C H A P T E R I

I N T R O D U C T I O N

INTRODUCTION

About two thirds of the population of the world live in developing countries and a substantial segment of the population in these countries is either undernourished or malnourished or both.

A state of malnutrition in the community is associted with high rates of infant mortality, low life-expectancy, poor work performance and poor agricultural productivity. Malnutrition and undernutrition during childhood result in permanent stunting of adult stature. Malnourished individuals are believed to be more susceptible to infections and more prone to accidents (Berg, 1968). Recent work indicates that even intellectual development in the child may be affected by nutritional status (Scrimshaw and Gordon, 1968). Vitamin deficiencies may affect mental function even in the adult (Eiduson *et al*., 1964).

The poor man's diet in this country is based mainly on cereals with small quantities of foods such as pulses and vegetables. Foods of animal origin including milk are consumed in negligible quantities. The diets are lacking in good quality proteins, calcium, vitamin A, and riboflavine. Often, even the calorie supply is deficient.

Further, the distribution of food even within the same family may be far from equitable. For instance, in an otherwise adequately nourished family, young children may not get enough to eat because of the unsuitable nature of the meals prepared in the adult-oriented home. In this country addition of spices to legumes and vegetables makes them unsuitable for young children (Patwardhan, 1961). Similarly, people with teeth troubles or the convalescent may not find the meals normally prepared suitable. Food sharing practices may also operate against the equitable sharing of protective foods. The head of the house is served first and given favoured treatment whereas growing children and adolescents do not receive the same attention. Women including expectant and nursing mothers eat last resulting in an unequal sharing of protective foods.

Poor agricultural productivity and poor economic capacity combined with ignorance are mainly responsible for the poor nutritional status of the people. Foods such as milk and eggs are beyond the poor man's reach. His preference for milled rice rather than polished rice and for potatoes rather than leafy vegetables are the result of ignorance about their relative nutritive values and also of long-established food habits. Even an improvement in economic status may result in the greater consumption of tea, sugar and refined flour rather than more needed foods such as pulses, greens and milk.

Many programmes are being carried out at present for preventing malnutrition and undernutrition in children by various international agencies such as UNICEF and FAO (Autret, 1964; Harman, 1966). Such programmes generally aim at nutrition education as well as more efficient food production. However, the number of centres which carry out such programmes is at present limited.

Efforts have been made to popularise processed food mixtures based on plant materials with a high protein content, but they have hardly made any impact even in urban areas and are totally unknown in rural areas. This is due to several reasons. Processing inevitably increases the cost of foods, usually by at least 100%. In this country, the average amount of money spent on food is of the order of eighty-five paise per day in urban areas and sixty five paise in rural areas (Sukhatame, 1965) and the supplies available for this amount are hardly adequate even when the money is used for the purchase of raw foods. The villagers can hardly be expected to allow their supplies to dwindle further by the use of processed foods.

Secondly, the use of centrally manufactured foods pose problems in transportation and distribution. When we consider the difficulties involved in distributing even a part of the food grains consumed, the magnitude of the problem can be easily visualized. The acceptance of processed foods is yet another problem as pointed out by Gyorgy (1966).

It would therefore seem desirable to attempt improving the nutritional status of the poor man by educating him to make a more efficient use of locally available sources of foods. He must be educated on the relation between nutrition and physical stature, mental characteristics such as cheerfullness and alertness, efficiency of work performance, health, and susceptibility to infection etc. Any advice given to him must be based on what he already produces or can easily produce, and be consistent with his economic capacity. The availability of land and the cost of foods are crucial considerations as can be seen from the data of Tables 1 and 2. The food preparations suggested should be appropriate for the kind of kitchen equipment available in rural homes. The advice given is likely to be more effective if it is based on suitable modifications of the existing diet rather than novel foods unknown to the villagers. For instance, soyabean and its milk may be excellent foods, but, in this country, it will be easier to educate the farmer in the use of pulses which are commonly cultivated.

Table 1: Relative efficiency of vegetable foods and animal foods as suppliers of nutrients from an acre of land* (Rajalakshmi and Ramakrishnan, 1968)

Foodstuffs	Gross yield per acre (kg)	Approximate amount available per acre*					
		Calories x 10^5	Protein (kg)	Calcium (kg)	Iron (g)	Vitamin A (i.u.) x 10^5	Ribo-flavine (kg)
Cereals	350	12.0	35	0.10	21.0	3.5	0.35
Pulses	250	8.6	60	0.20	20.0	5.5	0.75
Oil seeds	300	16.5	78	0.15	4.8	1.8	0.90
Milk	360	2.4	12	0.63	0.6	3.0	0.30
Animal foods	20	0.4	4	0.05	0.4	0.1	0.06
Leafy vegetables	5000-10000	24-48	200-400	125-250	750-1500	3500-7000	5-10
Root vegetables	5000-10000	50-100	100-200	10-20	30-60	50-100	5-10
Other vegetables	2500-5000	10-20	50-100	1-2	50-100	75-150	1.5-3.0
Fruits	10000-20000	50-100	80-160	3-6	120-140	50-100	2-4
Sugar	2000	80	-	-	-	-	-

*Calculated from figures for yield and average nutrient composition of different food groups derived from values given in food tables for commonly consumed foods.

Table 2: Nutrients provided by a rupee's worth of different foods*
(Rajalakshmi and Ramakrishnan, 1968)

Foodstuffs	Amount (g) per one rupee	Nutrient present in rupee's worth foodstuff					
		Calories	Protein (g)	Calcium (mg)	Iron (mg)	Carotene or vitamin A (i.u.)	Riboflavine (mg)
Cereals	800 (other than rice)	2760	80	240	48.0	800	0.80
Pulses	400	1380	96	320	32.0	400	1.60
Oilseeds (groundnut)	500	2750	130	250	8.0	300	1.50
Milk (buffalo)+	750	600	23	1580	1.5	750	0.75
Animal foods (mutton)	250	485	50	30	5.0	75	0.68
Egg (hen)	75	125	10	45	1.5	1500	0.13
Leafy vegetables (amaranth, fenugreek, spinach)	2500	1250	100	6250	375.0	175000	2.50
Root vegetables	1500	1500	30	300	9.0	1500	0.30
Other vegetables	2000	800	40	800	40.0	6000	1.20
Fruits	1500	a 1500	12	450	18.0	c 15000	0.30
		b 750				d 750	

+Milk containing 5% fat, 3% protein and 5-6% carbohydrate.
a & b are fruits high and low in carbohydrate.
c & d are fruits high and low in carotene
*Based on price levels in Baroda during September-October, 1967.
1 U.S. dollar is equivalent to 7.7 rupees.

It is evident that, in order to give the right kind of advice, we have first to identify the existing dietary patterns and their inadequacies and consider how they can be improved with locally available resources.

Extensive diet surveys have been carried out in India during the past two decades (Govil et al., 1953; Rao et al., 1954; Radhakrishna Rao, 1956; Rao and Rao, 1958; Belavady et al., 1959; Pasricha, 1959; Jyothi et al., 1963; Rajalakshmi and Nanavaty, 1964; Saha and Seal, 1965). The results of 843 surveys in different parts of the country have been summarized by Mitra (1953). As mentioned earlier these surveys have shown that the diets are composed primarily of cereals with poor consumption of pulses and leafy vegetables and negligible consumption of animal foods such as eggs, milk and meat. They have generally pointed to a deficiency of calories, protein, vitamin A, and B vitamins, particularly riboflavine in all areas, and thiamine in areas consuming polished rice. However, these surveys have been mostly carried out on families using the oral questionnaire method.

A few studies have been carried out on school children and some of the available data on their food intake are presented in Table 3. They show the inadequacy of the diets

Table 3: Nutrient intake of school boys of the poor class reported from India

Authors	Region	Calories	Protein (g)	% protein calories	Calcium (mg)	Vitamin A value (i.u.)
Wilson and Mitra (1938)	Bengal	1308	35	10.7	103	596
Rao and Rao (1958)	Vellore	1181	32	10.8	346	662
Pasricha (1959)	Hyderabad	1231	25	8.1	N.R.	N.R.
Doraiswamy _et al._ (1962)	Mysore	1970	49	10.0	465	356
" (1962a)	Mysore	1313	37	11.3	302	352
" (1963)	Mysore	1834	47	10.3	352	960
" (1964)	Mysore	1669	39	9.2	329	1425
" (1965)	Mysore	1962	48	9.8	450	403
Devadas and Radharukmini (1964)	Coimbatore	1868	46	9.8	620	2742
Devadas _et al._ (1964)	Coimbatore	1412	35	9.9	365	1959
Median value		1540	38	10.0	365	662

with regard to calories, protein, vitamin A and calcium. Many of the studies show intakes of less than 1500 calories although variable values have been reported from Mysore and Coimbatore. In most of the studies protein calories form 10% of total calories so that the defiency in protein is primarily due to that in calories and in the quality of the protein in cereals. With an increase in food intake and the inclusion of pulses and greens, this deficiency can be corrected.

