CHAPTER III

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Studies on creatinine excretion on adult men and women (postgraduate students) :

The first series of investigations were carried out on 24 men and 15 women students aged 19-31 years. Detailed records of food intake in quantitative terms were obtained for a period of 7 days. Since they were students in the Biochemistry Department and with training in nutrition and the techniques used for the assessment of food intake, the records are considered fairly reliable. Most of them appeared to be highly motivated for participation in the study. The composition of the diet in terms of food stuffs was calculated using the recipe method and same is shown in Table 20. The nutritive value of the diets consumed as calculated from the food tables is shown in Table 20.

In previous studies in this laboratory a good agreement was found between calculated and analysed values for food energy and other nutrients as can be seen from Table 21.

The individual data on estimates of energy and protein intakes of the last two days of the study period (the period urine samples were collected) are shown in Tables 22 and 23. The mean energy intake and protein intakes were about 2500 Calories and 64 g for men and 1700 Calories and 42 g for women. The values obtained for calorie intakes represent an increment of 173% and 158% over estimates of basal metabolism (Table 24).

Table 20 : Composition of diets consumed by postgraduate students[@].

	approximate amounts (g) consumed per day*	
	men**	women**
no. of subjects	24	15
cereals	370	200
pulses	45	40
leafy vegetables	5	5
other vegetables	170	120
sugar and jaggery	50	40
milk and curd	360	340
oil and ghee	40	25
eggs	40 (11)	10 (5)
fruits	60 (15)	45 (10)
mutton	38 (5)	
fish and chicken	20 (2)	
	nutrients provided by the diet*	
energy (kilo calories)	2500	1650
protein (g)	65	44
carotene (µg)	900	550
+	+	+
vitamin A (µg)	160	165
thiamin (mg)	2.0	1.2
riboflavin (mg)	1.3	1.0
calcium (mg)	975	895
iron (mg)	30	19

@ values represent mean of daily intakes for 7 days.

* rounded figures

** values in parentheses indicate the number of subjects consuming the item specified.

Table 21 : Analysed values for nutrient content as compared to calculated values (Rajalakshmi and Ramakrishnan, 1969).

nutrient	no. of observations	amount in whole day diet	
		as analysed	as calculated
Calories*	10	1570	1420
fat (g)	10	35	20+
protein (g)	142	38	36
calcium (mg)**	222	470	450
iron (mg)	223	23	20
thiamin (mg)	62	0.80	0.80
riboflavin (mg)	62	0.50	0.48

* based on analysis of the diets of 5 subjects for two consecutive days for protein and fat and estimation of carbohydrate by difference.

** includes 50 mg in drinking and cooking water.

\+ only fats used as such and does not include intrinsic fat present in foods.

Table 22 : Energy and protein intakes of men students.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	kilo calories		protein (g)	
					day-1	day-2	day-1	day-2
1	22	54	175	1.65	2850	3360	82	96
2	19	49	180	1.62	2190	1830	59	47
3	21	65	179	1.80	2610	3000	68	82
4	20	48	157	1.45	3280	2760	86	74
5	21	50	181	1.63	3000	2780	80	65
6	31	44	158	1.47	1910	2060	38	47
7	22	48	171	1.54	2700	2600	65	68
8	21	50	167	1.54	2260	1970	56	53
9	20	53	176	1.65	2010	1980	43	50
10	21	52	180	1.66	2700	2200	76	64
11	20	46	160	1.44	2275	2070	55	52
12	22	43	171	1.47	2290	3320	-	-
13	22	37	163	1.50	1780	2450	42	49
14	22	51	172	1.59	2800	2050	75	60
15	21	50	162	1.51	3854	1500	80	43
16	21	45	165	1.47	1870	2530	44	59
17	21	48	168	1.57	3200	3000	73	71
18	21	50	165	1.53	1800	1840	55	50
19	23	64	170	1.74	2930	-	68	-
21	22	38	162	1.37	2620	-	64	-
22	22	58	175	1.70	2650	2780	68	67
23	21	50	165	1.58	2630	2190	78	73
24	22	60	175	1.73	3080	2400	81	64
mean ±	22	50	170	1.58	2580	2410	65	62
s.d.	2	6.2	7.3	0.4	530	510	15	14

Table 23 : Energy and protein intakes of women students.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	kilo calories		protein (g)	
					day-1	day-2	day-1	day-2
1	21	38	150	1.26	1470	1570	35	39
2	21	43	165	1.42	1750	1710	40	36
3	20	56	167	1.61	1760	2080	49	70
4	22	60	162	1.63	1930	1970	49	48
5	21	53	160	1.53	1930	2230	46	56
6	21	41	151	1.31	1450	1490	36	41
7	21	50	152	1.43	1900	1700	44	45
8	21	43	153	1.36	1340	1460	34	42
9	21	64	160	1.65	1590	1730	40	49
10	22	43	146	1.31	1610	1750	36	36
11	21	44	156	1.40	1510	1380	37	29
12	21	53	155	1.50	1880	1800	44	43
13	23	43	161	1.41	2040	1670	48	40
14	20	45	149	1.36	1960	1420	45	38
15	22	41	159	1.37	1080	1150	23	30
mean ±	21	48	156	1.44	1680	1660	40	43
s.d.	0.8	7.7	6.1	0.12	274	288	7.1	10.3

Table 24 : Energy intakes of adult men and women as compared to basal metabolic requirements.

subject no.	men			subject no.	women		
	kilo calories				kilo calories		
	for basal metabolism* (A)	consumption (B)	$\frac{B}{A}$ x 100		for basal metabolism* (A)	consumption (B)	$\frac{B}{A}$ x 100
1	1450	3250	224	1	990	1530	155
2	1470	2370	161	2	1110	1710	154
3	1610	2920	181	3	1260	2080	165
4	1300	2340	181	4	1270	1900	149
5	1460	2620	179	5	1200	2230	186
6	1250	1850	148	6	1020	1580	154
7	1360	2760	203	7	1120	1970	176
8	1380	2730	198	8	1060	1690	159
9	1480	2210	149	9	1290	1910	148
10	1490	2780	187	10	1020	1690	165
11	1290	2010	156	11	1090	1650	151
12	1290	2690	207	12	1170	1800	154
13	1320	2070	156	13	1100	1750	159
14	1400	2460	176	14	1060	1770	167
15	1350	2400	177	15	1070	1400	131
16	1320	2140	163				
17	1400	2300	164				
18	1370	2000	146				
19	1530	2610	170				
20	1450	2460	169				
21	1210	2160	178				
22	1500	2600	174				
23	1410	2420	171				
24	1520	2250	147				
mean	1400	2430	173		1120	1780	158
s.d.	99	336	20		95	215	13

* taken as 90% of Aub-Dubois standards on the basis of studies reviewed by Banerjee (1972).

In order to study the extent of day to day and diurnal variation in nitrogenous metabolites, two contiguous 12 h collections of urine were made for two consecutive days. The urine samples were analysed for nitrogen, creatinine, urea nitrogen, ammonia nitrogen and uric acid.

The values obtained for urinary nitrogen are compared with estimates of nitrogen intake and estimates of fecal nitrogen and dermal losses in Table 25. The data presented suggest the reasonableness of the values obtained for urine nitrogen and therefore, of the authenticity of the collections.

The values obtained by other investigators vary from 5 to 8 g except for one study reporting a higher value and the value in the present study is in the upper half of the values reported (Table 26).

The mean daily excretion of creatinine was of the order of 1080 mg in men with a range of 760-1430 mg and 725 mg in women with a range of 535-1000 mg. The values for men are comparable with the value of 1080 mg reported by Picou and Reatgue (1962) and the other values presented in Table 27. The relatively small differences are likely to be accounted for by variation in the proportions of animal protein. The values are, however, very much less than those reported in the West (Table 28).

In the case of women, the value obtained compares with that of 633 mg reported by Reddy (1964). Dakshayani and Ramanamurthy

Table 25 : Urinary excretion of nitrogen in relation to estimates of food nitrogen in men and women.

subject no.	men			subject no.	women		
	nitrogen (g)*				nitrogen (g)*		
	food**	urine	fecal and dermal losses@		food**	urine	fecal and dermal losses@
1	14.3	8.8	3.8	1	5.9	5.0	1.9
2	8.5	8.9	2.4	2	6.1	3.3	2.1
3	12.0	6.4	3.4	3	9.5	3.9	2.8
4	12.8	8.0	3.4	4	7.8	3.8	2.5
5	11.6	6.2	3.5	5	8.2	5.7	2.5
6	6.8	5.5	2.2	6	6.2	5.6	2.0
7	10.7	7.5	3.0	7	7.1	7.2	2.2
8	8.7	7.5	2.6	8	6.1	4.2	2.0
9	7.5	6.4	2.4	9	7.1	5.9	2.4
10	11.2	6.8	3.2	10	5.8	3.5	1.9
11	8.6	6.2	2.6	11	5.3	3.6	1.8
12	7.3	6.1	2.3	12	9.5	4.4	2.2
14	10.8	8.2	3.3	13	7.1	5.3	2.2
16	8.2	6.0	2.2	14	6.7	5.1	2.1
17	11.6	8.4	3.2	15	4.3	4.6	1.6
18	8.4	5.9	2.6				
19	10.9	9.2	3.2				
21	10.2	6.5	2.8				
22	10.8	7.8	3.1				
23	12.1	9.1	3.3				
24	11.6	10.4	3.3				
mean	10.2	7.4	2.9		6.7	4.7	2.1
s.d.	2.0	1.4	0.5		1.3	1.1	0.3

* based on values for two consecutive days in most cases.

** calculated from careful records of food intake using the recipe method and according to food tables.

@ fecal nitrogen was taken as 20% of food nitrogen (Hegsted, 1964; Rajalakshmi and Ramakrishnan, 1969) and dermal losses were taken as approximately 1g (about 0.6 g/sq.m.) according to Mitchell and Edman (1962).

Table 26 : Reported values for urinary nitrogenous constituents in adult men (Indians studies)

investigators	total nitrogen (g)	nitrogen (g) excreted per day as						
		urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined*
1	2	3	4	5	6	7	8	9
present study**	7.5	5.0	0.42	5.4	0.40	0.13	0.32	1.6
Rammurthi (1955)***	5.2	3.4	0.30	3.7	0.30	0.14	-	1.1
Phansalkar and Patwardhan (1954)@	5.4	3.5	0.41	3.9	0.45	0.15	0.18	0.9
Gokhale (1963)@	5.6	4.0	0.38	4.4	0.46	0.17	0.42	0.6
Karambelkar et al (1952)*@	5.8	-	-	-	0.44	-	-	-
McCay (1908)	6.0	6.1	-	-	-	0.15	-	-
Gokhale (1963)@	6.5	4.9	0.41	5.3	0.47	0.17	0.41	0.6
Nageswara Rao et al (1975)@	6.5	-	-	-	-	-	-	-
Niyogi et al (1941)	7.0	-	-	-	0.45	-	-	-
Phansalkar and Patwardhan (1954)@	7.1	4.8	0.38	5.2	0.44	0.17	0.10	1.3
Karambelkar et al (1952)@	7.1	-	-	0.48	-	-	-	-

contd

Table 26 : contd.

1	2	3	4	5	6	7	8	9
Narayanan (1935)	7.1	4.9	0.49	5.4	0.49	0.16	-	1.1
Pain and Banerjee (1957)	7.8	4.3	1.18	5.5	0.47	0.12	-	1.8
Phansalkar and Patwardhan (1954)@	7.9	5.9	0.59	6.5	0.47	0.20	0.25	0.8
Hughes et al (1931)	8.2	5.3	0.36	5.7	0.43	0.09	-	2.0
Phansalkar and Patwardhan (1954)@	8.4	6.4	0.46	6.9	0.50	0.21	0.25	0.9
Rammurthi (1955)@	10.9	7.9	0.8	8.7	0.41	0.09	-	1.8

* including the values for amino nitrogen (this was not determined in many of the studies.)

** postgraduate students.

*** low income groups.

@ high income groups.

Table 27 : Reported values for creatinine excretion in adult men and women (Indian studies).

investigators	weight (kg)	height (cm)	surface area (sq.m.)	creatinine (mg) excretion per			
				day	kg	cm	sq.m.
			men				
present report*	50	170	1.58	1076	21	6.2	666
Rammurthi (1955)	55	165	1.59	810	14.7	4.9	509
Hughes et al (1931)	-	-	-	1167	-	-	-
Karambelkar et al (1952)	58	165	1.62	1190	20.6	7.2	735
Phansalkar and Patwardhan (1954)	-	-	-	1204	-	-	-
Niyogi et al (1941)	-	-	-	1220	-	-	-
Gokhale (1963)	56	166	1.63	1230	21.9	7.4	754
Rammurthi (1955)	65	-	-	1230	18.9	-	-
Srivastava et al (1967)	58	165	1.62	1240	21.6	7.5	765
Ram and Reddy (1970)	-	-	-	1245	-	-	-
Gokhale (1963)	56	166	1.62	1260	22.5	7.6	778
Phansalkar and Patwardhan (1954)	-	-	-	1270	-	-	-
Karambelkar et al (1952)	58	165	1.62	1290	22.7	7.8	796
Phansalkar and Patwardhan (1954)	-	-	-	1355	-	-	-
Narayanan (1935)	-	-	-	1350	-	-	-
Ray and Ganguly (1957)	-	-	-	1380	-	-	-
			women				
present report*	48	156	1.44	727	15.3	4.6	504
Reddy (1964)	41			633	15.3		
Dakshayani and Ramanamurthy (1964)	48	159	1.45	1019	21.4	6.4	703

* postgraduate students.

