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SOCIO-CULTURAL MALNUTRITION IN THE ESTATE SECTOR

2. The Nutritional status of pre-school children

by

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SUMMARY An assessment of the nutritional status of 420 pre-scool children on 4 tea estates in the Kandy and Nuwara Eliya Districts, in the Kandy Superintendent of Health Services Division, has been made by a dietary survey and by anthropometric, biochemical and haematological measurements. The diet was found to be grossly deficient in energy and most nutrients, and marginally deficient in protein and iron. The mean arm muscle area was found to be comparable with that reported for children of the same weight in the U. S. A. but the mean arm fat area was much less, indicating that energy, rather than protein, is the limiting dietary factor. About 40% had packed cell volumes less than 33%, 70% had Hb levels less than 110 g l^{-1} and 88% had a mean corpuscular haemoglobin concentration below 33%. Serum albumin and transferrin levels were below the normal range for healthy children. Serum albumin levels were lower in the older age groups, in parallel with low Hb levels. The essential to non-essential amino acid ratio was >2 in most childern. According to the Waterlow classification 9.6% of the children between 4 and 72 months suffer from acute undernutrition, 33% from chronic undernutrition and 7% from concurrent acute and chronic undernutrition.

INTRODUCTION

The social, demographic, cultural, economic and dietary characteristics of 300 households randomly selected from 4 estates in the Kandy and Nuwara Eliya Districts have been described.[19]

Presented here is an assessment of the nutritional status of 420 pre-school children (6 years of age or less) in the 300 households.

MATERIALS AND METHODS

The nutritional status of the pre-school children was assessed by measurement of anthropometric, biochemical and haematological indices and by a dietary survey of a sub-sample of 171 children.

1. *Dietary Survey*

All children between 3 and 6 years of age (total 171) were selected for a dietary survey by the 24-hour recall method. Information was obtained from the mother on the approximate amount of both cooked and raw foods consumed during the previous 24 hr. The quantity of raw foods used in the preparation of the family diet was also noted. From this data the energy and nutrient intake of each child was estimated, using the ICMR food composition tables.[10]

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2. *Anthropometry*

Standard procedures were used for measuring length or height,[23] weight on a platform beam scale (J.W.Bauman, Waagenfabrik, Germany), head and chest circumference,[8,26] arm circumference [13] and triceps skin-fold thickness.[7]

3. *Haematology*

Haemoglobin (Hb) was estimated by the cyanmethaemoglobin method [5] using a standard obtained from Ortho-Diagnostic, U.S.A. Blood drawn from a puncture of the finger into a Sahli haemoglobinometer capillary tube (20 μl) was blown on to a Whatman No. 1 filter paper, allowed to dry and transported to the laboratory for subsequent analysis. Packed-cell volume (PCV) was estimated using heparinised micro-haematocrit tubes.[34]

4. *Biochemistry*

The ratio of free non-essential to essential amino acids was estimated by the method of Whitehead and Dean.[39] Serum albumin and transferrin concentrations were determined by the immunoelectrophoretic method of Axelson, Kroll an Weeke[2] and total serum proteins by the method of Lowry[20]. These estimations were done on 252 childern (60 % of the total sample) due to insufficiency of chemicals and reagents.

RESULTS

1. *Dietary Survey.*

The results of the dietary survey are given in Tables 1 and 2.

TABLE 1. The amount of foods consumed (g per child per day), by 171 pre-school children, 3 to 6 years old, compared with ICMR recommendations.[10,11]

	Rice	Wheat Flour	Pulses	Leafy Veg.	Roots & Tubers	Other Veg.	Oils & Fats	Muscle	Milk	Sugar	Fruits
$\bar{X}$	60	75	20	25	30	10	10	15	50	20	09
SD	22.4	31.7	4.2	4.3	5.5	6.8	1.2	3.1	12.2	3.2	8.1
R	150-200		40-50	50-75	30-50		20-25	30	200	30-40	40-50

$\bar{X}$ = Mean Consumption
SD = Standard Deviation
R = Recommended Intake.

TABLE 2. The average daily intake of energy and nutrients by 171 pre-school children, 3 to 6 year old, compared with ICMR recommendations.[10,11]

	Energy (kJ)	Protein (g)	Ca (mg)	Fe (mg)	Retionl (μg)	Thiamin (mg)	Riboflavin (mg)	Ascorbic Acid (mg)
$\bar{X}$	3349	19	200	13.0	280	0.43	0.66	12.0
SD	328	7.4	51.2	1.2	85.7	0.14	0.24	1.3
R	5023-6279	18-22	400-500	15-20	300-400	0.60-0.80	0.70-0.80	30-50

$\bar{X}$ = Mean Consumption
SD = Standard Deviation
R = Recommended range.

The children are fed from the common 'family pot' and in most households only the three main meals are given. The foods commonly eaten are bread and roti, made of wheat flour and grated coconut, with a sambal of chillies, onion and salt. Rice is cooked for dinner and eaten with one or two curries prepared with cabbage, beetroot, tomato, beans, lentil, pumpkin, leeks, dried fish, etc. Only a few families enjoy a rice meal for lunch. Dried fish, meat, fresh fish and egg are eaten only on a few occasions each week. Coconut and coconut oil and other cooking oils are used rarely. Dark green leafy vegetables are eaten only occasionally. Fruits from part of the diet on special occasions, the commonly eaten fruits being banana and papaw.

The diet is grossly deficient in energy and all nutrients other than protein, in agreement with the findings of Ruberu and Weerasinghe[30] in 4 other tea estates in the Nuwara Eliya District. Results similar to those indicated in Tables 1 and 2 were obtained by Gopalan[9] in a study of children 3 to 5 years of age in poor rural communities in South India. The mean protein and energy intake were 20 g and 3.767 MJ (900kcal) respectively. According to Gopalan, protein-energy undernutrition (PEU) is frequent in the population studied.