Calcium intakes appear to be of the order 300-500 mg in most studies. The vitamin A content of the diets is also quite low.

Such poor diets during growth may be expected to affect physical stature as well as nutritional status.

During the past few years there has been a growing awareness of the relation between dietary intake and growth of children. Considerable evidence is now available on the effects of malnutrition on physical growth. Weight, height and growth measurements of children carried out in many areas of the world where dietary deficiencies exist indicate the effects of diet on body build. Some of the data on heights and weights are summarized in Tables 4 and 5. They do not suggest any great differences either between different

Table 4: Data on Heights (cm) of Primary school children in India

Reference	Region	Group	Sex	Heights in cm Age 6	7	8	9	10	11	12
Aykroyd and Krishnan (1936)	Coonoor		M	106.7 (55)	113.0 (83)	116.8 (95)	120.7 (76)	126.0 (93)	130.6 (73)	133.1 (61)
	Mettu-palayam		M	111.8 (20)	114.3 (47)	119.4 (34)	119.4 (31)	129.5 (49)	132.1 (45)	137.2 (37)
	Calicut		M	109.7 (47)	114.3 (54)	118.6 (57)	124.7 (70)	129.4 (61)	129.5 (50)	129.5 (35)
Daver (1946)	Hyderabad	Mohamma-dian	M	109.2 (150)	116.8 (255)	118.1 (320)	124.5 (362)	128.0 (436)	129.5 (363)	135.9 (463)
		Hindu	M	109.2 (181)	113.0 (285)	116.8 (279)	121.9 (315)	123.2 (383)	130.8 (288)	139.7 (287)
		Mohamma-dian	M	102.9 (231)	109.2 (358)	114.3 (472)	118.1 (379)	124.5 (350)	127.8 (466)	132.8 (626)
		Hindu	M	101.6 (200)	106.7 (353)	114.3 (439)	118.1 (371)	124.0 (449)	128.3 (374)	132.1 (606)
Krishnan (1939)			M	103.9 (25)	112.3 (26)	113.8 (38)	115.8 (25)	120.9 (30)	122.4 (32)	127.8 (34)
Mitra (1941)	Bihar		M	113.5 (126)	117.9 (173)	121.2 (152)	125.7 (122)	131.6 (69)	134.6 (77)	141.5 (69)
			F	109.5 (86)	115.6 (66)	118.9 (51)	125.2 (32)	128.8 (24)	133.4 (13)	134.4 (11)

contd...

Table 4 (contd.)

Reference	Region	Group	Sex	Heights in cm: Age 6	7	8	9	10	11	12
Mitra (1947)	Bihar		M	111.0 (460)	115.8 (381)	119.1 (491)	123.4 (583)	129.0 (516)	132.8 (497)	138.9 (361)
			F	110.5 (236)	115.1 (168)	118.4 (189)	122.2 (150)	127.0 (109)	130.6 (72)	136.1 (23)
Rao *et al.* (1961)	Vellore		M	103.8 (127)	109.5 (153)	117.6 (114)	120.2 (93)	124.0 (89)	129.0 (97)	131.0 (90)
			F	101.9 (73)	108.2 (76)	113.9 (44)	120.6 (42)	125.0 (62)	127.1 (23)	132.4 (20)
Rao *et al.* (1961a)	Vellore		M	104.9 (63)	109.4 (67)	114.6 (96)	119.7 (80)	124.9 (94)	129.9 (99)	133.7 (139)
			F	104.5 (103)	110.0 (59)	116.3 (73)	119.3 (65)	124.6 (63)	130.9 (44)	135.2 (54)
Shourine (1939)	Najafgarh		M	110.7 (72)	115.1 (142)	120.1 (170)	123.7 (183)	126.7 (164)	130.0 (135)	135.9 (119)
	S. India		M	108.7 (122)	113.8 (184)	117.9 (186)	121.9 (177)	128.0 (203)	130.6 (168)	133.4 (133)
Wilson and Mitra (1938)	Assam		M	108.7	108.7	128.6	123.2	125.5	128.3	135.6
	Barasat		M		116.3	119.9	126.4	131.3	134.9	138.9
	Calcutta		M		122.2	123.2	130.3	133.1	136.7	143.5

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Table 4 (contd.)

Reference	Region	Group	Sex	Heights in cm Age 6	7	8	9	10	11	12
Wilson *et al.* (1937)	Bengal	Bengali	M (UC)		122.2 (15)	123.4 (28)	130.3 (57)	133.1 (77)	136.9 (80)	143.5 (74)
			M (MC)		115.8 (28)	120.4 (64)	125.0 (84)	129.8 (127)	134.4 (110)	139.2 (88)
			M (LC)		115.3 (114)	120.9 (140)	124.0 (104)	128.5 (121)	135.1 (87)	141.7 (32)
		Mohammadian	M (UC)		118.6 (2)	118.4 (5)	128.5 (12)	134.6 (34)	138.4 (30)	144.8 (33)
			M (LC)		114.8 (58)	110.2 (40)	124.5 (42)	129.0 (45)	133.6 (37)	142.2 (28)
		Marwari	M (UC)		113.8 (14)	118.4 (17)	124.7 (14)	129.2 (48)	135.4 (60)	136.9 (70)
			M (LC)		116.3 (29)	122.7 (33)	128.3 (31)	134.1 (32)	145.0 (4)	139.2 (9)
		Anglo Indian	M (UC)		121.2 (8)	123.2 (17)	128.3 (26)	133.4 (31)	133.9 (31)	142.7 (29)
			M (LC)		120.1 (6)	121.9 (26)	124.2 (18)	129.0 (23)	133.9 (22)	138.2 (11)
Median value				109.0	114.1	118.4	122.6	127.4	130.3	135.8
Median value derived from Someswara Rao (1961)				105.7	111.8	116.9	121.5	126.4	130.2	134.5

Table 5: Data on weights (kg) of Primary school children in India

Reference	Region	Group	Sex	Weights in kg, Age 6	7	8	9	10	11	12
Aykroyd and Krishnan (1936)	Coonoor		M	15.9 (55)	17.7 (83)	21.0 (95)	21.5 (76)	23.0 (93)	24.5 (73)	25.7 (61)
	Mettu-palayam		M	17.1 (20)	17.1 (47)	18.7 (34)	19.2 (31)	21.5 (49)	21.8 (45)	24.5 (37)
	Calicut		M	17.2 (47)	18.4 (54)	19.5 (57)	21.5 (70)	23.4 (61)	23.3 (50)	25.1 (35)
Daver (1946)	Hyderabad	Mohamma-dian	M	16.6 (105)	18.6 (255)	20.2 (320)	21.8 (362)	22.7 (436)	24.5 (363)	27.4 (463)
		Hindu	M	16.6 (181)	17.2 (285)	19.3 (279)	20.8 (315)	22.3 (383)	24.7 (288)	27.0 (287)
		Mohamma-dian	M	15.0 (231)	16.3 (358)	17.9 (472)	19.5 (379)	21.3 (550)	22.3 (466)	24.9 (626)
		Hindu	M	15.0 (200)	16.3 (353)	18.0 (439)	19.0 (371)	21.0 (449)	22.8 (374)	24.5 (606)
Krishnan (1939)			M	15.0 (25)	15.9 (26)	17.2 (38)	17.7 (25)	19.0 (30)	19.5 (32)	23.1 (34)
			F	15.0 (19)	15.9 (27)	16.8 (30)	17.7 (20)	17.5 (29)	20.9 (21)	22.2 (30)
Mitra (1941)	Bihar		M	16.6 (126)	18.3 (137)	19.8 (152)	21.4 (122)	23.8 (69)	24.9 (77)	29.6 (69)
			F	15.7 (86)	17.3 (66)	18.4 (51)	19.9 (32)	22.2 (24)	24.2 (13)	26.2 (11)

contd...

Table 5 (contd.)