Table 28 : Reported values for creatinine excretion in the West (men).

investigators	weight (kg)	height (cm)	surface area (sq.m.)	creatinine (mg) excretion per			
				day	kg	cm	sq.m.
present report*	50	170	1.58	1076	21.0	6.2	666
Clark et al (1973)	71	177	1.86	1630	22.6	9.2	876
Paterson (1967)	71	179	1.88	1663	23.6	9.3	884
Clark et al (1974)	66	176	1.78	1680	25.1	9.4	939
Calloway (1975)	60	181	1.9	1680	23.6	9.3	881
Hansen et al (1970)	-	-	-	-	22.9	-	-
Siersbaek-Nielson et al (1971)	-	-	-	-	23.8	-	-
MacMillan and Reid (1965)	69	176	1.83	1700	24.8	9.7	929
Mudowney et al (1957)	73	177	1.96	1735	24.0	9.8	971
Zorab et al (1969)	-	-	-	1764	-	-	-
Cramer et al (1967)	-	-	-	1788	-	-	-
Vestergaard et al (1958)	-	-	-	1800	-	-	-
Norris et al (1963)	71	181	1.9	1827	25.7	10.1	962
Chinn (1967)	73	178	1.88	1919	26.4	10.8	1020
Doolan et al (1962)	-	-	1.96	2020	-	-	1030
Corsa et al (1950)	77	175	1.91	2030	26.5	11.6	1117
Plough and Consolazio (1959)	66	172	-	2094	31.5	12.2	-
Vysotskii et al (1974)	71	-	-	2560	36.2	-	-

* postgraduate students.

(1964) have reported a higher value of 1020 mg for midwives and nurses staying in the hostel of a medical school. Their diet is not specified but is likely to have provided generous amounts of animal protein. The values are, however, very much less than those reported ~~in the~~ for healthy women (Table 29) and even obese women in the West (Table 30).

The contribution of creatinine in total nitrogen was of the order of 6% and did not vary between men (6.3%) and women (5.7%).

The coefficient of variation for creatinine excretion was of the order of 21 in men and 22 in women. The same was comparable with the values derived from other studies (Karambelkar et al, 1952; Cramer et al, 1967; Paterson, 1967) reinforcing our confidence in the reliability of the collections.

The average creatinine coefficients (mg of creatinine per kg of body weight) were 21 and 15 in men and women, respectively and they compare with the literature values. If the fat content of the body is taken as 20% for men and 30% for women as reported by Bent Friis-Hansen (1965) these values would work out per kg of fat-free body weight to 16.8 mg for men and 10.5 mg for women so that the differences can not be entirely accounted for by the differences in the same. Nor is it possible to attribute this to a greater amount of fat in women as the women were obviously of lean body build with a height of 156 cm, weight of 48 kg and weight/height ratio of 0.31 as compared to 0.36 derived from western values (see Table 29).

Table 29 : Reported values for creatinine excretion in the West (women).

investigators	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	creatinine (mg) excretion per			
					day	kg	cm	sq.m.
present report*	21	48	156	1.44	727	15.3	4.6	504
Comen (1967)	adults	60	165	1.65	1100	18.9	6.6	667
Nakagawa et al (1973)	22	58	158	1.57	1155	20.1	7.4	735
MacMillan and Reid (1965)	18-22	58	165	1.62	1170	20.1	7.1	722
Young et al (1963)	16-30	59	168	1.69	1177	19.9	7.0	696
Southgate and Durnin (1970)	20	58	162	1.60	1190	20.6	7.4	744
Vestergaard et al (1958)	31	-	-	-	1170	-	-	-
Doolan et al (1962)	33	-	-	1.70	1300	-	-	764
Peters et al (1975)	40	-	-	-	1030	-	-	-
Young et al (1963)	30-40	60	165	1.66	1182	20.0	7.2	712
Hansen et al (1969)	50	-	-	-	-	20.6	-	-
Muldowney et al (1957)	51	70	156	1.68	985	14.8	6.3	606
Young et al (1963)	50-60	62	161	1.62	1176	18.7	7.3	726
Young et al (1963)	60-70	64	161	1.68	1103	17.2	6.8	656
Southgate and Durnin (1970)	74	69	156		830	12.0	5.3	494

* postgraduate students.

Table 30 : Studies on creatinine excretion in malnourished and obese women.

investigators	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	creatinine (mg) excretion per			
					day	kg	cm	sq.m.
				women on a low plane of nutrition				
Duque et al (1975b)	29	34	-	-	323	9.8	-	-
Duque et al (1975a)	25	37	-	-	375	10.0	-	-
Mayoral et al (1975)	31	36	-	-	386	10.8	-	-
Duque et al (1975a)	31	36	-	-	388	10.8	-	-
Oomen (1967)	adults	43	145	1.31	560	13.0	3.8	427
Tripathy et al (1970)	29	37	-	-	456	12.3	-	-
Rajalakshmi and Ramakrishnan (1969)	adults	-	-	-	414	-	-	-
				Obese				
Jourdan et al (1974)								
0.31 + 600 Cal.	35	117	163	2.15	1230	10.8	7.6	557
3.3N + 600 Cal.	35	117	163	2.15	1120	9.9	6.9	505
12 N + 1150 Cal.	36	125	163	2.23	1330	10.8	8.1	595
0.31N + 2382 Cal.	35	123	164	2.22	1340	11.0	8.1	603
12 N + 2383 Cal.	35	123	164	2.22	1400	11.7	8.5	628
Peters et al (1975)	40	-	-	-	1300	-		
Bray et al (1970)	27	122	168	2.27	1200	10.0	7.2	532
	36	144	160	2.34	1389	10.0	8.7	597
	42	164	167	2.58	1347	8.2	7.4	521
	55	170	168	2.61	1024	6.1	6.1	394

The values for men were comparable to those reported for other groups in this country (Karambelkar et al, 1952; Ramamurthi, 1955; Ghokhale, 1963) although slightly higher values were obtained when a large amount of animal protein was fed (Phansalkar and Patwardhan, 1954). The differences between Indian and Western subjects tended to diminish when the values are considered in relation to body weight reinforcing the view that body weight and muscle mass are major determinants.

The mean creatinine excretion per square meter of surface area as calculated from Boothby and Sandiford standards was 670 mg in men and 500 mg in women. The values ranged from 511 to 911 mg in the former case and 376 mg to 624 mg in the latter case. The coefficient of variation was 21 and 18 in men and women respectively.

On the basis of the reported excretion of 1 mg of creatinine per basal calorie (Palmer et al, 1914) and 40 Calories and 36 Calories per sq.m. per h. (Boothby, Berkson and Dunn, 1936) these values which work out to 0.71 and 0.58 mg per basal calorie must be deemed quite low.

In view of the above findings basal metabolism was measured in a few subjects. The conditions of measurement were described on page 80. The consistency of the measurements obtained are presented in Tables 31 and 32. The basal metabolic rate was found to be about 10% less than Aub-Dubois standards in the case of men and about

Table 31 : Consistency of the values obtained for basal metabolism in men.

subject no.	weight (kg)	height (cm)	surface area (sq.m.)	basal metabolism (Cal/sq.m./h)					
				day 1		day 2		day 1	day 2
				(i)	(ii)	(i)	(ii)		
1	2	3	4	5	6	7	8	9	10
1	59	175	1.70	37.4	38.5	-	-	37.9	-
2	51	180	1.66	33.2	32.1	31.1	32.1	32.6	31.6
3	64	179	1.80	32.5	32.0	35.4	34.9	32.3	35.1
4	48	157	1.45	-	-	41.5	41.5	-	41.5
5	48	181	1.61	32.0	37.9	-	-	35.0	-
6	45	158	1.42	36.3	-	37.6	-	36.3	37.6
7	49	171	1.56	40.8	43.0	-	-	41.9	-
8	53	167	1.58	41.4	40.8	43.5	-	41.1	43.5
23	55	170	1.70	36.4	-	37.4	35.9	36.4	36.6
25	54	182	1.69	32.6	32.6	32.1	33.1	32.6	32.6
26	57	173	1.66	36.3	35.8	37.3	36.3	36.0	36.8
27	56	164	1.59	34.6	33.5	33.5	33.5	34.0	33.5
28	43	166	1.44	44.2	40.6	40.6	36.4	42.4	38.5
29	47	168	1.50	34.4	34.4	37.8	36.7	34.4	37.3
30	53	166	1.56	39.7	39.7	40.2	39.7	39.7	40.0
31	49	159	1.47	38.6	38.6	41.0	38.6	38.6	39.8

contd...

Table 31 : contd.

1	2	3	4	5	6	7	8	9	10
32	51	172	1.59	37.9	37.9	36.8	33.5	37.9	35.1
33	45	174	1.51	45.6	45.6	39.9	39.9	45.6	39.9
34	61	178	1.75	36.6	-	35.4	35.4	36.6	35.4
35	59	180	1.74	39.5	38.5	40.5	-	39.0	40.5
36	48	161	1.47	-	-	41.0	41.0	-	41.0
37	55	168	1.60	47.8	46.2	47.3	-	47.0	47.3
38	52	167	1.57	48.2	47.7	40.5	39.4	48.0	40.0
39	47	163	1.47	37.4	36.9	37.4	-	37.1	37.4
mean	52	170	1.59	38.3	30.5	38.5	36.7	38.3	38.1
s.d.	55	7.7	0.11	4.7	4.7	3.8	3.0	4.5	3.7

(i) and (ii) are two consecutive measurements.

Table 32 : Consistency of the values obtained for basal metabolism in women.

subject no.	weight (kg)	height (cm)	surface area (sq.m.)	basal metabolism (Cal/sq.m./h)					
				day-1		day-2		day-1	day-2
				(i)	(ii)	(i)	(ii)		
1	36	150	1.24	38.8	37.5	36.1	-	38.1	36.1
3	51	167	1.56	33.1	32.5	33.1	-	32.8	33.1
4	62	162	1.64	32.5	31.5	34.6	-	32.0	34.6
6	43	151	1.33	38.8	41.4	40.1	41.4	36.4	40.7
7	45	152	1.38	29.9	-	26.2	26.2	29.9	26.2
8	41	153	1.32	38.4	38.4	39.1	-	38.4	39.1
9	55	163	1.57	38.3	36.8	36.7	34.0	37.5	35.3
16	33	149	1.20	43.0	44.4	40.1	40.1	43.7	40.1
17	42	152	1.33	36.2	36.2	35.6	-	36.2	35.6
mean	45	155	1.4	36.6	37.3	35.7	35.4	36.1	35.6
s.d.	9.0	6.7	0.16	4.0	4.3	4.3	6.9	4.1	4.4

(i) and (ii) are two consecutive measurements.

the same in case of women (Tables 33 and 34). The latter observations on women were made about ~~in~~ the middle of the menstrual cycle. Since ovulation takes place about this period, this could be associated with an elevated BMR (Mason and Benedict, 1931; Mitchell, 1962). In other studies in this laboratory, the basal metabolic rate in women of the same social class was found to be 33 Calories per sq.m. per h. (Subbulakshmi, unpublished) and ~~to~~ vary from 28 to 39 Cal/sq.m./h in the middle of the menstrual cycle (Kamalam, unpublished). A lower value of 31 has been reported by Banerjee (1962).

In the case of subjects in whom basal metabolic rate could be measured, creatinine excretion per basal calorie was found to be 0.75 mg for men and 0.61 mg for women. Assuming a similar BMR for other subjects (i.e. 90% Aub-Dubois standards) the corresponding values for the entire group would be 0.77 and 0.65 mg. This discrepancy between expected and observed values for creatinine ~~are~~ is thus much greater when considered in relation to surface area or basal metabolism than when considered in relation to body weight; this is consistent with the apparently greater correlation of creatinine with body weight than with other parameters such as height, surface area or basal metabolism.

As mentioned earlier, ~~women showed more diurnal variation than men~~ collections were made over two cantiguous 12 h periods of two consecutive days (8 A.M. to 8 P.M. and 8 P.M. to 8 A.M.)