2. *Anthropometry*

Table 3 shows the variation in weight and height of the pre-school children with age (obtained from birth certificates)

TABLE 3. Change with age of weight, height and the ratio weight x 100/ height ^{2} of pre-school children

Age months	n	Height cm	Weight kg	Weight x100 / Height^2
0— 3.99	15	48.9 ± 10.65	4.16 ± 1.09	.183 ± 0.048
4— 6.99	29	63.1 ± 2.57	5.85 ± 1.46	.172 ± 0.033
7—11.99	47	66.9 ± 3.34	7.34 ± 1.57	.162 ± 0.035
12—23.99	74	73.9 ± 6.48	8.52 ± 1.85	.151 ± 0.043
24—35.99	84	82.5 ± 5.03	10.06 ± 1.92	.146 ± 0.029
36—47.99	53	89.1 ± 5.68	11.60 ± 1.58	.144 ± 0.023
48—59.99	74	94.1 ± 5.93	12.82 ± 1.51	.140 ± 0.014
60—71.99	74	98.7 ± 5.27	13.67 ± 1.64	.142 ± 0.029

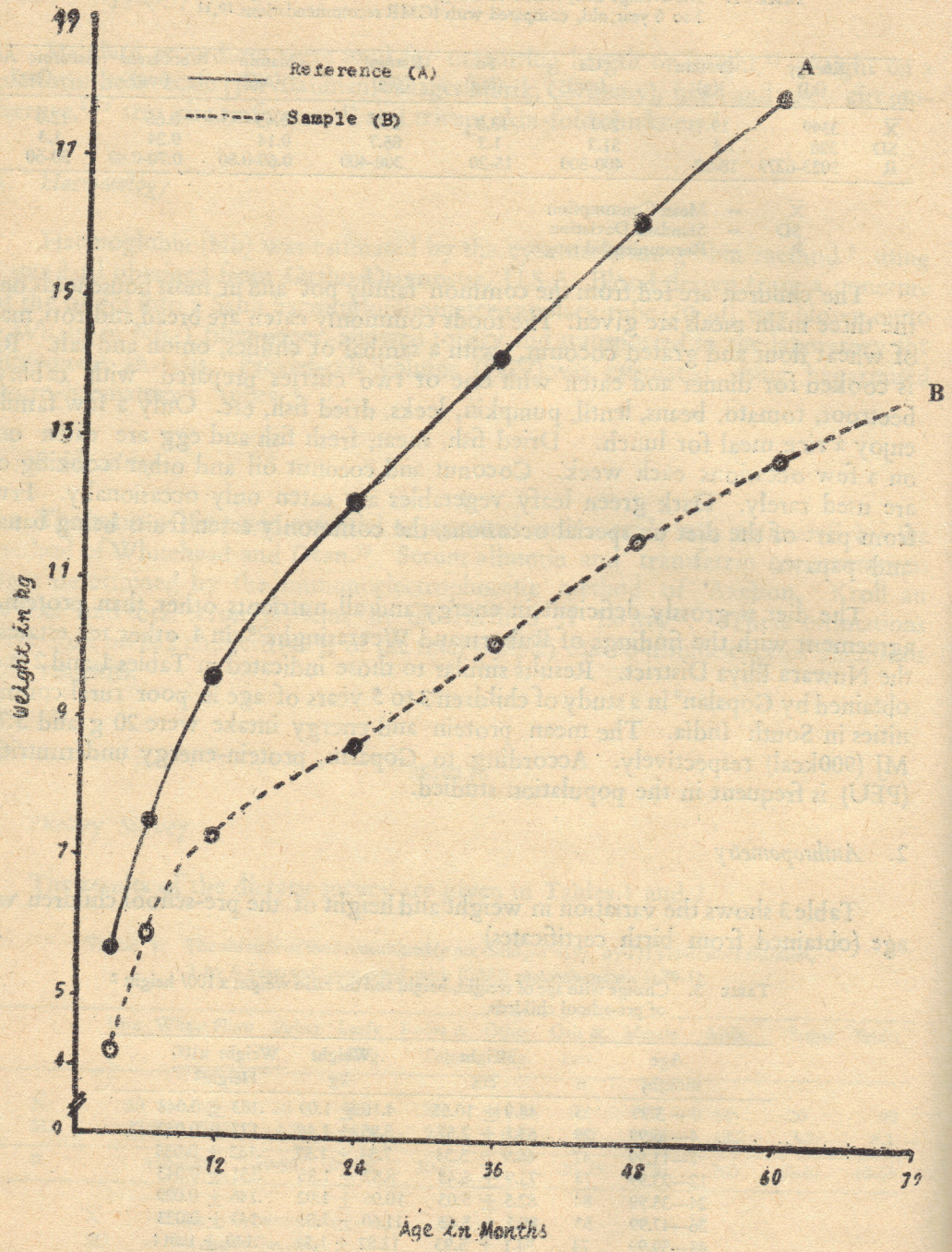

Fig. 1 Change in weight of pre-school children with age compared with the WHO Reference Median.[40]