Reference	Region	Group	Sex	Weights in kg, Age 6	7	8	9	10	11	12
Mitra (1947)	Bihar		M	17.2 (460)	18.5 (381)	19.7 (491)	21.3 (583)	23.2 (516)	25.7 (497)	28.5 (361)
			F	16.7 (236)	18.1 (168)	19.2 (189)	20.9 (150)	23.1 (109)	25.1 (72)	28.3 (23)
Rao *et al.* (1961a)	Vellore	Urban	M	15.9 (63)	16.9 (67)	18.5 (96)	20.5 (86)	22.9 (94)	25.0 (99)	27.0 (139)
			F	15.8 (103)	16.9 (59)	19.9 (73)	19.9 (65)	22.5 (63)	25.5 (44)	28.0 (54)
Rao *et al.* (1961)	Vellore	Rural	M	16.1 (127)	17.2 (153)	20.0 (114)	20.9 (95)	22.3 (84)	24.3 (97)	25.6 (90)
			F	15.4 (73)	17.1 (76)	18.3 (44)	21.0 (42)	22.6 (62)	23.5 (23)	26.0 (20)
Shourie (1939)	Najafgarh		M	18.1 (72)	19.1 (142)	20.8 (170)	22.1 (183)	23.6 (164)	25.3 (135)	27.7 (119)
	South India		M	16.6 (122)	17.8 (184)	19.1 (186)	21.1 (177)	22.8 (203)	23.4 (168)	25.2 (133)
Wilson and Mitra (1938)	Assam		M		15.8	18.7	20.2	21.4	22.9	26.2
	Barasant		M		18.5	19.9	23.1	24.8	27.1	28.6
	Calicut		M		21.6	22.8	22.8	26.4	28.7	34.0

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Table 5 (contd.)

Reference	Region	Group	Sex	Weights in kg Age 6	7	8	9	10	11	12
Wilson *et al.* (1937)	Bengal	Bengali	M (LC)		21.6 (15)	22.7 (28)	25.4 (57)	26.4 (77)	28.8 (80)	34.0 (74)
			M (MC)		19.2 (28)	20.4 (64)	22.4 (84)	24.2 (127)	26.8 (110)	31.1 (88)
			M (LC)		17.7 (114)	19.7 (140)	21.0 (104)	22.8 (121)	25.5 (87)	29.2 (32)
		Mohamma-dian	M (UC)		19.5 (2)	21.0 (5)	22.4 (12)	26.8 (34)	27.6 (30)	31.5 (33)
			M (LC)		17.7 (58)	18.5 (40)	20.7 (42)	23.0 (45)	25.2 (37)	28.5 (28)
		Marwari	M (UC)		18.8 (14)	20.4 (17)	22.8 (14)	24.9 (48)	28.2 (60)	29.2 (70)
			M (LC)		18.3 (29)	20.7 (33)	23.4 (31)	25.8 (32)	28.0 (4)	28.0 (9)
		Anglo Indian	M (UC)		20.8 (8)	22.9 (17)	23.9 (26)	26.3 (31)	29.0 (31)	31.7 (29)
			M (LC)		19.2 (6)	20.8 (26)	21.1 (18)	23.7 (23)	26.0 (22)	27.9 (11)
Median value				16.6	17.7	19.7	21.3	22.9	24.5	27.0
Median value derived from Someswara Rao (1961)				15.8	17.8	19.3	21.0	22.8	24.6	26.9

regions or between Hindus and Muslims nor do they suggest serious difference between boys and girls. Nor do weights and heights seem to have changed during the last few decades. But they do show the impact of economic status. Similar observations have been made in this laboratory (Figs. 1-2, 3-4).

The effect of retardation of growth during childhood may be permanent stunting evident in the adult stature attained in later years. Thus, although birth weight does not differ much between the lower and upper classes, growth rates during the post-weaning period and the subsequent period are found to differ markedly as shown in Fig. 5 (Rajalakshmi, 1969). The adult man in the upper class weighs about 55-60 kg whereas the corresponding figure for the lower class is 45-50 kg. Similarly, women in the two classes weigh 45-55 kg and 35-45 kg.

The difference in physical stature between the lower and upper classes found in the studies cited earlier suggests that the growth potential of the lower class is not realised because of the restricted supply of food. The same is also suggested by the fact that demonstrable increases in height and weight have been reported with even a marginal improvement of the diet with the addition

Fig. 1. Weights of boys in the lower and upper classes in Gujarat as compared to Western norms.

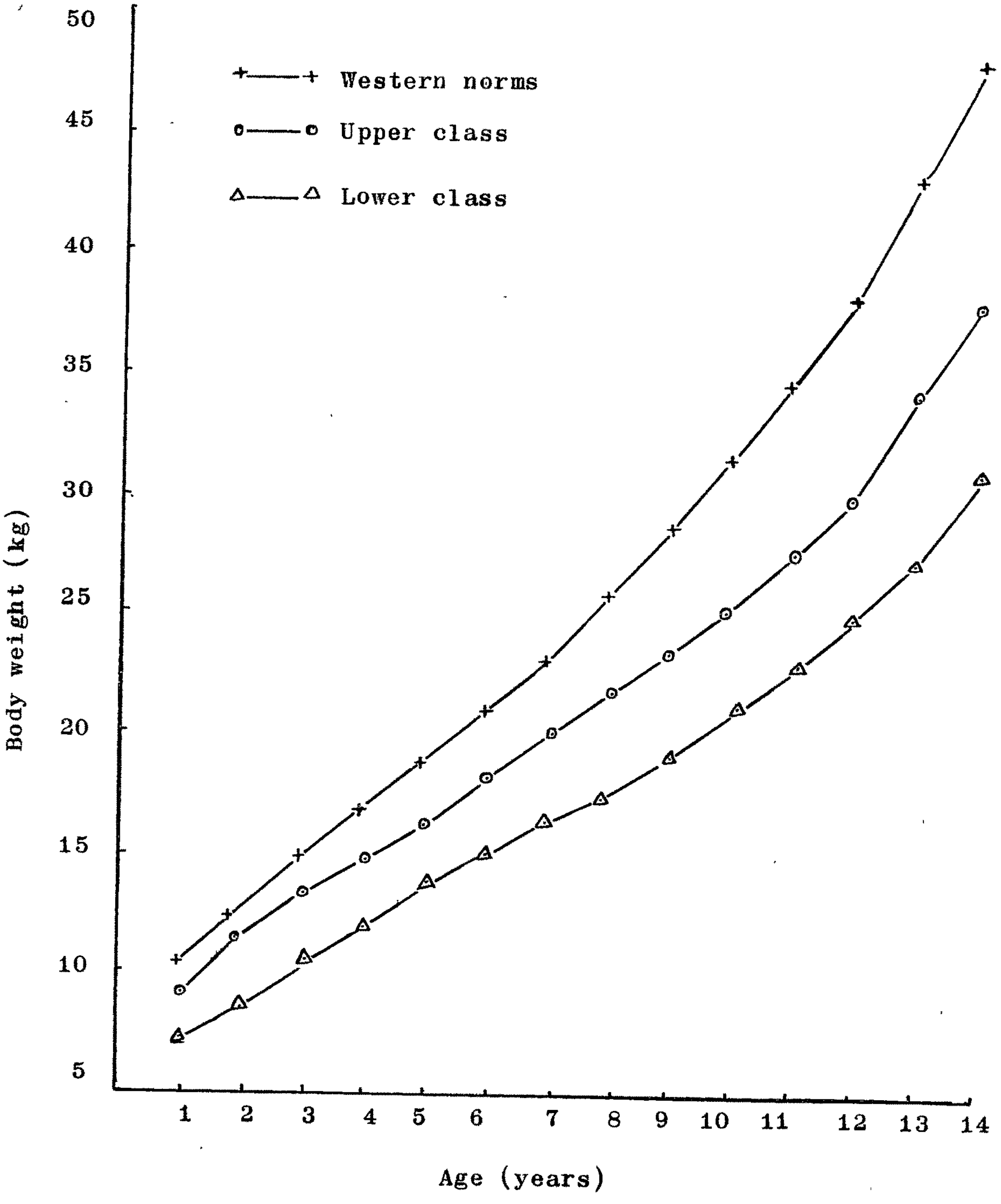


Fig. 2. Heights of boys in the lower and upper classes in Gujarat as compared to Western norms.