Table 33 : Basal metabolic rates in adult men.

subject no.	weight (kg)	% expected weight*	height (cm)	surface area (sq.m.)	basal metabolism (Cal/sq. m./h	% expected BMR**
1	59	86	175	1.70	37.9	93
2	51	71	180	1.66	32.1	76
3	64	90	179	1.80	33.7	81
4	48	86	157	1.45	41.5	100
5	48	66	181	1.61	35.0	85
6	45	80	158	1.42	37.0	93
7	49	75	171	1.56	41.9	103
8	53	86	167	1.58	42.3	102
23	55	86	170	1.70	36.5	88
25	54	74	182	1.69	32.6	79
26	57	86	173	1.66	36.4	88
27	56	93	164	1.59	33.8	82
28	43	70	166	1.44	40.5	97
29	47	75	168	1.50	35.8	86
30	53	85	166	1.56	39.9	96
31	49	86	159	1.47	39.2	95
32	51	78	172	1.59	36.5	88
33	45	68	174	1.51	42.7	103
34	61	87	178	1.75	36.0	86
35	59	82	180	1.74	39.7	96
36	48	82	161	1.47	41.0	99
37	55	89	168	1.60	47.2	113
38	52	85	167	1.57	44.0	108
39	47	80	163	1.47	37.2	96
mean	52	81	170	1.59	38.4	98
s.d.	5.5	7.4	7.7	0.11	3.8	9.6

* based on desirable weights given by Bloch, Miles and Shils, (1978).

** expected BMR based on values reported by Boothby, Burkson and Dunn, (1936).

Table 34 : Basal metabolic rates in adult women.

subject no.	weight (kg)	% expected weight	height : (cm)	surface area (sq.m.)	basal metabolism (Cal/sq.m/h)	% expected BMR**
1	36	77	150	1.24	37.1	103
3	51	88	167	1.56	33.0	91
4	62	115	162	1.64	33.8	92
6	43	89	151	1.33	38.5	107
7	45	92	152	1.38	28.0	77
8	41	83	153	1.32	38.7	107
9	55	102	163	1.57	36.4	101
16	33	71	149	1.20	40.9	116
17	42	88	152	1.33	35.9	99
mean	45	89	155	1.4	36	99
s.d.	9	13	6.7	0.16	3.8	11

* based on desirable weights given by Bloch, Miles and Shils, (1975).

** expected BMR based on values reported by Boothby, Burkson and Dunn, (1936).

in order to get an idea regarding diurnal variation.

The mean day to day variation in different nitrogenous constituents are shown in Table 35. Women showed much more variation in urine volume and uric acid than men but less in the case of other metabolites. It is well-known that water retention varies more in women of reproductive age than in men because of fluctuations in the same during the menstrual cycle, In both cases variation for creatinine and total nitrogen was less than for othermetabolites. Creatinine was found to show significant variation from day to day and between apparently similar subjects.

The individual data on diurnal and day to day variation in creatinine for young men and women are presented in Tables 36 and 37. Diurnal variation is found to be more in women than in men.

Studies on military personnel

An mentioned earlier conflicting reports have been made regarding the effects of exercise on the urinary excretion of creatinine (Starling and Evans, 1956; Srivastava et al, 1967; Best, 1961). An increase during exercise (Srivastava et al,1967; Best, 1951)followed by a fall during recovery has been reported by Starling and Evans (1956) whereas others have reported a decrease (Slonim, 1961).

Table 35 : Comparative data on variation in different urinary nitrogenous constituents in men and women.

	mean for day-1 and day-2 (A)		mean difference between day-1 and day-2 (B)		$\frac{B}{A}$ x 100	
	men	women	men	women	men	women
volume (ml)	1042	867	227	259	20	29
total nitrogen (g)	7.60	4.96	1.20	0.50	16	12
urea nitrogen (g)	4.90	3.20	0.80	0.50	17	16
ammonia nitrogen (g)	0.43	0.29	0.09	0.05	19	17
uric acid (g)	0.39	0.25	0.07	0.07	17	29
creatinine (g)	1.03	0.70	0.12	0.07	12	11

Table 36 : Day to day and diurnal variation in creatinine excretion in men.

subject no.	creatinine (mg) excretion					
	day-1		day-2		day-1	day-2
	(A)	(B)	(A)	(B)	A + B	A + B
1	720	660	621	725	1380	1346
2	591*	567*	702	729	1058*	1431
3	945	575	652	611	1520	1263
4	625	648	599	504	1273*	1103
6	486	368	378	273	854	651
7	320	506	463	298	826	761
8	526	640	499	486	1165	986
9	574	425	523	460	1000	983
10	481	594	468	401	981	869
11	445	393	373	322	839	695
12	395	480	509	404	875	913
13	462	454	451	394	916	844
14	572	578	449*	374*	1150	823*
15	867	509	586*	441*	1376	1028*
16	706	578	388*	390*	1283	778*
17	484	555	456	539	1038	995
18	422	363	350	480	785	830
19	804	669	624	497	1472	1122
20	855	472	562	468	1326	1030
21	449	363	340	372	812	712
22	802	451	732	456	1253	1188
23	550	688	540	570	1237	1110
24	660	502	554	630	1162	1184
mean	596	515	520	481	1107	1001
s.d.	178	103	113	127	230	220
cv	30	20	22	26	21	22

A and B represents two contiguous 12 h. values.

* not included in calculating mean.

Table 37 : Day to day and diurnal variation in creatinine excretion in women.

subject no.	creatinine (mg) excretion					
	day-1		day-2		day-1	day-2
	(A)	(B)	(A)	(B)	A + B	A + B
1	375	403	352	328	778	680
2	245	214	356	255	459	611
3	563*	127*	447	431	690*	878
4	400	369	240*	295*	769	532*
5	468	429	466	474	897	938
6	351	440	458	387	791	845
7	164	360	165	429	524	594
8	218*	250*	303	260	468*	563
9	508	462	480	485	970	965
10	377	259	352	225	636	577
11	194	496	384	228	689	612
12	418	578	284*	335*	996	600*
13	370	351	360	280	720	640
14	211	290	282	308	502	588
15	154	531	350	360	685	710
mean	326	399	357	339	724	708
s.d.	118	106	90	89	169	146
c.v.	36	26	25	26	23	21

A and B represents two contiguous 12 h. values.

* not included in calculating mean.

In the studies just described, creatinine excretion was found to be lower than in the West. The subjects studied differ from those in the west with regard to body weight, protein intake and perhaps activity level as well. As creatinine excretion is likely to be influenced by all these factors, attempts were made to investigate a group expected to have relatively higher intakes of food energy and protein and having a bigger body build and activity level.

The subjects selected were personnel from the military school for Electrical and Mechanical Engineers in Baroda. The subjects had a relatively rigorous routine consistent with training for the Army. Twenty two subjects aged 20-33 years, 160-179 cm tall and weighing 54-72 kg were used in the investigations. Typically, the daily routine of the subjects included; personal care, 5 a.m. to 6 a.m.; physical training 0.5 h; study period 3.5 h. in the morning, 2h in the evening, games 1.5 h and heavy manual work, 2 h. The activity increment calculated on this basis was found to be 73% over basal metabolism as shown in Table 38.

Food intakes were recorded for three consecutive days. The mean energy intakes and protein intakes and the energy intake in relation to height, weight and BMR are given in Table 38.

The calories needed for basal metabolism were determined using Aub-Dubois standards for surface area and BMR. The energy cost of activity was calculated using the data on their daily

Table 38 : Protein and energy intakes of military personnel.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	calculated		calories requirement**	dietary intake		$\frac{B}{A}$ x 100
					BMR@ (A)	activity		calories (B)	protein (g)	
1	2	3	4	5	6	7	8	9	10	11
40*	31	60	167	1.66	1567	1080	2647	2630	92	167
41*	25	54	160	1.54	1488	1000	2488	2240	75	151
42*	29	65	167	1.71	1633	1174	2807	3100	97	190
43*	26	72	179	1.89	1826	1296	3122	3150	91	173
44	21	55	166	1.60	1590	991	2580	2760	84	174
45*	22	55	170	1.62	1588	990	2578	2710	85	171
46	25	60	169	1.68	1623	1080	2703	2210	65	136
47*	30	56	170	1.63	1539	1000	2539	2270	81	147
48*	32	63	172	1.73	1633	1134	2767	2670	89	164
49*	20	61	175	1.73	1719	1095	2814	3400	118	198
50	22	56	164	1.60	1568	1008	2576	3612	117	230
51	25	64	174	1.76	1700	1155	2855	3044	105	177
52	24	60	168	1.67	1613	1095	2708	2880	111	179
53	27	57	168	1.63	1597	1031	2628	2080	81	130
54	23	60	174	1.71	1676	1080	2756	2700	108	161
55	20	56	176	1.68	1670	1008	2678	2980	109	178

contd...

Table 38 : contd.

1	2	3	4	5	6	7	8	9	10	11
56*	20	60	171	1.69	1680	1080	2760	2925	106	174
57	22	57	169	1.63	1597	1031	2628	3540	104	222
59	21	66	173	1.78	1762	1188	2950	2560	75	145
60*	20	56	167	1.61	1600	1022	2622	3240	102	203
61*	33	66	169	1.75	1652	1188	2840	2370	86	143
mean	25	60	170	1.68	1634	1082	2716	2813	94	172
s.d.	4.2	4.8	4.4	0.08	77	82	150	439	15	26
c.v.	17	8	2.6	5	5	8	5	16	16	15

* non-vegetarians

** taken as BMR + activity; The increase due to SDA.is expected to be offset by the reduction during sleep and the lower BMR in Indians.

@ based on Aub-Dubois standards.

routine and body weight. Calorie requirements were taken as basal calories plus calories needed for various activities involved (the increase due to SDA was expected to be offset by other factors such as reduction in sleep). The values obtained were compared with estimate of intakes and found to be in broad agreement, though the mean value was much less than that of 3936 Calories reported for Indian troops in training by Malhotra and his associates (Malhotra, Chandra, Rai, Venkataswamy and Sridharan, 1966). Such agreement was not found in individual cases, the intakes being more than 10% of estimated requirements in 6 cases and being less than this in 5 cases. In this connection, the energy cost of the same activity shows marked individual variation (Banerjee, 1972). A similar variation is expected with regard to deviations of basal metabolism from Aub-Dubois standards as in the studies on post graduate students, they varied from 76 to 113% of the same (Table 33). Contrary to expectation, the activity increment was not much more than in the post graduate students and was of the order of 72%. The student group was younger and prone to a good deal of cycling.

24 h. urine was collected for 3 consecutive days and analysed for nitrogen as well as various nitrogenous constituents. The values for urine volume, nitrogen and creatinine and other nitrogenous constituents are shown in Tables 39 and 40. The day to day variation in creatinine excretion was less than 0.3 g in 13 out of 22 subjects studied and 0.5 g or less in 4 other subjects. In four other subjects

Table 39 : Urinary excretion of creatinine and nitrogen in military personnel.

(data reported for 3 consecutive days)

subject no.	age (yrs)	weight (kg)	height (cm)	volume (ml)			creatinine (g)			total nitrogen (g)		
				days			days			days		
				1	2	3	1	2	3	1	2	3
1	2	3	4	5	6	7	8	9	10	11	12	12
Category - A				day to day variation less than 0.3 g in creatinine								
40 *	31	60	167	800	830	600	1.0	1.1	0.8	4.2	6.2	4.4
41 *	25	54	160	740	780	680	1.0	1.0	0.9	6.1	-	6.0
42 *	29	65	167	2400	2400	3600	1.1	1.1	1.4	9.5	8.8	8.4
43 *	26	72	179	1300	1700	1500	1.3	1.6	1.5	7.6	9.7	8.4
44	21	55	166	1600	1500	1200	1.1	1.0	1.2	7.1	7.2	7.0
45 *	22	55	170	1000	950	500	0.6	0.6	0.8	-	-	4.0
46	25	60	169	1200	1300	600	0.9	1.1	1.0	5.5	5.9	3.8
47 *	30	56	170	1050	1200	1210	1.1	1.2	1.2	7.0	8.6	8.7
48 *	32	63	172	1200	1400	1200	1.6	1.5	1.5	7.1	10.4	7.8
49 *	20	61	175	1100	1300	1100	1.2	1.4	1.1	8.9	10.5	8.3
50	22	56	164	1200	1500	1400	1.2	1.1	1.3	7.8	7.4	7.0
51	25	64	174	1000	750	950	1.2	1.0	0.9	9.4	6.0	9.4
52	24	60	168	1400	900	1000	1.3	1.1	1.4	7.4	7.9	8.1
53	27	57	168	1300	-	-	1.0	-	-	6.8	-	-

contd...

Table 39 : contd.