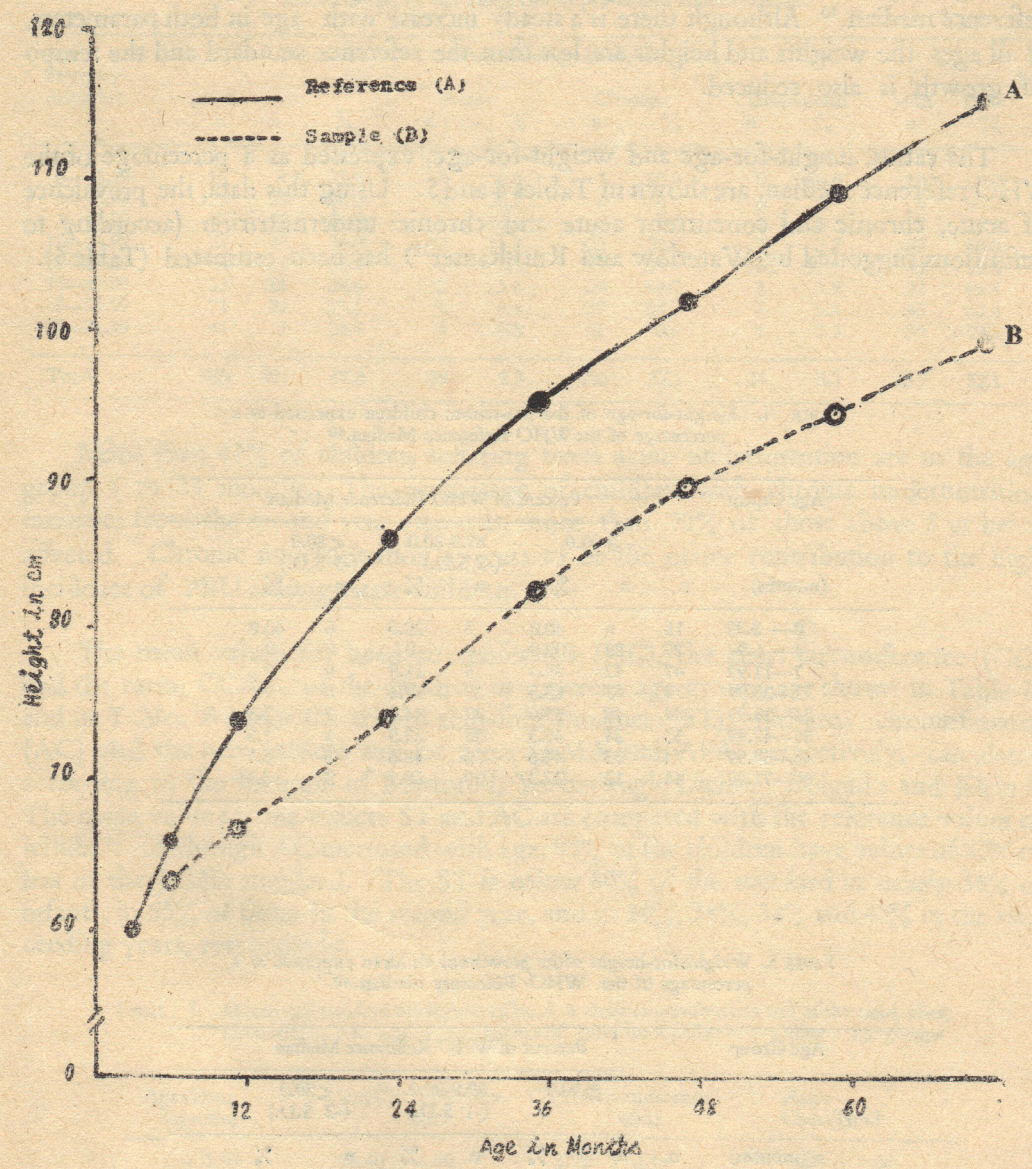

Fig. 2 Change in height of pre-school children with age compared with WHO Reference Median.[40]

Figs. 1 and 2 compare the changes in weight and height with age with the WHO reference median.[40] Although there is a steady increase with age in both parameters, at all ages the weights and heights are less than the reference standard and the tempo of growth is also reduced.

The ratios, height-for-age and weight-for-age, expressed as a percentage of the WHO reference median, are shown in Tables 4 and 5. Using this data, the prevalence of acute, chronic and concurrent acute and chronic undernutririon (according to definitions suggested by Waterlow and Rutishauser[38]) has been estimated (Table 6).

TABLE 4. Height-for-age of the pre-school children expressed as a percentage of the WHO Reference Median.[40]

Age Group		Percent of WHO Reference Median					
		≥90.0		89.9-80.0 (-2 S.D.)		<80.0 (-3 S.D.)	
(months)	n	n	%	n	%	n	%
0— 3.99	15	6	40.0	3	20.0	6	40.0
4— 6.99	29	29	100.0	0	0	0	0
7—11.99	47	42	89.4	5	11.9	0	0
12—23.99	74	47	63.5	27	57.4	0	0
24—35.99	84	45	53.6	37	44.0	2	2.3
36—47.99	53	24	45.3	28	52.8	1	1.8
48—59.99	74	33	44.6	36	48.6	5	6.7
60—71.99	44	12	27.3	30	68.1	2	4.6

TABLE 5. Weight-for-height ofthe pre-school children expressed as a percentage of the WHO Reference Median.[40]

Age Group		Percent of WHO Reference Median					
		≥90.0		89.9-80.0 (-1 S.D.)		<80.0 (-2 S.D.)	
(months)	n	n	%	n	%	n	%
0— 3.99	15	5	33.3	3	20.0	7	46.7
4— 6.99	29	15	51.7	8	27.6	6	20.7
7—11.99	47	22	46.8	20	42.6	5	10.6
12—23.99	74	31	41.9	29	39.2	14	18.9
24—35.99	84	39	46.4	29	34.5	16	19.0
36—47.99	53	26	49.1	24	45.3	3	5.7
48—59.99	74	40	54.1	26	35.1	8	10.8
60—71.99	44	22	50.0	18	40.9	4	9.1

TABLE 6. The percent prevalence of acute, chronic and concurrent acute and chronic malnutrition, by age categories in pre-school estate children.

Age category (months)		Normal		Protein Energy Undernutrition						Total with PEU	
				Acute		Chronic		Concurrent			
	n	n	%	n	%	n	%	n	%	n	%
0— 3.99	15	5	33.3	1	6.6	3	20.0	6	40.0	10	66.7
4— 6.99	29	23	79.3	6	20.7	0	0	0	0	6	20.7
7—11.99	47	38	80.8	5	10.6	4	8.5	0	0	9	19.1
12—23.99	74	37	50.0	12	16.2	23	31.0	2	2.7	37	50.0
24—35.99	84	39	46.4	6	7.1	29	34.5	10	11.9	45	53.6
36—47.99	53	21	39.6	2	3.8	29	54.7	1	1.9	32	60.4
48—59.99	74	29	39.1	4	5.4	37	50.0	4	5.4	45	60.8
60—71.99	44	9	20.4	3	6.8	31	70.4	1	2.3	35	79.5
Total	420	201	47.8	39	9.3	156	37.1	24	5.7	219	52.1

More than 47% of children suffering from acute undernutrition are in the age group 4 to 23 months. The percentage of children with chronic undernutrition increases from the second year onwards, more than 70% of those above 5 yr being affected. Chronic undernutrition appears to be the major contribution to the high incidence of PEU among estate children.