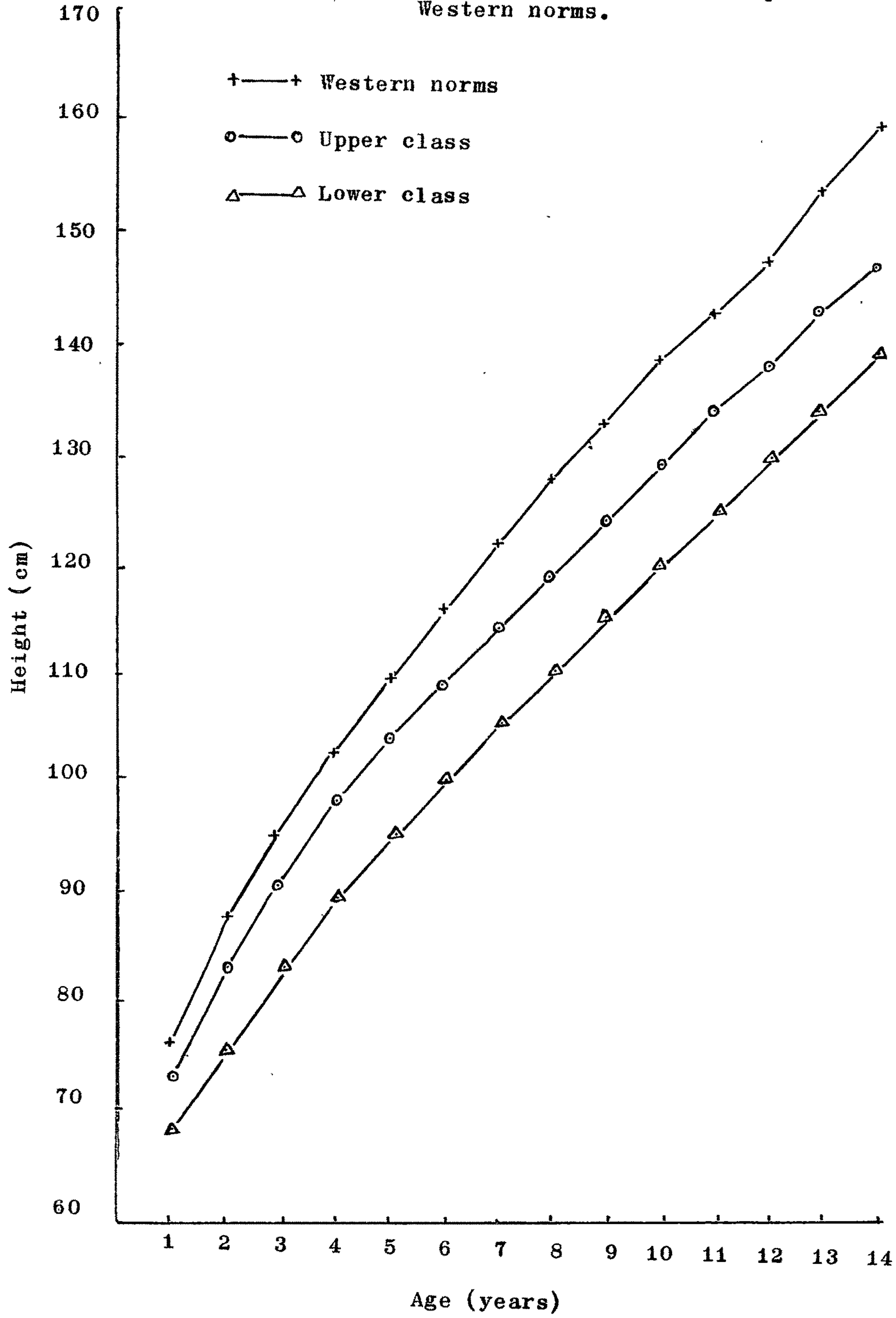


Fig. 3. Weights of girls in the lower and upper classes in Gujarat as compared to Western norms.

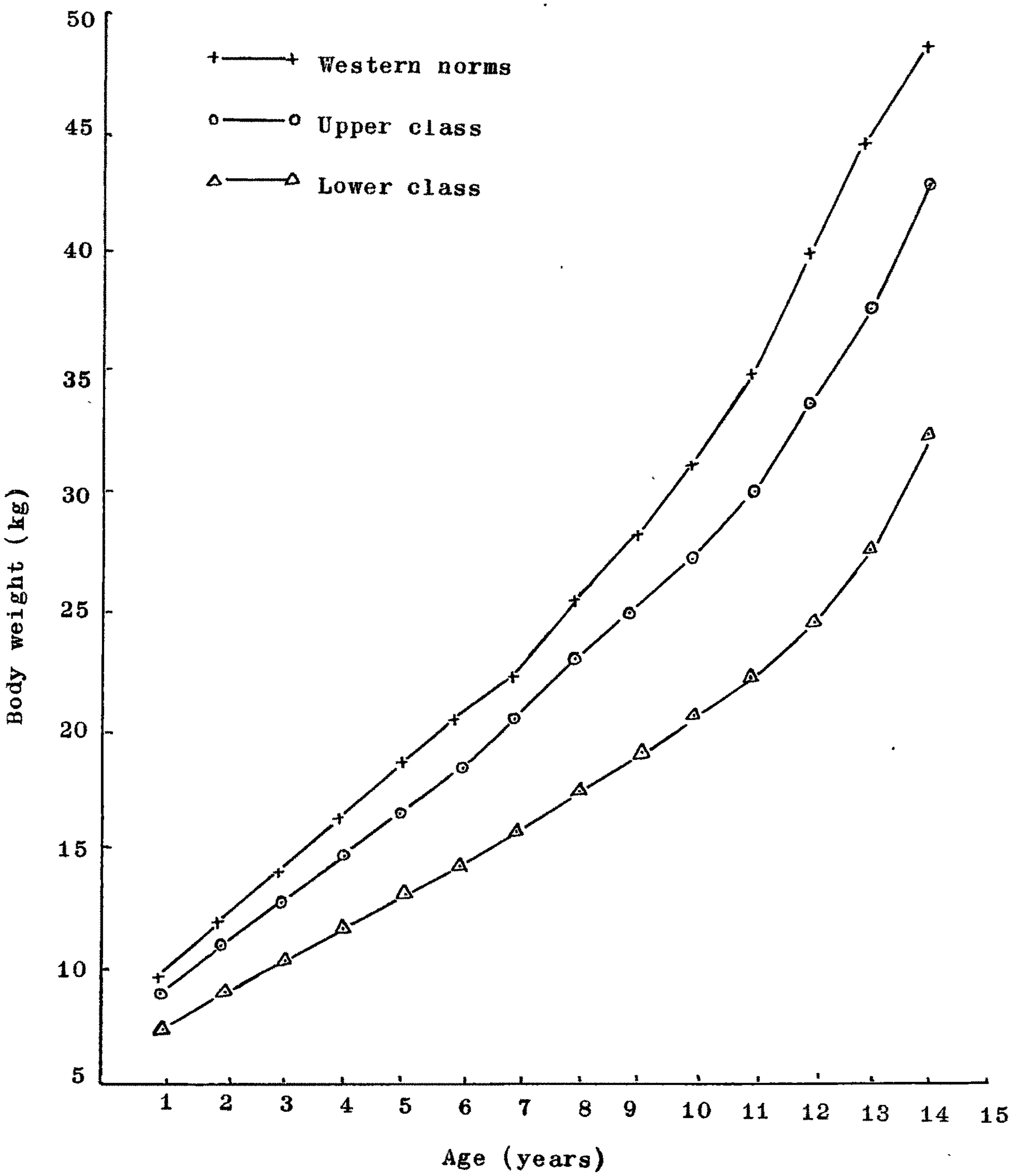


Fig. 4: Heights of girls in the lower and upper classes in Gujarat as compared to Western norms.