1	2	3	4	5	6	7	8	9	10	11	12	13
Category - B				variation more than 0.3 g, but consistent values for volume and nitrogen								
54	23	60	174	1010	1050	1030	1.1	1.1	1.6	6.5	8.1	10.6
55	20	56	176	800	900	1000	1.0	1.0	1.4	8.8	6.1	10.9
56*	20	60	171	1100	950	1000	1.3	0.8	0.9	7.9	6.2	6.0
57	22	57	169	1400	1400	1300	1.2	0.9	1.4	7.0	6.0	9.3
mean	25	60	170	1200	1224	1169	1.1	1.1	1.2	7.3	7.7	7.5
s.d.	3.8	4.5	4.6	374	429	689	0.21	0.24	0.27	1.4	1.6	2.1
c.v.	15	7.5	2.7	31	34	59	19	22	23	19	21	28
Category - C					fluctuation in both creatinine and nitrogen							
58	28	65	168	2090	1760	1010	1.8	0.9	0.9	11.7	6.9	-
59	21	66	173	1200	2000	750	1.0	2.0	0.7	6.3	9.6	4.0
60*	20	56	167	900	1000	1000	1.0	0.9	1.9	5.5	6.0	9.6
61*	33	66	169	1700	1700	1200	1.7	1.4	0.9	7.3	8.7	6.3

* Non-vegeterians.

Table 40 : Urinary excretion of nitrogenous constituents in military personnel.
(data reported for 3 consecutive days).

sub-ject no.	nitrogen (g) excreted as											
	urea			ammonia (mg)			uric acid (mg)			amino acid (mg)		
	days			days			days			days		
	1	2	3	1	2	3	1	2	3	1	2	3
1	2	3	4	5	6	7	8	9	10	11	12	13
Category - A	day to day variation less than 0.3 g in creatinine											
40*	-	4.2	3.3	0.24	0.31	0.25	0.05	0.09	0.09	-	0.21	0.20
41*	4.3	4.4	5.2	0.44	0.47	0.24	0.10	0.12	0.13	0.27	0.30	0.24
42*	5.2	4.6	5.2	0.56	0.47	0.69	0.14	0.16	0.14	0.44	0.44	0.40
43*	4.5	5.0	5.2	0.59	0.64	0.49	0.12	0.19	0.16	0.32	0.49	0.33
44	4.2	5.2	5.4	0.46	0.49	0.62	0.15	0.15	0.19	0.30	0.30	0.74
45*	2.6	2.6	3.1	0.33	0.28	0.24	0.07	0.08	0.09	0.10	0.11	0.37
46	4.1	4.4	2.9	0.28	0.33	0.18	0.12	0.11	0.11	0.20	0.16	0.19
47*	4.7	6.2	6.3	0.46	0.49	0.50	0.16	0.16	0.17	0.20	0.24	0.29
48	4.9	6.8	5.4	0.43	0.47	0.47	0.17	0.22	0.13	0.33	0.44	0.38
49*	6.6	6.7	5.9	0.60	0.59	0.56	0.17	0.21	0.15	0.33	0.40	0.30
50	5.6	5.3	4.8	0.44	0.41	0.36	0.18	0.22	0.20	0.32	0.29	0.27
51	7.0	5.2	7.6	0.41	0.35	0.27	0.14	0.13	0.15	0.22	0.18	0.27
52	4.9	6.3	5.9	0.39	0.30	0.43	0.11	0.16	0.17	0.20	0.22	0.24
53	4.9	-	-	0.39	-	-	0.11	-	-	0.25	-	-

contd...

Table 40 : contd.

1	2	3	4	5	6	7	8	9	10	11	12	13
Category - B				variation more than 0.3 g, but consistent values for volume and nitrogen								
54	4.4	6.0	7.5	0.32	0.48	0.62	0.09	0.11	0.14	0.21	0.28	0.37
55	5.2	4.6	8.2	0.36	0.48	0.78	0.14	0.11	0.18	0.25	0.23	0.40
56*	6.3	3.7	4.4	0.54	0.36	0.41	0.20	0.13	0.16	0.33	0.24	0.26
57	-	5.0	6.8	-	0.27	0.27	0.13	0.14	0.17	0.47	0.21	0.25
mean	5.0	5.1	6.5	0.43	0.42	0.43	0.13	0.15	0.15	0.28	0.28	0.32
s.d.	1.1	1.1	1.5	0.11	0.11	0.18	0.04	0.04	0.03	0.08	0.11	0.13
c.v.	21	22	28	25	25	41	30	30	22	29	38	39
Category - C				fluctuation in both creatinine and nitrogen								
58	9.6	5.2	5.9	0.60	0.40	0.39	0.19	0.09	0.14	0.20	0.23	0.36
59	4.7	6.7	2.5	0.38	0.71	0.26	0.11	0.18	0.06	0.26	0.49	0.18
60*	3.7	4.0	6.4	0.21	0.32	0.56	0.10	0.10	0.21	0.21	0.20	0.36
61*	6.8	6.4	4.4	0.57	0.50	0.33	0.23	0.20	0.18	-	0.42	0.29

* Non-vegetarians

the variation was greater but the average for 3 days seemed to be reasonable and the values considered reasonable as nitrogen excretion seemed consistent with estimates of nitrogen intake. Part of the variation could be due to differences in meat intakes. For instance, in the case of M.S.K. (Serial No. 60) creatinine excretion rose to 1.9 g on day 3 following dinner with meat the previous night. In the case of T.A.K. (Sr. No. 59) it would appear that the day 2 collection represented part of what should have been included on day 1 and day 3 samples.

The data were further analysed to get a clearer picture on day to day variation (Table 41). The values for two consecutive days varied by about 15-20 % and the means for first two and last two days were in fairly close agreement suggesting that collections for two consecutive days would give a fairly valid picture.

Creatinine excretion in men on low plane of nutrition

Since creatinine excretion is expected to be influenced by the plane of nutrition, similar data were obtained on young men belonging to the low income group (Class IV employees in the university). In previous studies in this laboratory, a similar group of men were found to consume 2000 Calories and 50 g protein. The data obtained for these subjects are shown in Table 42. Since the day to day variation was less than 0.3 g in the studies

Table 41 : Data on variation in different urinary nitrogenous constituents in military personnel.

	mean for day 1 & 3 (A)	mean for day 2 & 3 (C)	mean difference between day 1 & 2 (B)	mean difference between day 2 & 3 (D)	$\frac{B}{A} \times 100$	$\frac{D}{C} \times 100$	students* $\frac{B}{A} \times 100$
volume (ml)	1209	1195	153	250	13	21	20
total nitrogen (g)	7.60	7.80	1.54	1.70	20	22	16
urea nitrogen (g)	5.10	5.30	0.95	1.05	18	20	17
ammonia nitrogen (g)	0.43	0.43	0.07	0.10	16	24	19
uric acid (g)	0.43	0.44	0.09	0.07	19	16	17
creatinine (g)	1.11	1.14	0.14	0.22	12	19	12

* see table 35.

Table 42 : Individual data on urinary excretion of nitrogenous constituents in men belonging to the low income group.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	volume (ml)	crea-tinine (mg)	total nitro-gen (g)	nitrogen (g) excreted as					
								urea	ammo-nia	urea + ammo-nia	uric-acid	crea-tinine	undeter-mined
77	28	40	149	1.29	1060	1113	5.50	3.69	0.19	3.86	0.13	0.41	1.10
78	29	39	156	1.31	710	675	6.10	3.62	0.44	4.06	0.11	0.25	1.70
79	35	46	157	1.42	1150	826	5.30	3.78	0.27	4.05	0.09	0.31	0.85
80	35	43	155	1.37	880	968	7.90	5.80	0.75	6.55	0.14	0.36	0.85
81	24	48	161	1.47	2005	1202	6.40	4.60	0.44	5.04	0.11	0.45	0.81
82	30	60	166	1.58	660	906	5.80	3.50	0.48	3.98	0.08	0.34	1.47
mean	30	46	156	1.41	1077	948	6.20	4.20	0.44	4.59	0.11	0.35	1.13
s.d.	4.3	7.5	3.8	0.11	492	151	0.90	0.90	0.19	1.05	0.02	0.07	0.37
range	24-35	39-60	149-166	1.29-1.58	660-2005	675-12.2	5.3-7.9	3.5-5.8	0.19-0.75	3.86-6.55	0.08-0.14	0.25-0.45	0.85-1.7

described previously and the averages for the whole group were practically identical on consecutive days, only 24 hr. collections were obtained in this study. The subjects in this and other catagories to be described subsequently were not as cooperative as the professional groups and it became more or less necessary to confine the collections to a shorter period.

The value of 6.2 g for total nitrogen in urine was significantly less than on students. This is consistent with lower protein intakes.

The average value for creatinine excretion was 948 mg and the value was not appreciably lower than that of 1080 mg obtained for post graduate students. In terms of mg per kilogram body weight the values for the two groups were identical.

Variation in creatinine excretion with advancing age

Since creatinine has been reported to be influenced by age, similar studies were undertaken on two other groups of adult men, one aged 28-45 years and the other 51-73 years. Both groups belonged to the professional class i.e. the same class as postgraduate students. In most cases urine was analysed for two consecutive days. The values obtained for different nitrogenous constituents are shown in Tables 43 and 44.

The mean excretion of nitrogen was 6.5 g and 5.6 g in the two groups (young and elderly) with the values ranging from

Table 43 : Individual data on urinary excretion of creatinine and total nitrogen in young and elderly men.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	creatinine (g)		total nitrogen (g)	
					1	2	1	2
Young white collar workers								
62	29	53	163	1.53	1.35	1.14	8.4	8.4
63	30	66	159	1.65	0.86	1.04	4.8	5.5
64	28	56	180	1.70	1.27	1.24	8.8	8.0
65	45	50	158	1.48	0.88	-	5.0	-
66	35	78	171	1.89	1.21	-	4.5	-
67	30	53	160	1.53	1.00	-	7.6	-
mean*	29	58	167	1.63	1.16	1.14	7.3	7.3
s.d.	1	6.8	11.1	0.15	0.26	0.10	2.2	1.6
c.v.	3	12	7	9	23	9	30	22
Retired white collar workers (Elderly)								
68	62	55	166	1.59	0.67	0.71	3.5	3.3
69	69	59	169	1.8	0.84	1.07	4.6	4.2
60	69	63	173	1.75	1.07	1.15	10.3	10.2
71	64	59	165	1.64	0.86	0.86	5.3	4.7
72	69	72	166	1.79	0.78	0.70	4.7	5.4
73	64	46	161	1.45	0.55	0.64	2.5	3.0
74@	55@	57	173	1.67	0.85	0.75	4.4	3.9

contd..

Table 43 : Contd.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	creatinine		total nitrogen	
					1	2	1	2
75	73	54	160	1.53	1.16	-	8.5	-
76@	51ø	68	166	1.75	1.00	-	7.2	-
mean*	65	60	168	1.65	0.80	0.84	5.0	5.0
s.d.	5.1	8.8	4.4	0.14	0.17	0.20	2.5	2.5
c.v.	2	15	ø3	8	21	24	50	50

@ values for these subjects were not included for comparative studies in Table 45, 46 and 47.

* mean values were for those having values for two consecutive days.

Table 44 ; Urinary excretion of nitrogenous constituents in young and elderly men.

subject no.	Nitrogen (g) excreted as									
	urea		ammonia		uric acid		creatinine		undetermined	
days →	1	2	1	2	1	2	1	2	1	2
1	2	3	4	5	6	7	8	9	10	11
young white collar workers										
62	5.7	6.0	0.55	0.55	0.17	0.14	0.50	0.42	1.50	1.30
63	3.8	3.9	0.36	0.40	0.08	0.08	0.32	0.39	0.24	0.73
64	5.5	5.0	0.60	0.52	0.09	0.09	0.07	0.46	2.10	1.94
65	4.3	-	0.08	-	0.13	-	0.33	-	0.17	-
66	-	-	0.43	-	0.10	-	0.45	-	-	-
67	4.2	-	0.45	-	0.08	-	0.37	-	2.50	-
mean*	5.0	5.0	0.51	0.49	0.11	0.10	0.43	0.42	1.26	1.32
s.d.	1.0	1.0	0.13	0.08	0.05	0.03	0.10	0.04	0.93	0.61
c.v.	20	20	25	17	44	30	22	9	74	46
retired white collar workers (elderly)										
68	2.6	2.3	0.29	0.27	0.11	0.09	0.25	0.27	0.25	0.38
69	3.5	3.2	0.26	0.23	0.11	0.10	0.31	0.40	0.41	0.27
70	8.2	8.2	0.28	0.26	0.13	0.11	0.40	0.43	1.29	1.21
71	4.0	2.9	0.35	0.42	0.05	0.07	0.32	0.32	0.57	1.00

contd...

Table 44 : contd.

1	2	3	4	5	6	7	8	9	10	11
72	3.4	3.9	0.23	0.31	0.07	0.07	0.29	0.26	0.71	0.86
73	1.6	2.2	0.19	0.22	0.06	0.04	0.20	0.24	0.45	0.30
74@	2.7	2.9	0.34	0.34	0.07	0.08	0.31	0.28	0.98	0.31
75	6.8	-	0.29	-	0.12	-	0.43	-	0.86	-
76@	5.3	-	0.38	-	0.09	-	0.37	-	1.06	-
mean*	3.7	3.7	0.28	0.29	0.09	0.08	0.30	0.31	0.67	0.62
s.d.	2.1	2.1	0.06	0.07	0.03	0.02	0.06	0.07	0.36	0.39
c.v.	57	57	21	24	36	27	21	24	54	63

* mean values were for those having values for two consecutive dayss.