The mean values for head circumference (HC), the chest circumference (CC) and the ratio, CC/HC of the children in different age groups are shown in Table 7, and in Tables 8 and 9 the triceps skin-fold thickness (ST), mid-arm circumference (AC) and the arm muscle and fat areas (AMA and AFA) respectively, calculated according to the formula of Martorell, Yarborough, Lechtig, Delgado and Klein.[21] The mean value for the indices ST and AC are compared with the reference values of Jelliffe[13]. Although AC increased with age, 95% of the children have values of 85% or less of the Jelliffe standard. The ST is below 80% of the standard in nearly 56% of infants, in 55% of those in the second year, and in 36%, 38%, 34% and 45% in the succeeding years, respectively.

TABLE 7. Means and standard deviations of head & chest circumferences and of the ratio, chest circumference to head circumference of pre-school children in different age groups

Age Group (months)	Head Circumference (cm)	Chest Circumference (cm)	Ratio Chest/Head
0— 3.99	38.40 ± 4.00	37.50 ± 3.46	0.98 ± 0.06
4— 6.99	43.50 ± 6.26	41.84 ± 3.14	0.94 ± 0.15
7—11.99	43.28 ± 2.35	43.02 ± 2.08	0.99 ± 0.05
12—23.99	44.63 ± 1.80	45.15 ± 2.61	1.01 ± 0.05
24—35.99	46.57 ± 2.37	47.69 ± 2.68	1.03 ± 0.04
36—47.99	47.37 ± 2.41	49.89 ± 2.73	1.04 ± 0.05
48—59.99	48.75 ± 3.82	51.03 ± 2.92	1.05 ± 0.05
60—71.99	48.87 ± 1.67	51.22 ± 2.87	1.05 ± 0.07

TABLE 8. Mid-arm circumference and triceps skin fold thickness in children by age groups, compared with standards,[13]

Age Group (months)		Arm Circumference						Triceps Skin Fold Thickness									
		Above 85% standard		85% standard		Less than 85% standard		≥90 %		80-89 %		70-79 %		60-69 %		< 60 %	
	n	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
0— 3.99	15	4	26.6	7	46.6	4	26.6	3	20.0	4	26.6	3	20.0	2	13.3	3	20.0
4— 6.99	29	7	24.1	15	51.7	7	24.1	7	24.1	11	37.9	8	27.5	3	10.3	0	0
7—11.99	47	4	08.5	27	57.4	16	34.0	9	19.1	6	12.7	17	36.1	10	21.2	5	10.6
12—23.99	74	2	02.7	37	50.0	35	47.2	19	25.6	14	18.9	23	31.0	11	14.8	7	09.4
24—35.99	84	2	02.3	51	60.7	31	36.9	41	48.8	13	15.4	17	20.2	10	11.9	3	03.5
36—47.99	53	2	03.7	35	66.0	16	30.1	22	41.5	11	20.7	13	24.5	5	9.4	2	03.7
48—59.99	74	0	0	49	66.2	25	33.7	32	43.2	17	22.9	18	24.3	6	8.1	1	01.2
60—71.99	44	1	02.2	19	43.2	24	54.5	12	27.2	12	27.2	11	25.0	6	13.6	3	06.8
Total	420	22	05.2	240	57.1	158	37.6	145	34.5	88	20.9	110	26.1	53	12.6	24	05.7

TABLE 9. Arm muscle area and arm fat area of children by age groups, compared with 80 % of standard.[13]

Age group (months)	Arm muscle area mm^2	Arm muscle area 80% standard mm^2	Arm fat area mm^2
0— 3.99	634.30±261.78	910	409.94±124.81
4— 6.99	901.52±205.36	1029	492.37±130.68
7—11.99	971.82±186.74	1030	502.71±151.94
12—23.99	993.84±163.47	1050	510.47±127.21
24—35.99	1104.62±156.87	1030	524.63±133.27
36—47.99	1120.31±165.56	1120	555.01±123.86
48—59.99	1149.86±162.15	1130	557.42±118.40
60—71.99	1207.32±165.54	—	523.29±126.87

With the exception of ST, there is a gradual increase in these indices with increase in height (Table 10). The AC of those 75 cm or taller are within 90% of the Sri Lankan standard.[1] With the exception of weight and ST, all measurements are greater in boys than in girls in almost all age groups. Girls are heavier during infancy and later. The ST is greater in girls although AC is greater in boys, indicating a greater development of musculature in boys relative to subcutaneous fat. However, the increase of musculature with age is inadequate. During the first 3 years the AMA is less than 80% of the Jelliffe standard (Table 9).

TABLE 10. Relationship between head, chest and mid-arm circumferences and triceps skinfold thickness with height (mean ± S.D.)

Height cm	n	Head circumference cm	Chest circumference cm	Mid-arm circumference cm	Triceps skinfold thickness mm
35—40	4	35.35 ± 2.37	35.22 ± 1.29	10.07 ± 1.16	6.65 ± 0.77
41—45	3	37.46 ± 4.43	35.80 ± 1.15	10.40 ± 0.97	7.03 ± 1.39
46—50	0	—	—	—	—
51—55	4	38.40 ± 2.51	37.47 ± 1.56	11.15 ± 1.30	7.82 ± 1.52
56—60	9	41.58 ± 3.53	41.72 ± 3.23	12.76 ± 1.12	7.58 ± 1.29
61—65	39	42.61 ± 4.04	42.31 ± 3.46	12.88 ± 1.09	8.12 ± 1.69
66—70	44	43.52 ± 1.89	43.62 ± 2.02	13.70 ± 1.24	7.99 ± 1.56
71—75	45	44.68 ± 3.55	44.28 ± 2.06	13.71 ± 1.18	8.09 ± 1.87
76—80	46	45.76 ± 1.48	46.64 ± 1.98	13.89 ± 0.93	7.99 ± 1.52
81—85	51	46.58 ± 1.33	48.12 ± 2.68	14.21 ± 1.09	8.76 ± 1.96
86—90	51	47.06 ± 1.35	49.41 ± 2.47	14.38 ± 1.11	8.66 ± 1.62
91—95	51	47.94 ± 1.40	51.19 ± 3.98	14.69 ± 0.86	8.18 ± 1.73
96—100	46	48.14 ± 1.44	51.35 ± 1.79	14.65 ± 0.94	7.68 ± 1.54
101—105	25	49.00 ± 1.31	52.51 ± 3.15	14.80 ± 1.02	7.34 ± 1.34
106—110	02	53.75 ± 6.95	52.40 ± 1.0	15.0 ± 0.50	6.10 ± 0.7

3. *Haematology.*

The haemoglobin concentration (Hb), packed cell volume (PCV) and the mean corpuscular haemoglobin concentration (MCHC) of different age groups among the pre-school children are shown in Table 11 and 12.