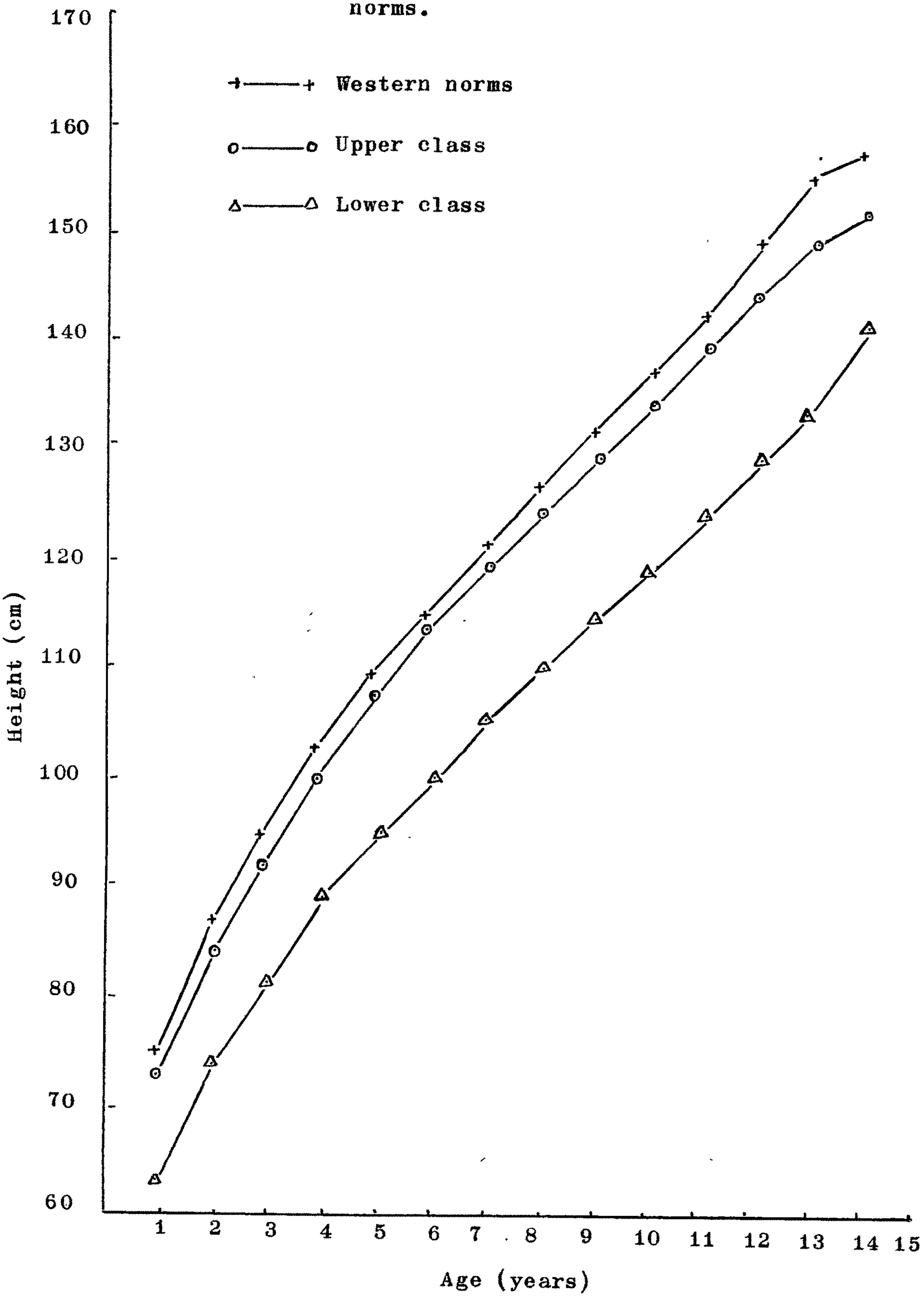
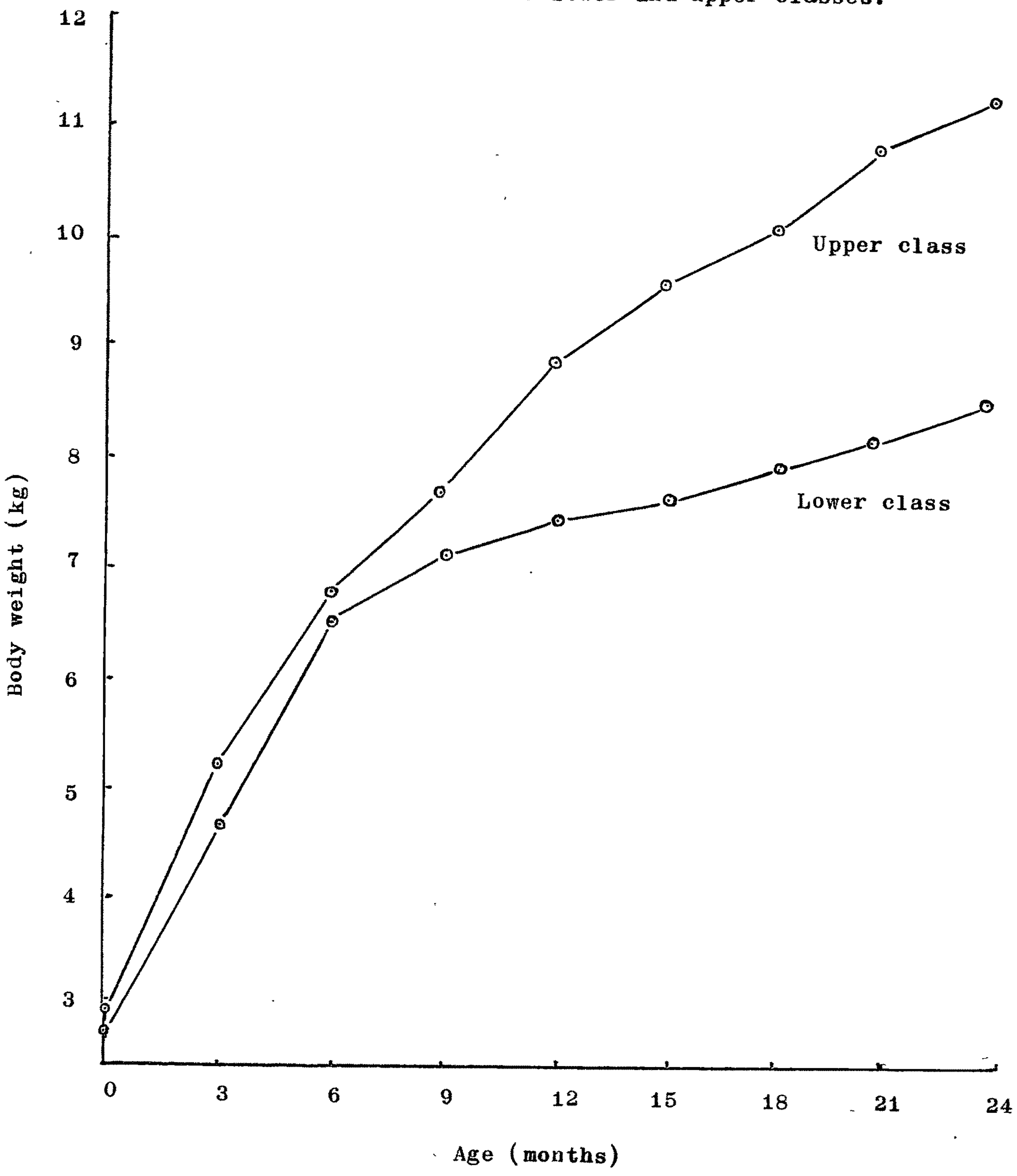


Fig. 5. Growth rates of children in the lower and upper classes.



of supplements or even an individual nutrient such as calcium lactate (Aykroyd and Krishnan,1937).

An inadequate diet not only affects growth and physical stature because of the quantitative inadequacy of the diet but also results in specific clinical symptoms because of particular deficiencies.

For the past 30 years a large number of surveys have been carried out on the clinical status of school children in different parts of India. Occurrence of xeropthalmia, bitot's spots, night blindness, angular stomatitis, angular conjunctivities, glossitis, phrynoderma, bleeding gums, and folliculosis are reported to the extent of about 54% in school children belonging to the low socio-economic groups.

Ocular manifestations are the most common signs observed in several of the nutrition surveys conducted in India (Gopalan and Someswara Rao, 1961). They include a variety of conditions such as diffuse or patchy pigmentation, xerosis, Bitot's spots, keratomalacia, corneal vascularisation, lachrymation etc. Although Bitot's spots cannot always be attributed to vitamin A deficiency (McLaren, 1960) it seems to be the most common cause on the basis of dietary intake, serium level and response to treatment (Bagchi *et al*., 1959; Pereira *et al*., 1966).

Next to ocular manifestations, skin changes like hyperkeratosis, folliculosis or phrynoderma are widely reported in India. Many of the studies suggest that the skin changes cannot be completely attributed solely to vitamin A deficiency, but may also be due to other factors including a deficiency of essential fatty acids and fats (Rajagopal and Chowdhury, 1952; Bagchi <u>et al</u>., 1959; Patwardhan, 1961).

Symptoms such as angular stomatitis, cheilosis, glossitis and bleeding gums are frequently found. Although these symptoms may appear due to variety of causes, many of these signs are associated with a deficiency of the B complex groups of vitamins, particularly riboflavine (Jolliffe, 1960).

Data reported by different investigators on the incidence of some of the above symptoms in school children are summarized in Table 6. These studies might have been done in schools catering to the middle classes in urban areas as a much higher incidence of deficiency is found in comparative studies on school boys carried out in Gujarat, Banaras and Madras (Rajalakshmi <u>et al</u>., unpublished) and in previous studies in this laboratory (Chandrasekaran, 1968).

Table 6 : Incidence of clinical deficiency symptoms reported in school boys

Reference	% incidence				
	No. of subjects	Xerosis	Bitot's spot	Angular Stoma-titis	Phryno-derma
Aykroyd and Rajagopal (1936)	779	N.R.	2.1	8.7	8.6
	337	"	5.6	12.7	7.7
	426	"	8.2	10.1	0.5
Wilson and Mitra (1938)	927	15.0	2.4	0.2	0.3
Aykroyd and Krishnan (1937)	927	N.R.	3.8	6.6	0.3
Aykroyd and Krishnan (1937a)	719	"	7.4	22.4	14.0
Mitra (1939)	539	2.0	1.0	6.3	0.5
Mitra (1941)	1042	8.0	N.R.	6.1	6.1
Daver (1946)	9722	N.R.	4.3	3.9	N.R.
	4947	"	2.9	2.7	"
Mitra (1947)	5013	2.1	N.R.	6.2	5.9
Lal (1949)	359	6.3	0.5	6.3	2.5
Someswara Rao _et al_. (1953)	207	N.R.	17.0	8.9	1.0
Someswara Rao _et al_. (1954)	1698	3.7	4.4	1.2	4.4
Lal (1954)	1914	1.9	N.R.	0.9	0.9
	360	2.2	"	1.6	1.6
Rao & Rao (1958)	120	14.2	1.7	19.2	3.3
Rao _et al_. (1961)	891	52.8	6.7	21.1	1.2
Rao _et al_. (1961a)	848	54.5	9.3	17.0	2.6
Median value		6.3	4.3	6.3	2.5

N.R. = Not reported.

