial hemoglobin levels. They were also found to be matched for psychological performance.

The results are presented in Table 65. The initial mean values were found to be about 12.8% for hemoglobin, 6.5% for serum protein and 3.8% for albumin. The value for hemoglobin was higher than the value of about 11 g obtained for adults in rural areas.

Some investigators have reported a significant increase in weight gain with vitamin B_{12} supplementation even in well nourished subjects (Mitchell, 1964). This was not found to be true in the present studies.

Supplementation of vitamin B_{12} either alone or with the intrinsic factor had no effect on any of the parameters measured. No improvement in performance in the psychological task administered was found in any of the groups.

The results are perhaps to be expected on the basis of several findings of a similar nature made in Hyderabad (Annual Report of National Institute of

Table 65: Effects of vitamin B_{12} supplement on the composition of blood and serum, and psychological performance.

	Values (g) per 100 ml of blood or serum						Paired Associate Learning			
	Hemoglobin		Total protein		Albumin		O.L.		R.L.	
	Initial	Final	Initial	Final	Initial	Final	Intial	Final	Initial	Final
Controls	12.8 ± 0.55	12.9 ± 0.59	6.7 ±0.10	6.7 ±0.13	3.9 ±0.09	3.9 ±0.12	8 (3-15)	7 (3-12)	10 (4-17)	9 (3-17)
Vitamin B_{12} (5 µg/day)	12.6 ± 0.12	13.1 ± 0.12	6.4 ±0.27	6.4 ±0.27	3.7 ±0.18	3.8 ±0.20	9 (4-15)	9 (3-14)	12 (8-19)	11 (4-19)
Vitamin B_{12} with intrinsic factor (5 µg/day)	13.2 ± 0.26	13.6 ± 0.23	6.4 ±0.22	6.5 ±0.23	3.7 ±0.23	3.9 ±0.14	10 (3-17)	11 (5-19)	15 (11-22)	15 (12-21)

Values are means ± S.E.'s; range shown in parentheses.

O.L. - Original Learning, number of trials required for learning the paired association of geometrical figures to symbols.

R.L. - Re-paired Learning, number of trials required to learn changed associations of the same.

Nutrition, 1968) and on the basis of reasonably satisfactory initial levels of the parameters studied. They confirm the general impression that vitamin B_{12} deficiency is not a serious problem in this country.