@ the values for these subjects were not included for comparative studies in Table 45, 46 and 47.

4.5 g to 8.4 g and 2.8g to 10.3g. These values were also not found to differ significantly from those for men students but the variability was more particularly in elderly. The low nitrogen excretion (2.75g) in the case of M.P. (No. 73) in the elderly groups was reasonable on the basis of a protein intake of only 25g per day.

The comparative values for the five groups of adult men investigated are shown in Table 45.

Inspite of their higher protein intake (95g as compared to 64 g in students) military personnel did not excrete more nitrogen in urine, perhaps, because of greater losses of nitrogen in sweat during the periods of vigorous exercise. Reduction of urinary nitrogen loss was observed during exercise associated with profuse sweating by some eorkers (Daly and Dill, 1937; Ashworth and Harrower, 1967; Bourges, 1968; Yawada, 1972; Huang et al, 1972; Huang et al, 1975). On the other hand, no compensatory reduction in urinary nitrogen in profuse sweating has been reported (Mitchell and Hamilton, 1949; Mitchell and Edman, 1962; Consolazio et al, 1963; Consolazio et al, 1975).

Except for the elderly, the different groups were not found to differ significantly with regard to creatinine excretion, especially, when the same was considered in relation to body weight, inspite of the differences in calorie and protein intake, confirming the common impression that creatinine excretion is not

Table 45 : Comparative data on urinary excretion of nitrogen and creatinine in adult men.

group		age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per day	creatinine (mg) excretion per kg	creatinine (mg) excretion per cm	creatinine (mg) excretion per sq.m.	creatinine (mg) excretion per basal calorie
postgraduates (n = 23)	m	22	50	170	1.58	7.5	1076	21	6.2	666	0.75+
	s.e.	0.46	1.4	1.5	0.02	0.29	46	0.88	0.29	29	0.06
	c.v.	10	14	4	7	19	21	20	23	21	25
											0.77++
											0.03
											18
military personnel (n = 18)	m	25	60***	170	1.68**	7.3	1131	19	6.6	673	0.70++
	s.e.	0.9	1.1	1.1	0.02	0.35	47	0.66	0.26	24	0.03
	c.v.	15	8	3	5	21	18	15	17	15	17
white collar workers (n = 6)	m	33	59	165	1.63	6.5	1090	18.8	6.6	670	-
	s.e.	2.6	4.3	3.6	0.06	0.73	69	1.5	0.33	37	-
	c.v.	19	18	5	9	28	16	20	12	13	-
unskilled workers (n = 6)	m	30	46	156***	1.41**	6.2*	948	21	6.1	676	-
	s.e.	1.8	3.1	1.55	0.04	0.37	78	2.0	0.53	58	-
	c.v.	14	16	2	8	15	20	23	21	21	-
elderly@ (n = 7)	m	67	60*	165	1.65	5.6	873*	14***	5.2	529*	-
	s.e.	1.5	3.5	1.8	0.05	1.02	83	1.4	0.49	49	-
	c.v.	6	16	3	9	48	25	26	25	25	-

m - mean; s.e. - standard error; c.v. - coefficient of variation.

values marked with asterisk significantly different from postgraduate values, p less than 0.05 for * 0.01 for ** and 0.001 for ***.

\+ as determined in 10 subjects.

++ calculated as 90% standard (Aub-Dubois) basal metabolism in all the subjects.

@ excluding values for subjects nos. 74 and 76.

influenced by the plane of nutrition. On the other hand, the values were less than for Western men suggesting that perhaps the plane of nutrition does count. The reason for the lack of difference between the different groups studied may be due to the fact that none of the groups had an exceptionally high level of protein intake. Even in the military personnel, it is likely that the protein intakes of the subjects before they joined the military were far less than that they get in the army and it is possible that established patterns of protein and creatinine turnover are not appreciably affected by a switch to a higher protein diet relatively in late life. The operation of such carry over effects has been observed in animal studies intthis laboratory to be discussed in a subsequent section.

The values obtained for the military personnel are comparable with reported values for army personnel by Srivastava et al (1967) for creatinine and creatinine coefficient(1240 mg and 21.6 mg respectively).

The creatinine excretion of about 950 mg for unskilled workers compares with the value of 810 mg reported by Ramamurthi (1955) for the labourers whose calorie and protein intakes were 1600 cal ad 43 g respectively, but is less than the value of 1788 mg reported by Cramer et al (1967) for workers.

The some-what lower creatinine excretion in the elderly may be due to decreased muscle mass. Norris et al (1963) reported creatinine excretion in the age groups 20-29 years and 60-69 years to be 1827 and 1570 mg per day. Hansen et al (1970) observed that elderly men excrete less creatinine as compared to younger ones. Excretion of creatinine was generally higher in persons under 30 years and fell from age of 55 years (Takagi et al, 1975). Although the values in the present study were not comparable, the pattern was similar.

A similar pattern is observed with regard to creatinine coefficient which was 18.8 mg in young men and 14 mg in the elderly. The latter compares with the value of 13.9 mg reported by Hansen et al (1970) but a lower value of 10.6 mg and a higher value of 19.9 mg have also been reported (Southgate and Durnin, 1970; Norris et al, 1963).

Urinary creatinine per kg of body weight was found to fall on an average about 50% from 3rd to 9th decade of age (Goult and Cockroft, 1975; Siersback-Nielsen et al, 1971).

The means values of creatinine per cm of height were 6.6 mg and 5.2 mg in youngmen and the elderly respectively. The values for similar age groups were found to be 8.6 mg and 4.3 mg in the study of Southgate and Durnin (1970) and 10.1 mg and 8.8 mg in the study of Norris et al (1963) respectively.

As mentioned earlier, studies were made of other nitrogenous constituents in urine.

The absolute and relative amounts of nitrogenous constituents studied in five groups of adult men are shown in Tables 46 and 47.

The values for other groups as % of the values for students are shown in Table 46a.

As pointed out earlier, the major component of urinary nitrogen is urea nitrogen as it reflects the intake of protein of an individual. Though the differences found in urea nitrogen excretion in the groups studied were not significant, the values were found to alter with age and plane of nutrition as can be seen from Table 46a and the values were consistent with estimates of protein intakes.

The high variability in urea excretion in the elderly as compared to other groups is expected on the basis of a similar variation in protein intakes (Table 48). Two subjects (P.K.V. (No. 71) and G.M.C. (No.72)) had high protein intakes whereas in the case of M.P.D. (No. 73) intake was just sufficient tobalance endogenous nitrogen loss. In this connection the food intakes and activity levels of elderly individuals are highly variable and may ~~be~~ not be much less than in younger subjects ~~suggests~~ in the case of active individuals (Durnin, 1967).

Table 46 : Comparative data on urinary excretion of nitrogenous constituents in adult men.

group		total nitrogen (g)	nitrogen (g) excreted as						
			urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined[a]
postgraduates (n = 23)	m	7.5	5.0	0.42	5.4	0.40	0.13	0.32[b]	1.6
	s.e.	0.29	0.22	0.03	0.23	0.02	0.008	0.04	0.13
	c.v.	19	21	29	21	20	30	31	38
military personnel (n =16)	m	7.3	5.2	0.42	5.6	0.42	0.14	0.29	1.2
	s.e.	0.35	0.23	0.03	0.24	0.02	0.007	0.02	0.14
	c.v.	21	19	26	18	17	21	27	48
white collar workers (n = 6)	m	6.5	4.7	0.41	5.1	0.40	0.11*	-	1.3
	s.e.	0.73	0.34	0.07	0.43	0.02	0.01	-	0.40
	c.v.	28	18	44	19	15	29	-	76
unskilled workers (n = 6)	m	6.2*	4.1	0.43	4.6	0.35	0.11	-	1.11*
	s.e.	0.37	0.37	0.08	0.43	0.03	0.008	-	0.15
	c.v.	15	22	45	23	20	18	-	33
elderly[@] (n = 7)	m	5.6	4.3	0.28***	4.5	0.32*	0.09**	-	0.67***
	s.e.	1.0	0.87	0.02	0.9	0.03	0.01	-	0.13
	c.v.	48	54	22	53	25	33	-	51

m - mean; s.e. - standard error; c.v. - coefficient of variation.

values marked with asterisk significantly different from postgraduates values, p less than 0.05 for *, 0.01 for **, and 0.001 for ***.

(a) values including amino nitrogen.
(b) based on only 7 subjects.
@ excluding values for subjects nos. 74 and 76.

Table 46a : The comparative data of Table 46 expressed as percentages of those for postgraduates.

group	total nitrogen (g)	nitrogen (g) excreted as						
		urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined
postgraduate	7.5	5.0	0.42	5.4[illegible]	0.40	0.13	0.32	1.56
		values as % value for postgraduates						
military personnel	97	104	102	104	105	105	91	79
white collar workers	87	94	98	94	101	78	-	84
unskilled workers	83	82	103	85	88	82	-	71
elderly	75	86	66	83	81	67	-	43

Table 47 : Contribution of various urinary nitrogenous constituents to total nitrogen in adult men.

group		total nitrogen (g)	% contribution to nitrogen in urine						
			urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined[a]
postgraduates (n = 23)	m	7.5	66	5.6	72	5.3	1.7	4.1[b]	20.5
	s.e.	0.29	1.3	0.06	1.3	0.23	0.08	0.35	1.4
	c.v.	19	9	6	9	20	21	22	33 (16.5)
military personnel (n = 18)	m	7.3	71*	5.8	77	5.9	2.0*	4.3	16.0*
	s.e.	0.35	1.5	0.24	1.3	0.21	0.08	0.35	1.3
	c.v.	21	9	17	7	15	18	35	35 (12.0)
white collar workers (n = 6)	m	6.5	70	6.3	75	6.6	1.73	-	17.4
	s.e.	0.73	4.8	1.1	4.7	0.73	0.24	-	4.8
	c.v.	28	17	41	14	27	35	-	67 (13.4)
unskilled workers (n = 6)	m	6.2*	67	6.7	74	5.8	1.8	-	18.5
	s.e.	0.37	2.5	0.9	2.6	0.57	0.13	-	2.8
	c.v.	15	9	33	9	24	18	-	37 (14.5)
elderly@ (n = 7)	m	5.6	74**	5.7	80	6.4	1.7	-	12.0***
	s.e.	1.0	1.8	0.8	1.1	0.6	0.25	-	1.1
	c.v.	48	6	37	4	25	39	-	24 (8)

m - mean; s.e. - standard error; c.v. - coefficient of variation.

values marked with asterisk significantly different from postgraduate values, p less than 0.05 for *, and 0.01 for ** and 0.001 for ***

(a) including the values for amino nitrogen. The values in parentheses give estimates of undetermined nitrogen assuming a values of 4% for the same for last 3 groups.

(b) based on only 7 subjects.

@ excluding values for subjects no. 74 and 76.

Table 48 : Energy and protein intakes in the elderly as compared to estimates of BMR

subject no.	age	weight (kg)	height (cm)	BMR* Calories	Calorie intake**		protein intake**		expected requirements	
					day-1	day-2	day-1	day-2	Calorie	protein	Calorie	protein
74	55	56	173	1300	1950	2090	42	52	2020	47	1950	48
71	64	59	165	1257	2380	2710	63	66	2545	65	1887	47
72	69	72	166	1346	2290	1910	68	54	2100	61	2019	50
73	64	46	161	1111	1080	1280	20	31	1180	26	1665	42

* taken as 90% of Aub-Dubois standards.

** based on careful records of food intakes.

The mean values obtained for postgraduate men were in agreement with those reported by Gokhale (1963) and Narayanan (1935) for similar groups of subjects and Phansalkar and Patwardhan (1954) on subjects whose protein intakes were not controlled (Table 26).

The mean urea nitrogen excretion was 4.7 g and 4.3 g in young men and the elderly respectively. The values in young and elderly were found to be 11.4 g and 9.7 g in the study of Southgate and Durnin (1970) and 14.3 g and 9.6 g in study of Ellestel-sayed et al (1975) respectively. Although the values in the present study were not comparable the pattern was similar.

The value of 5.2 g obtained for military personnel was comparable with the value of 5.3 g reported for Punjabis by Hughes et al (1931). That for unskilled workers was more than the reported values of 3.4 g by Rammurthi (1955) for labourers.

The relative contribution of urea nitrogen to total nitrogen found in the elderly was found to be significantly lower than that in the students (74% and 66% respectively) and the pattern was consistent with that observed by Southgate and Durnin (1970) for similar groups, though the values (86% and 79%) were greater.

The mean percentage values obtained for Indian men were found to be of the same order as that found in the present study

(Table 49) and less than that found in Western subjects (Tables 50 and 51) both in absolute and relative terms confirming the view of Allison et al, (1946) that the protein stores were not maximal in Indians.

It is generally stated that an increase in the amount of ammonia nitrogen excretion leads to decrease in the amount of the urea excretion and vice versa. This is found to be the case in some of the subjects, when urine collections were made for 2-3 days. In other cases ammonia nitrogen increased without an associated decrease in urea nitrogen excretion. This may be due to the ammonia produced at the level of tubular epithelium to maintain acid base balance. The variability was less when the two components were considered together.