In addition there is a localised incidence of nutritional diseases such as beriberi which is prevalent in areas such as Andhra consuming highly polished rice. Pellagra has been occasionally reported in people consuming rice (Raman, 1933), maize (Bajaj, 1939) and jowar (Gopalan and Srikantia, 1960). Goitre is a major public health problem in the Himalayan regions (Ramalingaswami, Subramanian and Deo, 1961). Fluorosis is found to occur in certain areas where water has a high fluorine content (Pandit *et al.*, 1940; Venkateswarlu *et al.*, 1952). Frank scurvy has rarely been reported although common diets are not rich in vitamin C, but subclinical forms of the same are suspected (Chakravarty et al., 1958; Manchanda and Gupta,1959; Kurup *et al.*, 1961).

Assessment of nutritional status by clinical examination suffers from certain limitations as sub-clinical deficiencies cannot be detected by such examination. With the development and refinement of biochemical techniques and greater knowledge about the biochemical parameters affected by malnutrition, biochemical criteria are increasingly used in the assessment of nutritional status(Arroyave, 1962; Pearson, 1962; ICNND, 1963). However, in this country hemoglobin and serum proteins are the most commonly used parameters and no extensive data are available on other parameters such as serum vitamin A and carotene, serum ascorbic acid, and urinary excretion of creatinine, thiamine, riboflavine, nitrogen etc. especially in the case of school children.

The first effect of protein deficiency is to reduce the protein content of the cell especially the liver. The gradual withdrawal of protein from cells is at first sufficient to maintain a normal concentration of protein in the circulating plasma of the blood, but with increasing protein depletion the plasma proteins are also affected (Davidson and Passmore, 1963). Serum protein levels have therefore been used as a criterion for assessing protein nutritional status.

The total amount of protein in the serum may not always reflect protein nutrition status. For instance, in malnourished subjects albumin synthesis may be depressed whereas globulin synthesis is elevated so that the total protein may remain unaltered (Arroyave, <u>et al</u>., 1957). The albumin content of serum and the ratio it bears to globulin have therefore been used as more sensitive criteria although the latter may not be altered when both albumin and globulin synthesis are decreased.

Bronte-Stewart et al. (1961) showed a significant relation between serum albumin level and intake of animal protein upto an intake of 30 g/day. A gross reduction in albumin with or without a concomittant rise in globulin in cases of nutritional oedema was observed by several workers (Bose, 1927; Rao, 1960). In most of the cases total protein was below 5 per cent and albumin below 2 per cent.

Only a few studies have been done on serum albumin and protein (Table 7) levels in school children. The values reported by Chaudhury et al. (1964) suggest that the values may be low in children belonging to poor socio-economic status. Much lower values have been reported in pre-school children (Haideri et al.,1961; Chaudhuri et al., 1964). The relatively higher values reported by Rao et al. (1959; 1961) are not consistent with expectation for the low income group. The subjects in these studies might have belonged to a better income group.

Serum levels of carotene and vitamin A have been used as criteria of vitamin A nutrition. The former is believed to reflect recent intake (Pearson, 1962a). The use of these criteria for assessing vitamin A status suffers from some limitations. The level of vitamin A in blood does not decrease seriously till body stores are severely depleted. Analysis of vitamin A in biopsy samples of the liver has been considered more reliable but this is obviously not practicable.

Table 7: Values for albumin and protein content of serum reported in school boys in India

Reference	Age (years)	No. of subjects	Total protein (g/100 ml)	Albumin (g/100 ml)
Chaudhari *et al.* (1964)	1-12	99	5.7	3.3
Rao *et al.* (1959)	0-15	299	7.0	4.3
Rao *et al.* (1961)	0-15	283	7.1	4.6

However, studies carried out at Vellore have shown a good correlation between serum levels and clinical symptoms (Pereira et al., 1966). Moreover, although a deficiency state may exist inspite of normal levels, low levels can be generally taken as indication of suboptimal nutrition. In any case, even if serum level is not always a reliable criterion for assessing the nutritional status of an individual the existence of differences in serum carotene and vitamin A levels between the lower and upper classes and between fed and control children suggest (Ramachandran,1968; Chandrasekaran,1969) the same to be valid measures for assessing the impact of school lunch programmes and the like.

Low levels of vitamin A may also be caused by protein deficiency which is believed to affect absorption, transport and storage of vitamin A and also the efficient conversion of carotene to vitamin A (Jagannathan and Patwardhan,1960; Deshmukh et al.,1964). In the treatment of kwashiorkor,the serum vitamin A level has been found to increase in conjunction with increase in serum albumin, even though no vitamin A was given (Arroyave et al., 1961). Only limited data seem to be available on serum carotene and vitamin A levels in school boys. The few values that have been reported seem to be somewhat better than what might be expected on the basis of data on dietary intakes and incidence of clinical deficiency symptoms reported from the same laboratory if not by the same authors (Table 8). Again it is possible that subjects in these studies belonged to a better income group.

As the synthesis of hemoglobin is affected by a number of factors including nutritional status with regard to protein, iron and vitamins, the level of the same in blood has been used as a general index of nutritional status. The low values for hemoglobin generally reported (Table 9) may be due to complex factors as the diets are poor in protein, iron, folic acid, and vitamin B_{12}. Intestinal infestation with hookworms and other parasites which affect the absorption of nutrients constitute a contributory factor. The common prevalence of microcytic hypochromic anemia implicates iron deficiency as a major factor. Although common diets in this country are reasonably adequate in iron content, many factors such as presence of phytates, poor protein quality of the diet, and presence of intestinal parasites and low calcium content of the diet may operate against its efficient utilization. Further, common diets are limiting in ascorbic acid and methionine which are found to facilitate the absorption of iron.

Because the end products of nitrogen metabolism are mainly excreted through urine and as its collection and

Table 8: Values for vitamin A and carotene of serum in children

Reference	Place	Age (yrs)	Sex	No. of subjects	Vitamin A* µg/100 ml	Carotene µg/100 ml
Chandra *et al.* (1960)	Hyderabad	N.R.	M+F	6	24.0	50.0
Rao *et al.* (1961)	Vellore (rural)	Below 12	M	103	29.0	-
			F	49	31.6	
Rao *et al.* (1961a)	Vellore (urban)	Below 12	M	17	46.1	-
			F	16	27.4	
Chikhalikar *et al.* (1961)	Bombay	3 - 12	M	29	30.6	112.0
			F	21	28.8	105.0

*Values given in terms of I.U. have been converted to µg assuming that 0.3 µg = 1 I.U.

Table 9: Hemoglobin content of blood in school boys

Reference	Hemoglobin (g/100 ml)
Bhave and Bopaiya (1942)	9.9
Rao *et al.* (1961)	10.1
Rao and Rao (1958)	10.2
Krishnaswamy Rao and Sunder Rao (1951)	10.4
Swaminathan *et al.* (1960)	11.3
Rao *et al.* (1961)	11.4
Rowlands *et al.* (1968)	11.5
Chaudhuri *et al.* (1964)	11.6
Someswara Rao *et al.* (1954)	12.6
Nutrition Survey (1952)	13.5
Banerjee and Biswas (1957a)	14.8

analysis are much easier than that of blood, the amount of nitrogenous constituents in urine has been used as an index of protein nutrition status. Since the output of creatinine is reasonably constant for an individual and as the same is believed to represent the rate of endogenous protein metabolism in the body (Folin, 1905), the amount of creatinine present in urine as well as the ratio it bears to total nitrogen content has often been measured (Pearson, 1966). The excretion of creatinine has also been related to the body weight and height of an individual (Mitchell, 1962). The creatinine coefficient expressed as mg of creatinine excreted in 24 hours per kg body weight has been found to be depressed when the nutritional status of an individual is impaired (Mitchell,. 1962). The creatinine-height index expressed as mg of creatinine excreted in 24 hours per cm of body height has been advocated as a better index over the creatinine coefficient as it is unaffected by the amount of adipose tissue (Arroyave, 1962). The daily creatinine excretion is closely correlated with total musculature in children and may thus serve as an index of the adequacy of the protein intake.

Also, because the rate of creatinine excretion is reasonably uniform throughout the day, it is possible to make enlightened guesses about the output of creatinine during a 24 hour period on the basis of collections of urine made during a known interval (Powell _et al_.,1961; Arroyave, 1962; Clarke _et al_., 1966). The total nitrogen content of urine represents both the nitrogen in the products of endogenous protein metabolism and that in nitrogenous substances derived from the food.