TABLE 11. Means and standard deviations of haemoglobin, packed cell volume (PCV) and mean corpuscular haemoglobin concentration (MCHC) of children in different age groups

Age Group (months)	Haemoglobin $g\ l^{-1}$	PCV %	MCHC %
0 — 3.99	—	—	—
4 — 6.99	101.1 ± 17.6	33.41 ± 3.33	30.06 ± 2.86
7 — 11.99	100.8 ± 15.5	33.47 ± 2.98	29.91 ± 2.69
12 — 23.99	97.5 ± 19.4	32.87 ± 3.64	29.42 ± 3.73
24 — 35.99	97.6 ± 18.4	32.55 ± 3.47	29.74 ± 3.17
36 — 47.99	97.9 ± 14.4	32.70 ± 3.24	29.83 ± 2.24
48 — 59.99	97.5 ± 19.8	33.02 ± 3.18	29.77 ± 3.62
60 — 71.99	96.0 ± 19.9	33.40 ± 3.34	28.54 ± 4.40

TABLE 12. Number of children in each age group with values for haemoglobin concentration, packed cell volume and mean corpuscular haemoglobin concentration below the WHO standards.[40]

Age (months)		PCV < 33%		Hb < 11g%		MCHC < 33%	
	n	n	%	n	%	n	%
4 — 6.99	29	12	41.4	18	62.1	22	75.9
7 — 11.99	47	18	38.3	30	63.8	42	89.4
12 — 23.99	74	30	40.5	51	68.9	67	90.5
24 — 47.99	137	60	43.8	97	70.8	123	89.8
48 — 71.99	118	49	41.5	86	72.9	102	86.4
Total	405	169	41.7	282	69.6	356	87.9

When the children are grouped according to the category of protein-energy undernutrition, all children severely undernourished (concurrent acute and chronic undernutrition) are also seen to be the most severely anaemic according to WHO standards (Hb < 110 g l^{-1}, PCV ≤ 33% and MCHC < 33%), although other groups are also affected (Table 13.)

TABLE 13. Relationship of anaemia in pre-school childeren (4-71 months) with Protein Energy Undernutrition

PEU	Number	PCV < 33%		Hb < 110 g l^{-1}		MCHC < 33%	
		n	%	n	%	n	%
Acute	38	22	57.9	32	84.2	36	94.7
Chronic	153	76	49.7	128	83.7	143	93.5
Concurrent	18	17	94.4	17	94.4	18	100.0
Normal	196	54	27.6	105	53.6	175	89.3
Total	405	169	41.7	282	69.6	372	91.9

4. *Biochemistry*

Table 14 presents biochemical data on 250 of the pre-school children (60% of the total sample), according to age-group. The concentrations of albumin and transferrin are below the normal range for healthy children. The albumin level decreases with age, in parallel with the fall in Hb levels. The protein levels are lowest among children suffering from chronic undernutrition.

TABLE 14. The concentration of total serum proteins, and of albumin and transferrin, and the amino acid ratio, non-essential to essential, in children of different age groups (mean ± S.D.)

Age Group (months)	Total Protein g l^{-1}	Albumin g l^{-1}	Transferrin g l^{-1}	Amino Acid Ratio
0— 3.99	—	—	—	—
4.0— 6.99	—	—	—	—
7.0—11.99	48.8 ± 13.0	28.7 ± 17.0	1.76 ± 0.36	2.9 ± 1.2
12.0—23.99	48.2 ± 17.0	26.4 ± 24.0	1.69 ± 0.49	4.6 ± 1.6
24.0—35.99	52.1 ± 16.0	20.6 ± 26.0	1.63 ± 0.57	5.4 ± 0.5
36.0—47.99	51.4 ± 14.0	23.4 ± 19.0	1.82 ± 0.52	4.3 ± 1.0
48.0—59.99	48.7 ± 19.0	15.6 ± 16.0	1.74 ± 0.36	2.5 ± 1.1
60.0—71.99	51.3 ± 18.0	19.3 ± 31.0	2.50 ± 0.46	3.4 ± 1.7

DISCUSSION

Anthropometry.

The heights and weights of the estate children studied are lower than those recorded in 1936 by Nicholls[25] for Sri Lankans in the low-income groups. However, their growth pattern is better than that of South Indian children in the low income groups[9] although, when compared with apparently healthy children among the urban poor[17] or in the suburbs of New Delhi,[12] Sri Lankan estate children are seen to be of smaller build.

Quetelet's index or the ratio, weight (kg) X 100/height $(cm)^2$, is a parameter of growth status that is age-independent.[16,24,29] It is a measure of weight for height that is largely independent of actual height and is also referred to as the body mass index (BMI).[41]

A value greater than or equal to 0.15 is accepted as normal,[29,31] children suffering from PEU having indices between 0.11 and 0.14[29]. In the present study 10 children in the 7-11 m age group, 4 in the 24-35 m group and 6 in the 60-71 m age group, considered normal according to the Waterlow classification, have Quetelet's indices less than 0.15, which supports the view that this index is a more sensitive indicator of chronic undernutrition than height-for-age.[29,31]

Mid-arm circumference and the triceps skin-fold thickness enable the estimation of arm muscle and fat areas. Up to the end of the 3rd year the amount of muscle is less than 80% of the standard (Table 9). When the values for the estate children are compared with those obtained by Martorell *et al.*[21] for moderately under-nourished Guatemalan and healthy American children, it is seen that, at a particular body weight, there is considerably less fat in the Guatemalan children than in the other two groups. For example, at a body weight of 10 kg the mean arm fat areas are 400 $mm,^2$ 520 mm^2 and more than 600 mm^2, for Guatemalan, Sri Lankan and American, respectively, whereas the mean arm muscle area is the same for all three groups (about 1100 mm^2). Both the estate and Guatemalan children have deficient fat stores probably due to a limitation of energy intake. The conclusion that energy rather than protein is the main nutritional problem is borne out by the data on diet (Table 2).