A greater variability was generally found in ammonia nitrogen excretion than in other nitrogenous constituents.

The low ammonia nitrogen excretion found in the elderly was significantly lower than that found in students. The other groups studied did not vary in this respect.

The values for ammonia nitrogen in absolute and relative terms in the case of students compared with those reported by Phansalkar and Patwardhan (1954). Those for unskilled workers were more than the values reported by Rammurthi (1955) for labourers.

Table 49 : Contribution of urinary nitrogenous constituents to total nitrogen in adult men (Indian studies).

investigator	total nitrogen (g)	% contribution to nitrogen						
		urea	ammonia	urea + ammonia	creatinine	uric acid	amino amid	undetermined**
present report**	7.5	66	5.6	72	5.3	1.7	4.1	20.5
Rammurthi (1955)	5.2	65	5.8	71	5.8	2.7	-	20.7
Phansalkar and Patwardhan (1954)	5.4	65	7.5	73	8.3	2.9	3.3	16.3
Gokhale (1963)	5.6	72	6.8	79	8.2	3.0	7.5	10.0
Karambelkar et al (1952)	5.8	-	-	-	7.6	-	-	-
McCay (1908)	6.0	-	-	-	-	2.5	-	-
Gokhale (1963)	6.5	75	6.2	81	7.2	2.6	6.3	9.0
Niyogi et al (1941)	7.0	-	-	-	5.3	-	-	-
Phansalkar and Patwardhan (1954)	7.1	67	5.4	72	6.2	2.4	1.45	19.0
Karambelkar et al (1952)	7.1	-	-	-	6.8	-	-	-
Narayanan (1935)	7.1	69	6.9	76	6.9	2.3	-	15.0

contd...

Table 49 : contd.

investigator	total nitrogen (g)	% contribution to nitrogen						
		urea	ammonia	urea + ammonia	creati-nine	uric acid	amino acid	undeter-mined*
Pain and Banerjee (1957)	7.8	55	15.1	70	6.0	1.6	-	22.3
Phansalkar and Patwardhan (1954)	7.9	74	7.4	81	6.0	2.6	3.1	10.0
Rammurthi (1955)	8.1	70	4.4	74	4.7	1.4	-	19.5
Hughes et al (1931)	8.2	64	4.4	68	5.2	1.1	-	25.3
Phasnsalkar and Patwardhan (1954)	8.4	76	5.5	82	6.0	2.5	3.0	10.0
Rammurthi (1955)	10.9	72	7.3	79	3.8	0.8	-	16.1

* postgraduate ~~studies.~~ students.

** including the values for amino nitrogen.

Table 50 : Values reported for the urinary excretion of nitrogenous constituents in other countries in men.

investigator	total nitrogen (g)	nitrogen (g) excreted as					
		urea	ammonia	urea + ammonia	creati-nine	uric acid	undeter-mined**
1	2	3	4	5	6	7	8
present report*	7.5	5.0	0.42	5.4	0.40	0.13	1.6
Clark et al (1973)	5.8	-	-	-	0.61	-	-
Inou et al (1974)	6.0	-	-	-	-	-	-
Clark et al (1974)	6.6	-	-	-	0.66	-	-
Calloway (1975)	6.5	5.2	-	-	0.62	0.13	-
Concepician (1918)	7.1	4.5	0.53	5.0	0.55	0.13	1.27
Campbell (1919)	7.7	6.2	0.58	6.8	0.41	0.12	0.39
Clark et al (1974)	8.4	-	-	-	0.70	-	-
Inou et al (1974)	8.7	-	-	-	-	-	-
Oomen (1967)	9.5	7.8	0.46	8.3	0.53	-	-
Clark et al (1974)	9.7	-	-	-	0.67	-	-
Nakagawa et al (1973)	10.6	-	-	-	0.50	-	-

contd...

Table 50 : contd.

1	2	3	4	5	6	7	8
McDonald and Margen (1976)	10.9	8.8	-	-	0.56	0.16	-
Clark et al (1974)	10.9	-	-	-	0.69	-	-
Smith (1926)	11.8	9.6	0.54	10.1	0.66	0.17	0.83
Clark et al (1974)	12.0	-	-	-	0.73	-	-
Consolazio et al (1975)	13.2	-	-	-	-	-	-
Vysotskii et al (1974)	13.7	10.5	1.46	12.0	0.95	0.24	0.52
Southgate and Durnin (1970)	13.9	10.8	1.06	11.9	0.38	0.15	1.49
Southgate and Durnin (1970)	14.9	11.9	1.12	13.0	0.58	0.19	1.03
Cole (1933)	16.0	14.0	0.50	14.5	0.58	0.23	0.70
Folin (1905)	16.8	14.7	0.50	15.2	0.58	0.18	0.85

* postgraduate students.

** including the values for amino nitrogen.

Table 51 : Contribution of urinary nitrogenous constituents to total nitrogen in other countries in men.

investigator	total nitrogen (g)	% contribution to nitrogen in urine					
		urea	ammonia	urea + ammonia	creati-nine	uric acid	undeter-mined**
1	2	3	4	5	6	7	8
present report*	7.5	66	5.6	72	5.3	1.7	20.5
Clark et al (1973)	5.8	-	-	-	10.4	-	-
Clark et al (1974)	6.6	-	-	-	10.0	-	-
Calloway (1975)	6.5	81	-	-	9.6	2.0	-
Concepicion (1918)	7.1	64	7.5	72	7.7	1.8	17.9
Campbell (1919)	7.7	81	7.5	89	5.3	1.6	5.0
Clark et al (1974)	8.4	-	-	-	8.4	-	-
Oomen (1967)	9.5	82	4.9	87	5.6	-	-
Clark et al (1974)	9.7	-	-	-	6.9	-	-
Nakagawa et al (1973)	10.6	-	-	-	4.7	-	-
McDonald and Margen (1976)	10.9	81	-	-	5.1	1.4	-
Clark et al (1974)	10.9	-	-	-	6.3	-	-

contd...

Table 51 : contd.

1	2	3	4	5	6	7	8
Smith (1926)	11.8	82	4.6	87	5.6	1.4	7.0
Clark et al (1974	13.0	-	-	-	6.1	-	-
Vysotskii et al (1974)	13.7	77	10.7	88	6.9	1.8	3.8
Southgate and Durnin (1970)	13.9	78	7.6	86	2.6	1.1	10.7
Southgate and Durnin (1970)	14.9	80	7.5	88	3.9	1.3	6.9
Cole (1933)	16.0	88	3.1	91	3.6	1.4	4.4
Folin (1905)	16.8	88	3.0	91	3.5	1.1	5.1

* postgraduate students.

** including values for amino nitrogen.

Although values reported for ammonia nitrogen excretion by Southgate and Durnin (1970) for the young and the elderly were not comparable with those in the present study the pattern was similar.

An alternative pathway for nitrogen excretion in man is provided by diversion of aminoacid nitrogen into purines with subsequent uric acid excretion (Gutman, 1965). Uric acid nitrogen in urine may therefore be taken to reflect purine turnover.

Uric acid nitrogen excretion showed a tendency to decrease with age and the plane of nutrition, though significant differences were found only between the students and the elderly. This cannot be altogether attributed to decreased renal clearance of the same in the elderly (Vanpilsum and Seljeskog, 1958; Hansen et al, 1970) as ultimately this metabolite is excreted in the urine.

The percentage contribution of uric acid nitrogen to total nitrogen was significantly higher in military personnel than in the students.

The reported values for uric acid nitrogen both in absolute and relative terms were higher than those found in the present study (Tables 26 and 49).

Amino nitrogen excretion was studied in students and military personnel to get an idea of the amount of excretion in urine. The variation in aminoacid nitrogen excretion was found to be as much as in other nitrogenous constituents.

The values for amino nitrogen in the present study were greater than those reported by Phansalkar and Patwardhan (1954) and less than those reported by Gokhale (1963).

The difference between total nitrogen and the contribution of various nitrogenous constituents was expressed as undetermined nitrogen. The variability in this was found to be greater than that with regard to the various components studied. This may be an ϕartifact to some extent. A similar variability was found in the studies of Rammurthi (1955).

Undetermined nitrogen was found to change with age and plane of nutrition. Variation with age has been found by Southgate and Durnin (1970). The values obtained for unskilled workers and for the elderly were significantly lower than in the students.

In conclusion, although creatinine excretion showed the expected variation with age and plane of nutrition the differences practically disappeared when the values were considered in terms of body weight and surface area except in the case of the elderly who showed a decreased excretion on all counts. But the values were less than in the west.

Total nitrogen in urine varied with nitrogen intake as might be expected except in the case of military personnel in whom excretion was much less than the expected value presumably because of sweat lesses.

Urea nitrogen paralleled nitrogen excretion and the percentage contribution of urea nitrogen to total nitrogen was less than that inferred from reports in the west and somewhat more in military personnel and the elderly.

Ammonia excretion showed a greater variability and often seemed to vary inversely with urea excretion. The two together showed a more consistent pattern.

The other nitrogenous constituents including undetermined nitrogen showed the expected pattern although the values were some what higher than those in western studies in the case of undetermined nitrogen.

Elderly were found to excrete significantly less ammonia, uric acid, and undetermined nitrogen as compared to students, but these differences were abolished when the values were considered in relation to total nitrogen except in the case of undetermined nitrogen.

Studies on adult women

As mentioned earlier, studies were carried out simultaneously on adult women to investigate variations in the excretion of nitrogenous constituents in urine with age, plane of nutrition and pregnancy and lactation.

For studies on variations with age (during maturity), the data reported previously for young women(postgraduates aged 20-23 years) were compared with those obtained for women belonging to the professional class, aged 25-38 years and 52-74 years. In the case of women in the low income group data were obtained only for two age groups, namely 19-24 years and 25-38 years.

Variations with the plane of nutrition were investigated by comparing the data obtained on upper class women with those on poor women.

The possibility of changes in pregnancy and lactation was investigated in studies on poor women in Baroda. Additional data were obtained on pregnant and parturient women in Kerala belonging to a similar income group.

In the case of women in the professional class, urine samples were collected for two consecutive days. As the day to day variation in different nitrogenous constituents was not appreciable and was of the order of no more than 15-25%, the values for the two consecutive days are pooled together. In the case of the poor women only 24 h. collections were made.

Creatinine excretion for the different groups are compared in Table 52. In the case of young women the data obtained on creatinine excretion in relation to physical stature, surface area and body weight have been presented earlier. The individual data for the other groups are presented in Table 52a.

The elderly women studied had a greater body weight of 60 kg as against 48 kg in the younger groups. This is probably due in part to sample variation but is consistent with the trend observed in previous studies in this department (Rajalakshmi and Chandrasekharan, 1966). This difference in weight is all the more remarkable, because of the shorter stature of the elderly. It is also interesting to note that in spite of this difference creatinine excretion per unit height was less in elderly.

The two younger groups did not show statistically significant differences from each other with regard to any of the parameters studied, but the elderly women tended to show a diminished excretion of creatinine in both absolute terms and relative to body weight. The differences persist even when the comparisons are made in terms of 'ideal' rather than actual body weight. If the percentage body fat in young women assumed to be of the order of 25 (Keys, 1955; Young et al, 1963) that in the elderly can be expected to be of the order of 40 on the basis of difference in body weights and the expected adiposity of the excess weight.

Table 52 : Comparative data on the urinary excretion of nitrogen and creatinine in different groups of women.

	age (yrs)		age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per day	kg	cm	sq.m.
	1		2	3	4	5	6	7	8	9	10
High Income Group@											
A.	20 - 23 (n = 15)	m	21	48	156	1.44	4.9	727	15.3	4.6	504
		s.e.	0.21	2.0	1.56	0.43	0.26	40	0.69	0.25	23
		cv	4	16	4	8	20	21	18	21	18
B.	25 - 38 (n = 5)	m	32	48	153	1.42	5.0	691	14.6	4.4	495
		s.e.	2.2	3.3	2.2	0.05	0.67	92	2.0	0.63	50
		cv	16	16	3	9	30	30	31	32	28
C.	52 - 74 (n = 6)	m	63	60	150	1.54	3.6*	580	9.6***	3.8	376*
		s.e.	3.3	2.8	1.4	0.03	0.41	75	0.98	0.49	44
		cv	13	11	2	5	28	32	25	31	29
Low Income Group											
D.	19 - 24 (n = 6)	m	22	42	149	1.31	3.8	554	13.2	3.7	419
		s.e.	0.8	2.8	2.2	0.05	0.25	57	0.94	0.33	33
		cv	9	17	4	9	16	25	17	22	19
E.	25 - 38 (n = 16)	m	30	38	148	1.25	4.7	481	13.0	3.3	388
		s.e.	1.0	0.98	0.93	0.02	0.30	40	1.2	0.28	34
		cv	13	10	3	6	26	33	37	33	35

contd...