The amount of creatinine excreted varies with the plane of nutrition as well as basal metabolic rate (Mitchell, 1962). For instance it decreases in fasting subjects (Mitchell, 1962). In studies carried out in this laboratory, women belonging to the upper class are found to excrete more creatinine than those of the lower class (Rajalakshmi,1969).

Studies on groups of apparently normal adult men mostly from the upper class have reported a creatinine excretion of about 1-1.5 g and a nitrogen excretion of about 5-10 g.

Since the watersoluble vitamins not utilised by the body spill over in urine, the amounts in which they are present are believed to indicate the vitamin nutritional status of the subject. Wherever possible the excretion of the vitamin during a 24 hour period is determined, and where this is not possible the amount of vitamin excreted per gram of creatinine in casual samples is used as an index

(Lowry, 1952; Hegsted et al., 1956; Plough and Consolazio, 1959). The ICNND has published tables of tentative standards for use in interpreting nutrition survey results based primarily on excretion per gram of creatinine. Pearson (1962) has presented a tentative guide for the interpretation of the thiamine excretion (μg/g of creatinine) by children.

Similarly the amount of vitamin C excreted per gram of creatinine has been used as a measure of vitamin C status. Load tests for water soluble vitamins such as vitamin C involve measurement of the amount excreted in the urine in response to a massive dose of the vitamin. When almost all the vitamin administered is excreted in the urine the tissues are said to be saturated with the vitamin. To determine the amount needed for saturation the administration of large doses daily is continued till almost all the vitamin or a specified proportion is found to spill over in the urine. This approach is based on the assumption that no vitamins are destroyed in the alimentary tract and that they are completely absorbed by the body. There are studies which indicate that this is not always true for vitamins such as riboflavine (Selye, 1943; Morrison, Pereisse and Campbell, 1960). It is also assumed that vitamins such as ascorbic acid are not metabolized in the body but there are reports which suggest that this vitamin is oxidised in the body (Burns and Evans, 1956; Hellmann and Burns, 1956; Chan *et al.*, 1958). Similarly the approach in the analysis of vitamins in urine ignores the fact that part of the vitamins may be excreted in the form of products derived from them. In studies carried out in this laboratory, vitamin C status as judged by blood levels is found to be satisfactory inspite of low levels of urinary excretion. On the other hand, the excretion of riboflavine when expressed in terms of creatinine excretion is found to be satisfactory even in subjects having clinical deficiency symptoms, presumably because of the relatively low levels of creatinine excretion.

To summarize, nutritional status has been sought to be assessed in terms of dietary intake, physical stature, incidence of clinical deficiency symptoms and analysis of blood and urine. Inspite of the limitations in the use of these criteria, they have enabled assessment of nutritional status when several of them are used in combination. Although they may not always be very reliable for evaluating the nutritional status of an individual, they enable a fair comparison of groups.

More refined criteria and additional measures have been used occasionally. For instance, work stamina has also been measured by using apparatus such as the bicycle ergometer. In the case of vitamin A, tests such as capacity for dark light adaptation have been used. The electroencephalograph has been used for measuring protein and vitamin B_{12} status (Platt, Heard and Stewart, 1964). Tests of psychological performance have also been included in some studies (Hecht and Mandelbaum, 1938). In the case of calcium whose deficiency seldom produces clinically observable symptoms except in the case of young children, the bone has to be examined radiologically for a more reliable assessment. Conditions such as hypothyroidism caused by iodine deficiency are diagnosed by measurement of the basal metabolic rate or by the uptake of radioactive iodine. Fractionation of serum proteins by electrophoretic techniques and assay of serum enzymes are also carried out. Balance studies have been used in the case of nitrogen, iron, calcium, phosphorus etc. Studies carried out in this country have generally used only one or two of these criteria and seldom has nutritional status been sought to be assessed using several criteria at the same time. It seems desirable to assess the nutritional status of groups such as school children using multiple criteria for studying the impacts of school lunch programmes and the like.

School lunch programmes

The widespread interest in the organisation of school lunch programmes in different countries reflects an increasing concern all over the world for the welfare of growing children. A well-managed school lunch programme is generally accepted as being one of the most practical, efficient and economical means not only of providing more nourishing food to the school child, but also of establishing nutritionally sound food habits which will be of lasting value.

The school lunch programme had its earliest beginning in Europe. The famous 'Oslo Breakfast' introduced in the schools of Norway in the latter 1920's consisted of milk, sandwiches made of rye bread or biscuits, vitaminised margarine, whey , cheese, cod liver oil paste and carrots. The lunches served in the United States and England included half a point of milk per child (Scott,1953; Martin, 1954). The Regional nutrition committee for South East Asia convened by the FAO in Phillipines in 1948 recommended the following general pattern for lunch cereals, 2½ oz; pulses 1/4 oz; fish (rich in calcium), 1/4 oz; leafy vegetables, 1 oz; oil, 1/4 oz and salt, 1/6 oz (FAO, 1948). The school health committee of the Government of India recommended the following school lunch for general use in schools throughout the country; cereals and millets, 2½ oz; pulses, 1 oz; leafy vegetables, 1 oz; non-leafy vegetables, 1 oz; and oils and fats, 1/4 oz. Since 1925, supplementary school feeding programmes have been in operation in different parts of the country (Ministry of Health, Government of India, 1961).

Studebaker (1944) states "the school lunch provides an unique opportunity for helping children secure an adequate noon meal and for getting practical experience in nutrition education". The United States Department of Agriculture (1943) emphasized that school lunch played an important role in the overall educational programme, by furnishing a nutritionally adequate meal so that children could be healthy and well nourished, a condition necessary for their normal physical, mental and social development. The school lunch could be an effective tool to teach nutrition to school children (Jacobson _et al._, 1959; Webby and Turquist, 1960).

As lunch programmes were introduced in schools it became apparent that the availability of food has a salutary effect on school attendance. Attendance at school was significantly greater in schools where midday meals were offered than in schools where such meals were not being served. In addition to increasing attendance, the lunch programme was reported to have had a noticeable effect on alertness and general receptivity to scholastic endeavours (Johnston, 1968).

Several international organizations such as the UNICEF, CARE, Food for Peace, and Meals for Millions Association and some church organisations have been assisting school lunch programmes in this and other countries. However, the impact of these programmes on nutritional status have not been assessed systematically although a few studies have been made of height, weight and occasionally other body measurements. Data on the effects of either a school lunch or a supplement such as skim milk on height and weight are presented in Table 10.

Most of these studies have aimed at improving nutritional status through a particular commodity and practically no attempts have been made to plan lunches based on locally available foods. Further, apart from height and weight a thorough assessment of the impact of such programmes on nutritional status has not been made.

<u>Formulation, administration and evaluation of low cost meals based on locally available foods</u>

As pointed out earlier, the diet of poor Indians is usually inadequate with regard to calories, protein, calcium and vitamin A. Because of poor agricultural production and increasing pressure on land caused by a growing population, the possibility of meeting these deficiencies by increased

Table 10 : Effects of dietary supplements on the weights and heights of school children.

Authors	No. of subjects	Treatment given for Experimental (E)	Treatment given for Controls (C)	Period of treatment (months)	Increments in Weight (Kg) (E)	Increments in Weight (Kg) (C)	Increments in Height (cm) (E)	Increments in Height (cm) (C)
1	2	3	4	5	6	7	8	9
Krishnan (1938)	20	Skim milk	-	3	0.87	0.38	1.68	0.94
	24	Skim milk	Biscuits	2½	0.69	0.04	1.55	0.84
	18	Skim milk	Biscuits	2½	0.59	0.41	1.70	0.94
Aykroyed and Krishnan (1939)	43	Skim milk(5g)	Peppermint	2½	0.61	0.01	1.50	1.07
	46	Calcium lactate (1g)	-	-	0.36	-	1.60	-
Reddy _et al._ (1954)	29	Rice diet + tapioca flour	Rice diet	6	0.59	0.49	1.73	1.68
Subrahmanyan _et al._ (1954)	42	Vegetables milk curd + rice diet	Rice diet	6	1.16	0.58	2.44	1.60
Sur _et al._ (1954)	48	Mysore flour	Rice	6	1.18	0.77	1.70	1.57
Subrahmanyan _et al._ (1957)	23	Multipurpose food	Basal	6	0.71	0.45	2.44	1.32
Subrahmanyan _et al._ (1958)	18	Tapioca macroni	Rice	6	0.88	0.83	1.57	1.55
" (1958a)	18	Enriched wheat	Rice	6	3.05	1.83	2.49	2.01
" (1959)	20	Rice + Protein food	Rice	8	1.51	0.56	4.20	3.20

contd...

Table 10 (contd.)