The brain and skull reach 50% of their maximal size by the end of the 2nd year of post-natal life and 90% by the age of eight.[35] On the other hand the chest grows rapidly after birth, so that, by the end of the 6th month, chest circumference should equal head circumference. The estate children have similar chest and head circumferences only at the end of infancy (Table 7) and the growth of the chest continues to be low even thereafter. As increase in chest circumference is determined by growth of the chest cavity as well as of muscle and adipose tissue round it, a slow increase in the chest/head ratio would be an indication of chronic undernutrition. On the basis of a ratio less than one, 47% of the children could be considered undernourished in the second half of infancy, about 38% in the 2nd year, and 25%, 16% and 9% in the 3rd, 4th and 5th years, percentages that are lower than those based on heights and weights, for children older than 12 months (Table 6).

Haematology.

The data in Table 11 indicates the severity of anaemia among the children studied. Four percent of the total population are very severely anaemic and 19% severely anaemic. Sonnadara [33] reported higher percentages in a study of Colombo urban pre-school children. In both studies there is no significant difference either in the

average or in the range of Hb levels in the different age groups. As seen in previous studies,[6,33] body weight does not influence Hb levels. The Hb level was below 110 g l^{-1} in 54% of the children grouped as normal according to the Waterlow classification. There are more anaemics in the concurrent acute and chronic undernutrition group (94%) than in the acute or chronic undernutrition groups (84% in both). The most common cause of anaemia is iron deficiency which could be determined as much by the hookworm load as by the availability of dietary iron for absorption. Among estate workers round worm infestation could be as high as 100% and hookworm infestation up to 98%[4]. Worm loads have to reach a critical level before they can significantly influence Hb levels. In a Venezuelan study the critical load was 2000 ova g^{-1} of faeces for women and chidren and 5000 ova g^{-1} faeces for men[18] The worm load in the estate children is not known. The diet is deficient in iron (Table 2).

Biochemistry.

The non-essential to essential amino acid ratios are high among the estate children (Table 14), being greater than 4 in the age group 12-48 months. Although the value of the ratio as an indication of those at risk or in distinguishing kwashiorkor from other forms of PEU is disputed, [22,23] there is general agreement that a high ratio is characteristic of undernutrition. The high ratios seen among the estate children are in agreement with other data in indicating the presence of undernutrition among a significant proportion of the population.

The serum albumin concentration is low in all age groups and decreases with increase in age up to 5 years. In marginal undernutrition the total protein and albumin concentrations are maintained at low normal values by a reduction in protein breakdown and a contraction of the extra-vascular pool, so that a very low albumin concentration can be interpreted as indicating a long-continued, though not necessarily severe, deficiency of food.[37] Reduced transferrin levels could also indicate a chronic protein-energy deficiency. As transferrin is intimately associated with iron deficiency levels, being elevated in iron-deficient patients, the direction of change in transferrin levels would depend on the preponderance of iron deficiency over protein-energy deficiency. The co-existence of these contradictory stimuli invalidates to some extent the value of transferrin levels as a measure of protein-energy deficiency.

Acute Undernutrition.

The data in Table 6 indicate that more than 15% of the children between 4 and 24 m of age suffer from acute undernutrition. In the first ever island-wide survey of nutritional status of preschool children in Sri Lanka, conducted by the Ministry of Health in 1975/76, the percent prevalence for the age category 6-71 m for the Kandy SHS Area was 3.0%, the range for the country being 2.1% to 4.7%, 3.4 % for the age category 6-11 m, 7.0% for the category 12-23 and 2.9% for the third year of life.[3]

The percent prevalence in all age categories shown in Table 6 are much higher than the rates found in 1975/76, with a shift towards the 4 to 12 m category. Similar results have been reported from surveys conducted in 1980/81 by the Ministry of Plan Implementation[28], which are summarised in Table 15.

TABLE 15. The percent prevalence of acute undernutrition in pre-school children according to age categories (from Perera 28).

District	Sector	Sample size	Age Category (months) 6-12	13-24	25-36	37-48	49-60	6-60
Colombo	urban	2,329	11.5	13.3	2.4	4.1	6.7	7.2
	rural	1,346	11.4	16.7	3.4	7.8	6.0	7.6
Jaffna	urban	659	16.3	15.7	2.0	1.9	5.3	7.4
	rural	1,650	9.2	12.6	0.7	1.4	1.8	4.9
Nuwara Eliya	rural	465	17.0	6.0	6.7	—	—	5.6
	estate	750	7.0	4.3	1.1	—	—	2.4
Kandy	rural	1,228	10.2	13.2	2.8	—	—	6.1
	estate	266	9.6	9.3	3.0	—	—	6.4

According to this report, the recent trend, chracterized by high prevalence rates of acute undernutrition in the first year of life, as well as in the second, in rural areas appears to have emerged in the estate sector as well. Among the causal factors listed are early weaning to nutritionally poor diets, poor housing, overcrowding, polluted environments and drinking water supplies, ignorance of basic health and nutritional principles and the paucity of effective medical care. These conditions seem to have deteriorated since the 1975/76 survey and are very apparent in the estates investigated in the present study.[19]

Chronic Undernutrition.

Data in Tables 4 and 6 indicate that the percent prevalence of chronic undernutrition is high (40%) in the age group 12-60 m, and 70. 4% in the 60-72 m age category. In the 1975/76 survey the percent chronically undernourished, according to age in months, were as follows:

6-12 m 10.2%, 12-23 m 21.0%, 24-35 m 29.1%, 26-47 m 37.4%, 48-59 m 39.3%, 60-71 m 42.3%, with an average of 31.3 for the island.[3] The results of the 1980/81 surveys,[28] summarized in Table 16, are in agreement with the results of the present study.