Table 52 : contd.

1			2	3	4	5	6	7	8	9	10
High Income Group											
A + B	20 - 38 (n = 20)	m	24	48	156	1.43	4.9	718	15.1	4.6	500
		s.e.	1.2	1.7	1.3	0.03	0.25	37	0.69	0.24	22
		cv	22	16	4	8	25	23	20	23	20
Low Income Group											
D + E	19 - 38 (n = 22)	m	28	39	148	1.27	4.5	501[c]	13.0	3.4[b]	396[b]
		s.e.	1.1	1.1	0.87	0.02	0.24	33	0.90	0.22	26
		cv	18	13	3	7	26	31	32	30	31

m - mean; s.e. ~~xx~~ standard error; cv - coefficient of variation.

@ values based on two consecutive days in case of High Income Groups.

values marked with asterisk significantly different from 20-23 years group (HIG) value, p less than 0.05 for *, ~~0.01 for~~ ** and 0.001 for ***.

significantly different from High Income Group)/(A+B) value, p less than 0.01 for b and 0.001 for c.

Table 52a : Individual values for the data of Table 52.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per			
						day	kg	cm	sq.m.
1	2	3	4	5	6	7	8	9	10
B. age 25-38 years (HIG)									
18	33	37	150	1.26	5.6	739	20.0	4.9	586
19	38	56	162	1.58	7.0	925	16.5	5.7	585
20	35	50	152	1.44	5.5	834	16.7	5.5	579
21	25	44	152	1.36	3.4	439	10.0	2.9	322
22	30	52	151	1.46	3.7	517	9.9	2.9	354
mean	32	48	153	1.42	5.0	691	14.6	4.4	485
s.d.	5.0	7.4	4.9	0.12	1.5	207	4.5	1.4	135
range	25-38	37-56	150-162	1.36-1.58	3.4-7.0	439-925	9.9-20.0	2.9-5.7	322-586
C. age 52-74 years (HIG)									
23	67	72	153	1.63	4.7	815	11.3	5.3	500
24	65	64	149	1.58	5.0	707	11.1	4.8	448
25	63	56	148	1.47	3.2	594	10.7	4.0	404
26	55	59	148	1.50	2.6	426	7.2	2.8	284
27	74	55	148	1.47	2.5	313	5.7	2.1	212
28	52	55	156	1.53	3.8	625	11.4	4.0	409
mean	63	60	150	1.54	3.6	580	9.6	3.8	376
s.d.	8.1	6.8	3.4	0.07	1.0	183	2.4	1.2	108
range	52-74	55-72	148-156	1.47-1.63	2.5-5.0	313-815	5.7-11.4	2.1-5.3	212-500

contd...

Table 52a : contd.

1	2	3	4	5	6	7	8	9	10
D. age 19-24 years (LIG)									
29	24	30	139	1.07	4.8	351	11.9	2.5	328
30	22	50	151	1.43	3.6	707	14.1	4.7	494
31	20	41	151	1.31	3.6	582	14.2	3.9	444
32	23	43	150	1.33	3.1	479	11.1	3.2	360
33	19	42	155	1.35	4.2	706	16.8	4.6	523
34	22	46	149	1.37	3.6	499	10.9	3.4	364
mean	22	42	149	1.31	3.8	554	13.2	3.7	419
s.d.	1.9	6.9	5.3	0.12	0.6	139	2.3	0.8	80
range	19-24	30-50	139-155	1.07-1.43	3.1-4.8	351-707	10.9-16.8	2.5-4.7	328-523
E. age 25-38 years (LIG)									
35	26	37	149	1.25	6.8	613	16.8	4.1	490
1 36	25	42	152	1.32	6.0	662	16.0	4.4	503
37	26	36	152	1.25	3.1	308	8.7	2.0	246
38	30	37	143	1.22	4.0	620	16.8	4.4	508
39	30	38	146	1.25	4.8	642	16.9	4.4	514
40	38	45	150	1.36	5.4	380	8.5	2.5	279
41	28	39	150	1.28	3.5	661	17.0	4.4	516
42	35	35	152	1.24	3.8	311	8.8	2.1	251
43	35	44	149	1.34	6.9	455	10.3	3.1	340

contd...

Table 52a : contd.

1	2	3	4	5	6	7	8	9	10
44	32	39	148	1.27	3.3	380	9.7	2.6	299
45	30	39	148	1.26	5.5	561	14.6	3.8	445
46	25	35	140	1.16	3.3	417	11.9	3.0	359
47	30	39	150	1.29	4.1	224	5.7	1.5	174
48	25	31	142	1.10	5.1	675	22.1	4.8	614
49	32	38	146	1.25	4.0	244	6.3	1.7	195
50	28	31	149	1.16	5.7	544	17.4	3.6	469
mean	30	38	148	1.25	4.7	481	13.0	3.3	388
s.d.	4.0	3.9	3.7	0.07	1.2	160	4.8	1.1	136
range	25-38	31-45	140-152	1.1-1.36	3.3-6.9	224-675	5.7-22.1	1.5-4.8	174-516
D + E age 19-38 years									
mean	28	39	148	1.27	4.5	501	13.0	3.4	396
s.d.	5.0	5.1	4.1	0.09	1.2	155	4.2	1.03	122
range	19-38	30-50	134-155	1.1-1.43	3.1-6.9	224-707	5.7-22.1	1.5-4.8	174-614

This figure would be consistent with the value of 40% reported by Keys (1955) and Young et al (1963) for women in the late 50's and 60's. The values for creatinine excretion per kg of lean body mass would work out to 20 mg, 19 mg and 16 mg. Thus, only part of the differences between the elderly and the young would appear to be due to the greater adiposity of the former and the remainder of the variation must be deemed to be due to the lower turnover of creatine. It will be recalled that a similar pattern was found in men. As already pointed out the decreased renal clearance reported in the elderly (Van Pilsum, and Seljeskog, 1958; Hansen et al, 1970; Siersback-Nielsen et al, 1971; Gault and Cockroft, 1975) can not account for this as eventually the creatinine has to find its outlet in urine.

Other studies reporting variations with age in adult women are presented earlier, (See Table 29). The present data are in accord with the same, both with regard to the lack of a difference between the two younger age groups (Young et al, 1963) and an appreciable decline in creatinine excretion in the elderly (Southgate and Durnin, 1970).

As might be expected, the poor women were shorter than upper class women (heights 156 cm and 148 cm) and lighter (weights, 48 kg and 39 kg). They also had a significantly lower excretion of creatinine in absolute terms. The differences persisted to some extent when considered in relation

to body size as judged by height, weight and surface area (Table 53). It will be recalled that similar differences were not found in men belonging to the two groups. This suggests either that the poor women are even more likely to suffer from a low plane of nutrition than poor men or that metabolic adaptations are more efficient in women.

These studies demonstrate that the plane of nutrition may have an impact on creatinine metabolism probably because of an effect on tissue turnover.

As mentioned earlier, pregnancy has been reported to be associated with a decreased excretion of creatinine (Beaton, 1961). This was not found to be the case in previous studies in this laboratory (Subbulakshmi, 1970). In order to rule out the possibility of error because of sample differences, the studies were repeated.

No differences were found with regard to creatinine excretion between women of pregnancy at different stages, post-partum and lactation, when compared with controls either in absolute terms or in relation to body size (Table 54).

Parturient women in Kerala were found to show a larger excretion of creatinine (Tables 55 and 55a) but the difference was not statistically significant and the values for parturient women were highly variable and some of the higher values for parturient women could well have been due to the fact that

Table 53 : Creatinine excretion in poor and upper class men and women in Baroda.

		Income group		$\frac{A}{B}$ x 100
		Low (A)	High (B)	
height (cm)	M	156	170	92
	F	148	156	95
weight (kg)	M	46	50	92
	F	39	48	81
surface area (sq.m.)	M	1.41	1.58	89
	F	1.27	1.43	89
creatinine excretion (mg) :				
per day	M	950	1075	88
	F	501	718	70
per kg	M	21	21	100
	F	13.0	15.1	96
per cm	M	6.1	6.2	98
	F	3.4	4.6	74
per sq.m.	M	676	666	102
	F	396	500	79

M - male; F - female

Table 54 : Urinary excretion of nitrogen and creatinine during pregnancy and lactation*.

group		age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per			
							day	kg	cm	sq.m.
controls@	m	28	39	148	1.27	4.5	501	13	3.4	396
(n = 22)	s.e.	1.10	1.10	0.87	0.02	0.25	33	0.9	0.22	26
	cv	18	13	3	7	26	31	32	30	31
pregnant :										
trimester I	m	24	40	150	1.29	4.9	496	12.8	3.3	388
(n = 28)	s.e.	0.87	0.83	1.00	0.02	0.18	23	0.81	0.16	27
	cv	20	11	4	6	19	25	34	25	37
trimester II	m	23	43	151	1.35	4.3	504	11.5	3.3	368
(n = 55)	s.e.	0.46	0.66	0.70	0.01	0.12	18	0.34	0.10	10
	cv	15	11	3	6	21	26	22	22	21
trimester III	m	24	46	149	1.37	4.1	512	11.2	3.5	375
(n = 57)	s.e.	0.50	0.77	0.62	0.01	0.13	19	0.41	0.13	14
	cv	16	13	3	7	24	28	28	28	28
parturient**	m	24	43	149	1.32	4.9	508	12	3.4	384
(n = 54)	s.e.	0.54	0.68	0.56	0.01	0.15	22	0.52	0.14	16
	cv	17	12	3	6	22	31	32	29	31
6 months	m	25	42	148	1.30	4.8	497	12.2	3.4	384
lactation	s.e.	0.76	0.95	0.64	0.02	0.18	22	0.61	0.15	18
(n = 36)	cv	18	13	3	7	22	27	30	26	27

M - mean, s.e. - standard error, cv - coefficient of variation.

* these studies were done in collaboration with Ila Dave.

@ non-pregnant and non-lactating women.

** within 24-48 hours post-partum.

Table 55 : Comparative data on urinary excretion of nitrogen and creatinine in pregnant and parturient women in Kerala.

group		age (yrs)	weight (kg)	total nitrogen (g)	creatinine (mg) excretion per day	creatinine (mg) excretion per kg
non-pregnant non-lactating (n = 6)	m	31	38	3.7	466	12.6
	s.e.	2.45	2.80	0.73	61	1.76
	cv	22	18	49	32	34
pregnant :						
trimester III (n = 13)	m	24*	46*	2.4	482	10.7
	s.e.	1.10	1.40	0.31	32	0.80
	cv	16	11	46	24	27
parturient@ (n = 8)	m	22**	44	5.4	637	14.6
	s.e.	1.00	1.50	0.88	88	2.00
	cv	13	9	46	39	38

M - mean, s.e. standard error, cv - coefficient of variation.

@ within 24-48 h post partum.

values marked with asterisk significantly different from non-pregnant and non-lactating women values, p less than 0.05 for *, 0.01 for **.

Table 55a : Individual values for the data of Table 55.

subject no.	age (yrs)	weight (kg)	total nitrogen (g)	creatinine (mg) excretion per	
				day	kg
1	2	3	4	5	6
non-pregnant and non-lactating					
69	35	31	3.6	320	10.4
70	23	45	2.1	250	5.5
71	30	35	2.7	483	13.8
72	28	39	7.3	609	15.6
73	40	31	3.3	541	17.7
74	28	47	3.3	594	12.8
mean	31	38	3.7	466	12.6
s.d.	6.0	6.9	1.8	149	4.3
range	23-40	31-47	2.1-7.3	250-609	5.5-17.7
pregnant :					
trimester III					
75	19	46	5.1	549	12.1
76	22	42	1.5	333	7.9
77	24	53	2.7	581	11.0
78	26	45	1.1	306	6.8
79	26	37	2.5	521	14.1
80	27	45	3.1	540	12.1

contd...

Table 55a : contd.

1	2	3	4	5	6
81	30	47	2.1	403	8.7
82	25	55	1.5	354	6.4
83	18	47	2.1	589	12.5
84	23	45	2.5	546	12.3
85	19	48	2.3	627	13.1
86	24	46	1.4	346	7.6
87	30	38	3.1	567	15.1
mean	24	46	2.4	482	10.7
s.d.	3.9	5.1	1.1	114	2.9
range	18-30	37-55	1.1-5.1	306-627	6.4-15.1
parturient					
88	19	43	6.7	1090	25.3
89	19	43	5.1	634	14.8
90	23	39	2.4	394	10.1
91	23	45	10.8	860	18.1
92	22	50	4.7	693	13.9
93	28	42	5.6	710	16.9
94	22	49	3.9	415	8.6
95	22	39	4.1	345	8.9
mean	22	44	5.4	637	14.6
s.d.	2.8	4.1	2.5	250	5.6
range	19-28	39-50	3.9-108	345-1090	8.6-25.3

pregnant women and controls were taken from the outpatient ward and parturient women from the hospital where they were provided generous quantities of fish. Most women took this diet, but a few took a light diet (the fever diet) because of cultural moves against the consumption of regular diet. This might account for the high variability in this group.