1	2	3	4	5	6	7	8	9
Subrahmanyam _et al_. (1960)	20	Rice+protein food	Rice	6	1.50	0.57	4.09	3.22
" (1961)	15	Paushtic atta	White wheat	3	1.05	0.74	1.93	1.63
Geervani (1961)	21	Rice+protein food	Rice	2½	1.34	0.4	1.68	0.13
Doraiswamy _et al_. (1962)	26	Rice + GNF	Rice	6	1.29	0.54	2.79	1.83
" (1962a)	21	Wheat+protein food	Wheat	6	1.24	0.63	2.72	1.73
" (1964)	20	Home diet + protein food	Home diet	5½	1.92	0.65	2.21	1.04
" (1964a)	25	Basal diet + protein food	Basal diet	6	1.39	0.65	3.91	2.18
Devadas and Radharukmini (1964)	30	School lunch	Home lunch	5	1.72	0.99	0.71	0.61
Devadas _et al_. (1964)	20	School lunch	Home lunch		1.60	0.80	1.9	1.4
		"	"	5	0.40	0.01	1.2	1.8
		"	"		0.53	0.43	1.1	0.9

contd...

Table 10 (contd.)

1	2	3	4	5	6	7	8	9
Doraiswamy _et_ _al_. (1965)	23	Basal diet + protein food	Basal diet	6	1.39	0.52	4.09	2.49
Anandam _et_ _al_. (1965)	16	Leafy vegetable	Home diet	7	1.90		2.54	
						0.68		2.00
		Nonleafy vegetable			1.29		2.05	
Devadas _et_ _al_. (1967)	16	MPF			0.76		3.4	
		Skim milk	Home diet	7	0.93	0.78	3.30	2.40
		Skim milk + MPF			1.09		3.90	
Devadas _et_ _al_. (1968)	36	Skim milk + MPF			1.19		2.4	
		Skim milk	Home diet	6	0.75	0.27	2.20	1.60
		Skim milk + Red gram			0.79		2.30	

E = Experimentals
C = Controls
MPF = Multipurpose food
GNF = Groundnut flour

production and consumption of foods such as milk, eggs and meat seems rather remote (Rajalakshmi and Ramakrishnan, 1968). Efforts are being made the world over to formulate balanced meals based on vegetable sources of foods.

Calorie intakes are inadequate partly because of a restricted supply of foods and partly because of the poor quality of the food, its unsuitable nature and poor appetite caused by malnutrition resulting in poor intakes of even available foods. The latter is particularly true of children in the weaning period, pregnant women, convalescents, and subjects suffering from anemia. A better appetite can be expected to result with improvement in the quality of the diet. Independent studies carried out in this laboratory show that the calorie intake of children fed a balanced diet <u>ad libitum</u> at a play centre increased from about 720 calories at the beginning to 1060 calories after a few weeks of feeding.

Where food intake is restricted because of non-availability, improved and diversified food production is the only remedy. In this connection, root vegetables have a higher calorie yield per acre (Rajalakshmi and Ramakrishnan, 1968) and supplementing the diet with root vegetables so that protein calories do not form less than 10% of total calories can help increase calorie intake without affecting the nutritional quality of the diet.

Cereals have a low protein content and cereal proteins are poor in quality because of a deficiency of aminoacids such as lysine. Studies the world over have shown that the protein quality of cereal diets can be improved by the inclusion of foods containing proteins of complementary amino acid composition. Studies in this laboratory (Table 11) suggest that legume supplements are as effective as milk, fish flour, or synthetic amino acids in improving the quality of cereal proteins.

A deficiency of vitamin A can be corrected by the regular inclusion in the diet of leafy greens and other vegetables which are rich sources of carotene (Aykroyd *et al.*, 1966). However, extensive data are not available on nutritional response of human subjects to the prolonged administration of vegetable sources of carotene. Studies carried out at Vellore with children (Prof. M.E. Dumm, Personal Communication) and in this laboratory with rats (Rajalakshmi and Chari, unpublished data) suggest the fair availability of carotene in leafy vegetables. Leafy vegetable provide not only carotene but also other nutrients such as iron, calcium, vitamin C and riboflavine which are lacking in ordinary diets. The addition of leafy vegetables

Table 11 : Data on biological evaluation of different supplements to wheat*

	supplement used					
	None	Bengal gram	Fenugreek	Skim milk powder	Fish flour	Lysine
Wt. gain (g) in four weeks	19.0 (10.0-31.0)	31.0 (26.0-37.0)	30.0 (21.0-38.0)	31.0 (26.0-34.0)	32.0 (27.0-40.0)	27.0 (20.0-32.0)
PER	1.21 (0.67-1.82)	1.82 (1.50-2.17)	1.86 (1.40-2.37)	1.82 (1.70-2.00)	1.91 (1.69-2.30)	1.68 (1.32-1.89)
Nitrogen retained %	50.0 (43.0-54.0)	64.0 (57.0-68.0)	62.0 (50.0-74.0)	67.0 (64.0-71.0)	65.0 (59.0-69.0)	62.0 (48.0-70.0)
Liver protein (g/100 g of wet tissue)	20.7 (17.7-23.0)	25.1 (24.0-26.5)	23.2 (18.8-26.0)	23.6 (19.7-26.3)	25.5 (16.3-29.3)	23.0 (18.9-25.8)
Liver iron (mg per 100 g of wet tissue)	25.2 (15.6-34.0)	29.9 (18.2-45.0)	26.1 (22.0-36.6)	29.6 (19.7-34.2)	27.9 (21.4-35.5)	26.6 (18.3-36.0)
Plasma protein (g/100 ml)	5.36 (4.70-6.40)	6.86 (5.00-8.10)	6.41 (4.70-7.50)	6.36 (4.70-8.60)	6.83 (5.50-8.10)	6.13 (4.70-7.50)

The values are means with ranges in parentheses.
The diets were iso nitrogenous and fed in nearly iso calorie amounts.
*Rajalakshmi and Tambe (unpublished).

to a cereal-legume mixture is found to result in significant improvement in the nutritional status of rats as can be seen from Table 12.

Animal foods are by far the best sources of riboflavine (Aykroyd _et al._, 1966). However, procedures such as sprouting and fermentation are found to increase the riboflavine content of foods (Radhakrishna Rao, 1964; Rajalakshmi, 1969). Increasing the intake of leaf greens also helps to augment the supply of riboflavine in the diet.

Milk is by far the best source of calcium (Aykroyd _et al._, 1966) but is in short supply. The consumption of leaf greens and the addition of slaked lime to sour foods can help to increase calcium intake (Rajalakshmi and Ramachandran, 1967).

As pointed out earlier, while isolated suggestions and studies have been made regarding the correction of particular deficiencies in the diet by the administration of appropriate supplements generally based on processed foods (Table 10) no studies appear to have been made on the formulation of balanced diets based on foods available in rural areas and the systematic evaluation of these diets.

Table 12 : Vitamin A content of serum and liver in rats fed different leaf greens*

Leaf green used	Vitamin A value (i.u. per day per rat)**	Vitamin A in liver (i.u. per g of fresh weight)	Vitamin A in serum (µg per 100 ml)
Amaranth	23	90 ± 5.2	21.3 ± 1.3
Colacasia	23	96 ± 6.0	20.2 ± 2.6
Drumstick	26	153 ± 11.0	17.0 ± 1.4
Fenugreek	25	210 ± 7.0	21.0 ± 1.1
Spinach	19	197 ± 15.2	24.7 ± 1.8
Standard vitamin A	38	280 ± 22.0	17.2 ± 2.9

Values are means ± S.E.'s.

*Rajalakshmi and Chari (unpublished).

**0.3 µg of vitamin A acetate and 0.6 µg of β-carotene taken as equal to one i.u.

An exploratory study was carried out previously in this laboratory (Chandrasekaran,1968), but this study suffered from some limitations such as the uneven matching of the experimental and control groups, the small size of the samples and day to day variation in the cereals/millets and legumes used at lunch. It was considered necessary to repeat and extend these studies in a more systematic fashion.

The present studies have been designed in the context of the foregoing to achieve the following objectives:

(a) to get comparative data on the dietary intake, physical stature and clinical, biochemical and radiological status of children of the school going age in the lower and upper classes and

(b) to formulate low cost balanced school lunches based on locally available resources so as to correct the major deficiencies in the home diet and to evaluate the effects of feeding the lunch formulated on the above parameters.

Comparative data were obtained on the effects of school lunch programmes sponsored by CARE using a mixture of cracked wheat, milk-powder and soyabean oil.

In the lunch formulated about 30 g of leafy vegetables were included. Although this resulted in a significant improvement in vitamin A status, deficiency symptoms persisted in some subjects. Animal studies and chemical analyses carried out in the meanwhile suggested that about 60 g of leafy vegetables may be more adequate. Additional studies were carried out in human subjects to test the validity of the assumption.

In the study on school children, the response of blood hemoglobin levels to nutritional improvement was not satisfactory. As the diets formulated were deficient in vitamin B_{12} an additional study was carried out on the effects of vitamin B_{12} supplementation on blood hemoglobin and other parameters.

These studies are incorporated in this thesis.