TABLE 16. The percent prevalence of chronic undernutrition in pre-school children, according to age categories (from Perera 28).

District	Sector	Sample size	Age category (months) 6-12	13-24	25-36	37-48	49-60	6-60
Colombo	urban	2,329	3.5	8.7	19.9	24.9	16.3	15.8
	rural	1,346	1.4	5.9	12. 3	12.3	12.6	9.5
Jaffna	urban	659	4.9	16.3	35.5	31.8	19.2	23.8
	rural	1,650	7.1	20.7	33.5	30.1	23.8	25.0
Nuwara Eliya	rural	465	11.3	29.9	33.7	40.8	48.9	34.6
	estate	750	28.9	47.0	56.6	53.1	56.0	49.2
Kandy	rural	1,228	8.8	18.1	35.3	47.1	36.5	31.1
	estate	226	12.9	18.5	37.3	51.5	53.9	36.8

Significantly higher prevalence of the condition is seen in the 3rd, 4th and 5th years of life, with the prevalence in the rural and estate sectors being higher than the rates in 1975/76, indicating either a lack of improvement of conditions or, perhaps, a worsening. Chronic undernutrition is an index of deprivation of energy and protein, relative to need, over a long period of time. "In a community where there are persistently nutritionally adverse influences, one would find a progressive increase in the proportions of chronically undernourished children with increasing age."[28] Those "stunted" in their second year of life in 1975/76 do not appear to have "caught up" during subsequent years, as the prevalence rate for the 5-7 yr old group in 1980/81 is high. With the liberalization of the economy in 1977 more food became available and a decrease in general undernutrition could have been expected. In the period 1977/79 more food was consumed, resulting in a decline in chronic undernutrtion in the younger age groups. However, with increase in inflation after 1979, acute undernutrition has become more prevalent in the young and chronic undernutrition has worsened in the older age categories.

Concurrent acute and chronic undernutrition.

Children affected by the most severe degree of PEU are the ones categorized under concurrent acute and chronic undernutrition. The peak prevalence of this condition is expected to occur in the second year of life. Among the estate children the highest incidence occurred in the 3rd year of life (11%), the percent prevalence being 5.7 for the entire population studied (Table 6). In the 1975/76 survey[3] the prevalence rates were 1.6, 3.8, 4.0, 3.4 and 2.6 for the age groups 6-12, 13-24, 25-36 37-48 and 49-60 months respectively, for the whole island. Table 17 gives some of the results of the 1980/81 surveys, summarized from Perera.[28]

TABLE 17. The percent prevalence of concurrent acute and chronic undernutrition in pre-school children (by age) (from Perera 28).

District	Sector	Sample size	Age category (months) 6-12	13-24	25-36	37-48	49-60	6-60
Colombo	rural	1,346	—	2.5	3.7	0.3	1.2	1.8
	urban	2,329	—	4.0	3.8	0.5	2.0	2.4
Jaffna	rural	1,650	—	2.7	3.5	0.4	0.7	1.6
	urban	659	—	5.4	3.3	—	—	2.1
Nuwara Eliya	rural	465	—	4.3	2.9	1.0	3.4	2.6
	estate	750	1.8	6.5	1.6	2.5	1.8	3.1
Kandy	rural	1,228	0.6	2.6	8.5	1.5	1.7	3.5
	estate	226	—	9.2	8.9	—	2.0	4.5

Prevalence of concurrent acute and chronic under nutrition is highest in the 2nd and 3rd years of life, more in the 2nd year in some sectors. As would be expected from the aetiology of the condition, children in urban areas are more affected than in rural areas in the same district. The problem is worse in the estate sector than in the rural sector of the same district. In agreement with the results in Table 6, the

prevalence rate is highest in the 3rd year of life in many sectors and a substantial proportion of children in their 5th year of life show a remarkable degree of wasting. The prevalence rates are higher than those observed in 1975/76, an appreciable increase, despite massive efforts at "supplementary feeding" with "triposha" since 1972.

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REFERENCES

1. ANDERSON, MARY A. (1975). Use of height-arm circumference measurement for nutritional selectivity in Sri Lanka school feeding. *American Journal of Clinical Nutrition* **28,** 775-781.

2. AXELSON, N.H., KROLL, J. & WEEKS, B. (1973). Comparison of antigens: the reaction of identity. *Scandinavian Journal of Immunology* **2,** sup. **1,** 91-94.

3. BRINK, E.W., PERERA, W. D. A., BROSKE, S. P., HUFF, N. R., STAEHLING, N.W., LANE, J. M. & NICHAMAN, M. Z (1978). Sri Lanka Nutrition Status Survey, 1975. *International Journal of Epidemiology* **7,** 41-47.

4. CULLUMBINE, H. and WIKRAMANAYAKE, T.W. (1949). Unpublished data.

5. DACIE, J. V. and LEWIS, S. M., (1975). In *Practical Haematology* 5th ed. p. 22. London: Churchill-Livingstone.

6. DE SILVA, C. C. and FERNANDO, R. P. (1966). Anaemias of Ceylonese children. *Indian Journal of Medical Science* **2,** 499-505.

7. EDWARDS, D. A.W., HAMMOND, W. H., HEALY, M.J. R., TANNER, J. M. and WHITEHOUSE, R. (1955). Design and accuracy of callipers for measuring subcutaneous tissue thickness. *British Journal of Nutrition* **9,**1 33-135.

8. FOMON, S. J. (1974). In *Infant Nutrition,* 2nd ed. p. 36. Philadelphia: W. B. Saunders & Co.

9. GOPALAN, F. A. M. S. (1970). Some recent studies on protein-calorie malnutrition. *Annals of the Indian Association of Medical Science.* **6,** 197-206.

10. GOPALAN, C, SASTRI, B. V. RAMA, and BALASUBRAMANIUM, S (1971). In *Nutritional Value of Indian Foods.* Hyderabad: National Institute of Nutrition.

11. GOSH, SHANTI ED. (1977). In *The feeding and care of infants and young children,* 2nd ed. New Delhi: Voluntary Health Association of India.

12. GUPTA, M, AGARWAL, K.N. and MANWANI, A. H. (1973). Nutritional status of pre-school children. *Indian Paediatrics* **10,** 81-86.

13. JELLIFFE, D. B. (1966). The assessment of nutritional status of the community. *WHO Monograph Series* No. **55,** pp. 10, 97, 132.

14. KELLER, W. (1983).Choice of indicators of nutritional status In *Evaluation of Nutrition Education in Third World Countries,* p. III. ed. B. Schurch. Nestle Foundation Publication Series, vol. 3. Bern: Hans Huber.

15. KOOPMAN, J. S., FAJARDO, L. and BERTRAND, W. (1981). Food, sanitation and socio-economic determinants in Colombia. *American Journal of Public Health.* **71,** 31-37.

16. KHOSLA, T. and LOWE, C. R. (1967). Indices of obesity derived from body weight and height. *British Journal of Social Medicine* **21,** 122-128.

17. KHURANA, V., AGARWAL, K. N., MANWANI, A. H., and SRIVASTAVA, S. (1971). Physical growth in the first five years. *Indian Paediatrics* **8,** 331-335.

18. LAYRISSE, M. and ROCHE, M. (1964). The relationship between anaemia and hookwork infestations: results of surveys of rural Venezuelan populations. *American Journal of Hygiene* **79,** 279-301.

19. LIYANAGE, CHANDRANI, E. and WIKRAMANAYAKE, T.W. (1985). Socio-cultural malnutrition in the estate sector of Sri Lanka. 1. Social, cultural, demographic and dietary characteristics of the population studied. *Ceylon Journal of Medical Science* **28,** 49-60.

20. LOWRY, O.H., ROSEBROUGH, N. J., FARR, A. L. and RANDALL, R. J. (1951). Protein measurement with the Folin-phenol reagent. *Journal of Biological Chemistry* **193,** 265-275.

21. MARTORELL, R., YARBOROUGH, C., LECHTIG, A., DELGADO, H. and KLEIN, R. E. (1976). Upper arm anthropometric indicators of nutritional status. *American Journal of Clinical Nutrition,* **29,** 46-53.

22. MCLAREN, D.S., KAMAL, W.W., and AYYOUB, N. (1965). Plasma amino acids and the detection of protein-calorie malnutrition. *American Journal of Clinical Nutrition* **17,** 152-157.

23. MILLER, D. C., NICHAMAN, M. Z. and LANE, J. M. (1977). Simplified field assessment of nutritional status in early childhood: Practical suggestions for developing countries. *Bulletin of the World Health Organization* **55,** 79-86.

24. NEWENS, E. M. and GOLDSTEIN, M. (1972). Height, weight and the assessment of obesity in children. *British Journal of Preventive and Social Medicine.* **26,** 33-39.

25. NICHOLLS, L. (1936). A nutritional survey of the poor classes in Ceylon. *Ceylon Journal of Science.* **4,** 1-49.

26. OWEN, G. M. (1973). The assessment and recording of measurements of growth of children. *Paediatrics* **51,** 461-464.

27. PATEL, M. (1980). Effects of the health service and environmental factors on infant mortality: the case of Sri Lanka. *Journal of Epidemiology and Community Health* **34,** 76-82.

28. PERERA, W. D. A. (1984). The nutritional status surveys of preschool children in Sri Lanka. In *Nutritional status, its determinants and Intervention Programmes (Final Report).* Colombo: Food and Nutrition Policy Planning Division, Ministry of Plan Implementation.

29. RAO, K. V. and SINGH, D. (1970). An evaluation of the relationship between nutritional status and anthropometric measurements. *American Journal of Clinical Nutrition.* **23,** 83-93.

30. RUBERU, T. S. and WEERASINGHE, CHANDRANI E. (1981). Health and Nutrition on four estates in the hill country of Sri Lanka. (Unpublished).

31. SASTRY, J. G. and SRI KANTIA, S. G. (1976). Using heights and weights, how close are our estimates of under nutrition in a community? *Indian Journal of Medical Research* **64,** 193-198.

32. SAUNDERS, S. J., TRUSWELL, A. S., BARBEZAT, G. O., WITTMAN, W. and HANSEN, J. D. L. (1967). Plasma free amino acid pattern in protein-calorie malnutrition. *Lancet ii,* 795-797.

33. SONNADARA, D. A., GUNARATNE, C. H. D., DE SILVA, C. C. and DE SILVA, J. (1961/62). Investigation of the haematological picture and parasitic infestation of pre-school children of the lower income groups in Ceylon. *Journal of the Ceylon Public Health Association* **1 & 2,** 282-289.

34. STRUMIA, M. M., SAMPLE, A. B. and HEARST, E. D. (1954). An improved microhaematocrit method. *American Journal of Clinical Pathology* **24,** 106.

35. TANNER, J. M. (1978). In *Foetus into Man.* London : Open Books.

36. TOMKINS, A. M., DRASAR, B. S., BRADLEY, A. K. and WILLIAMSON, W. A. (1978). Water supply and nutritional status in Northern Nigeria, *Transaction of the Royal Society of Medicine and Hygiene* **72,** 239-243.

37. WATERLOW, J. C. and ALLEYNE, G. A. O. (1971). In *Infant Nutrition*, ed. Fomon, S. J., 2nd. p. 128. Philadelphia: W.B. Saunders & Co.

38. WATERLOW, J. C. and RUTISHAUSER, I. H. E. (1974). Malnutrition in Man. In *Early Malnutrition and Mental Development*. Symposium of the Swedish Nutition Foundation, Uppsala, XII. Eds. Cravioto, J., Hambraeuse, L. and Vallequist pp. 13-16, Stockholm: Almquist and Wiksell.

39. WHITEHEAD, R. G. and DEAN, R. F. A. (1964). Serum amino acids in Kwashiorkor. 2. An abbreviated method of estimation and its application. *American Journal of Clinical Nutrition* **14,** 320-330.

40. WHO (1976). Methodology of Nutritional Surveillance. *Technical Report Series No.* 593, Geneva : WHO.

41. WHO (1985). Energy and protein requirements. *Technical Report Series No.* 724, Geneva: WHO.