A number of studies have been carried out in Hyderabad on pregnant and parturient women (Table 56). The values obtained in the present studies for pregnant women in the last trimester compare with those of Rao and Rao(1974). It is also relevant to point out that Blackburn and Calloway (1974) obtained a value not different from the range of values reported for women in the West, presumably, non-pregnant and non-lactating women (19-20 mg per kg of body weight). Certainly the data do not suggest a decreased excretion of creatinine during pregnancy.

The comparative data on nitrogenous constituents in urine both in absolute and relative terms for the different groups are shown in Table 57. The individual values in absolute terms for the different groups are shown in Table 57a.

The most significant features that emerge from comparison of young and elderly women in the upper class are decreased excretion of total nitrogen associated with decrease in urea, creatinine and undetermined nitrogen. The decrease in total nitrogen could not be accounted for by differences in intakes

Table 56 : Values reported for creatinine excretion in pregnant, parturient* and lactating women.

	weight (kg)	creatinine (mg) excretion per	
		day	kg
		pregnant women	
present report :			
trimester I	40	496	12.8
trimester II	43	504	11.5
trimester III	46	512	11.2
Rao and Rao (1974)			
trimester I	40	620	15.5
trimester II	48	694	14.5
trimester III	45	569	12.6
Reddy (1964)			
trimester III	46	720	15.8
		parturient women*	
present report :	43	508	12.0
Reddy (1964)	42	792	18.7
		lactating women	
present report	42	497	12.2
Dakshayani and Ramamurthy (1964) :			
within 10 days of lactation	46	786	17.0
11 days to 3 months of lactation	42	588	14.0
3 to 6 months of lactation	43	750	17.4
Blackburn and Calloway (1974)			
pregnant : trimester III	68	1320	20.0

* Studied after partus.

Table 57 : Comparative data on the urinary excretion of nitrogenous constituents in women in Baroda.

	total nitrogen (g)	nitrogen (g) excreted as					
		urea	ammonia	urea + ammonia	creati-nine	uric acid	undeter-mined
1	2	3	4	5	6	7	8
High Income group							
young women (20-38 yrs) (n = 20)							
m	5.0	3.3	0.29	3.6	0.27	0.09	1.08
s.e.	0.24	0.75	0.02	0.17	0.01	0.006	0.1
cv	23	23	28	20	22	28	40
elderly women (52-74 yrs) (n = 6)							
m	3.6*	2.5	0.29	2.8	0.22	0;07	0.50***
s.e.	0.41	0.32	0.07	0.36	0.03	0.01	0.06
cv	28	31	59	31	33	43	30
Low Income group							
young women (20-35 yrs) (n = 7)							
m	4.2	2.5	0.26	2.8	0.20	0.08	1.13
s.e.	0.45	0.37	0.02	0.39	0.02	0.01	0.25
cv	29	40	15	37	20	38	59

contd...

Table 57 : contd.

1	2	3	4	5	6	7	8
		% contribution to urinary nitrogen					
High Income group :							
young women (20-38 yrs) (n = 20)							
	m	67	6.0	73	5.5	1.8	20
	s.e.	1.4	0.37	1.5	0.29	0.07	1.5
	cv	9	27	9	23	18	34
elderly women (52 - 74 yrs) (n = 6)							
	m	70	7.7	77	5.9	1.9	14.3*
	s.e.	1.7	1.6	1.6	0.32	0.15	1.7
	cv	6	51	5	14	20	29
Low Income group :							
young women (20-35 yrs) (n = 7)							
	m	60	6.3	66	5.2	2.1	27
	s.e.	4.7	0.48	4.8	0.69	0.25	4.9
	cv	19	19	18	33	30	44

M - mean; s.e. - standard error; cv - coefficient of variation.
values marked with asterisk significantly different from young women (HIG) values, p less than 0.05 for * and 0.001 for ***.

Table 57a : Individual values for the data of Table 57.

subject no.	total nitrogen (g)	nitrogen (g) excreted as					
		urea	ammonia	urea + ammonia	uric acid	creatinine	undetermined
1	2	3	4	5	6	7	8
A. High Income group postgraduates (20-23 yrs)							
1	5.0	3.3	0.35	3.6	0.09	0.27	1.1
2	3.3	2.3	0.20	2.5	0.05	0.20	0.6
3	5.2	3.5	0.24	3.7	0.11	0.33	1.0
4	4.2	2.8	0.22	3.0	0.09	0.29	0.8
5	5.7	3.9	0.43	4.3	0.11	0.34	0.9
6	5.6	3.8	0.33	4.1	0.08	0.30	1.1
7	7.2	4.4	0.32	4.7	0.08	0.21	2.2
8	5.6	4.2	0.20	4.4	0.10	0.21	0.9
9	5.9	3.3	0.29	3.6	0.13	0.36	1.8
10	3.5	2.1	-	-	-	0.23	-
11	3.6	2.5	0.22	2.7	0.04	0.24	0.5
12	4.3	2.6	0.28	2.9	0.11	0.37	0.9
13	5.3	3.4	0.32	3.7	0.10	0.25	1.2
14	5.1	3.4	0.22	3.6	0.08	0.20	1.2
15	4.6	2.7	0.24	2.9	0.08	0.26	1.4
mean	4.9	3.2	0.28	3.6	0.09	0.27	1.1
s.d.	1.05	0.7	0.07	0.7	0.02	0.06	0.44
range	3.3-7.2	2.1-4.4	0.20-0.43	2.5-4.7	0.04-0.13	0.19-0.37	0.5-1.8

contd...

Table 57a : contd.

1	2	3	4	5	6	7	8
B. High Income group							
young women (25-38 yrs)							
18	5.6	3.9	0.39	4.2	0.11	0.27	1.0
19	7.0	5.0	0.29	5.3	0.13	0.34	1.3
20	5.5	3.4	0.45	3.9	0.10	0.31	1.2
21	3.4	2.7	0.34	3.0	0.06	0.16	0.1
22	3.7	2.8	0.25	3.1	0.07	0.19	0.4
mean	5.0	3.6	0.35	3.9	0.09	0.26	0.79
s.d.	1.5	0.9	0.08	0.93	0.03	0.08	0.53
range	3.4-7.0	2.7-5.0	0.25-0.45	3.0-5.3	0.06-0.13	0.16-0.34	0.1-1.3
A + B mean	5.0	3.3	0.29	3.64	0.09	0.27	1.08
s.d.	1.13	0.75	0.08	0.74	0.025	0.06	0.43
range	3.3-722	2.1-5.0	0.20-0.45	2.5-5.3	0.04-0.13	0.16-0.37	0.1-1.8
High Income group							
elderly women (52-74 yrs)							
23	4.7	3.5	0.22	3.7	0.12	0.30	0.56
24	5.0	3.5	0.54	4.0	0.08	0.26	0.57
25	3.2	2.2	0.44	2.6	0.05	0.22	0.33
26	2.6	1.8	0.11	1.9	0.05	0.16	0.54
27	2.5	1.9	0.13	2.0	0.04	0.12	0.32
28	3.8	2.5	0.30	2.8	0.07	0.23	0.70
mean	3.6	2.5	0.29	2.8	0.07	0.22	0.50
s.d.	1.0	0.78	0.17	0.88	0.03	0.07	0.15
range	2.5-5.0	1.8-3.5	0.11-0.54	1.9-4.0	0.04-0.12	0.12-0.30	0.32-0.70

contd...

Table 57a : contd.

1	2	3	4	5	6	7	8
Low Income group							
young women (20-35 yrs)							
51	5.7	2.8	0.29	3.1	0.13	0.20	2.2
52	5.5	3.2	0.33	3.5	0.12	0.23	1.7
53	3.1	1.9	0.22	2.1	0.09	0.24	0.6
54	3.2	1.7	0.27	2.0	0.08	0.23	0.9
55	3.4	2.0	0.21	2.2	0.06	0.15	1.0
56	5.2	4.4	0.28	4.7	0.05	0.23	0.2
57	3.5	1.8	0.22	2.0	0.05	0.15	1.3
mean	4.2	2.5	0.26	2.8	0.08	0.20	1.13
s.d.	1.2	0.99	0.04	1.03	0.03	0.04	0.67
range	3.1-5.7	1.7-3.9	0.21-0.33	2.0-4.7	0.05-0.13	0.15-0.24	0.2-2.2

as the protein content of the diets appeared to be practically identical on the basis of careful records of food intake. This difference is perhaps accounted for by greater endogenous losses of nitrogen through the fecal route or decreased digestibility of food nitrogen. It will be recalled that similar findings were made in the case of men. Southgate and Durnin (1970) have found similar differences in men but not in women.

Although the absolute values for urea, creatinine and undetermined nitrogen were less, the contributions to total nitrogen except in the case of undetermined nitrogen were comparable. An essentially similar picture is derived from the data of Southgate and Durnin (1970).

When young women in the high and low income groups are compared, differences in favour of the High Income group are observed in the case of total nitrogen, urea and creatinine. The differences in the latter two do not persist when considered in terms of percentage contribution to total nitrogen. The differences in total nitrogen are not entirely accounted for by differences in food nitrogen on the basis of estimates of protein and nitrogen intakes made from diet records of two consecutive days. Nitrogen intake was estimated to be of the order of 6.8 g in young women, about 6.0 g in elderly women and about 5.6 g in poor women. This would involve an excretion in urine of apparently 74, 50 and 73% of nitrogen ingested. Differences in digestibility could

perhaps account for atleast part of this difference. In upper class diets 35-50% of total protein is derived from milk whereas this figure is 5% in poor diets. In balance studies carried out previously in this laboratory on # pregnant women over a five day period fecal losses were found to be of the order of 20%.

Undetermined nitrogen is believed to be present in components such as hippuric acid, purines other than uric acid, hydroxy-proline, vitamins, other amino sugars etc. (Altman and Dittmer, 1974). A reduction in the excretion of the same in the elderly may perhaps represent a decreased turnover of these components. The reverse phenomenon is suggested by the studies of Southgate and Durnin (1970). But these subjects were on much higher intakes of nitrogen (about 13 g). Further studies are needed to resolve this anomaly.

The coefficient of variation tended to be higher in this case of undetermined nitrogen and ammonia. The variability was reduced when urea and ammonia were considered together. In general a greater variability was found in the low income group. This could be due to the smaller number of subjects or genuine differences in adaptation to a low plane of nutrition.

Data on nitrogen and creatinine excretion in pregnant and parturient women and women in established lactation are shown in Table 54. In other studies in this depaftment no appreciable

differences in calorie or protein intakes were found between similar groups of subjects (Rajalakshmi and Ramakrishnan, 1969b). All these findings are consistent with those of others such as Oomen and Malcolm (1958) in New Guinea and Whitehead in Gambia (personal communication) (Table 58).

If anything, pregnancy may be expected to be associated with increased rather than decreased intakes. It is therefore interesting to observe the decrease in nitrogen excretion with the progress of pregnancy. This is consistent with reports of reduced endogenous losses of nitrogen during pregnancy and a more efficient utilization of protein (Beaton, 1961), calcium (Spray, 1950; Beaton, 1961) and iron (Balfour et al, 1942; Hahn et al, 1957; Beaton, 1961; NRL, 1968). Although the difference in nitrogen excretion was not statistically significant the number of values below 3.5 g was much greater in pregnancy (Table 59).

As mentioned earlier decrease in creatinine excretion was observed with the progress of pregnancy. This was consistent with previous studies in this laboratory but contrary to the report of Beaton (1961). A frequency distribution (Table 60), however, suggested a significant increase in the number of both low and high values. This may represent two different types of responses and the conditions under which they take place need to be identified.

Table 58 : Calorie and protein intakes during pregnancy and lactation (Rajalakshmi, 1971).

	Calories	Protein(g)
	pregnant women	
poor Indian women :		
Rajalakshmi and Ramakrishnan (1969a)	1570	38
Sengupta and Bagchi (1961)	1680	41
Shankar, 1962		
trimester I	1390	40
trimester II	1520	
trimester III	1650	
Venkatachalam (1962)	1408	38
other countries :		
Goldsmith (New Foundland) (1950)	1302	44
Oomen and Malcolm (New Guinea) (1958)	1360	21
poor Indian women :	lactating women	
Rajalakshmi and Ramakrishnan (1969b)	1620	40
Sengupta and Bagchi (1961)	1723	42
Sallan and Puri (1962)	1703	51
upper class women :		
Rajalakshmi and Ramakrishnan (1969b)	2020	49

Table 59 : Frequency distribution for the urinary excretion of nitrogen in different groups in Baroda.

	nitrogen (g) per day			
	< 3.4	3.5 - 4.9	> 5.0	total
non-pregnant non-lactating	5 (22)	10 (43)	8 (35)	23 (100)
pregnant :				
trimester I	1 (4)	14 (50)	13 (46)	28 (100)
trimester II	12 (22)	32 (58)	11 (20)	55 (100)
trimester III	18 (32)	31 (54)	8 (14)	57 (100)
parturient*	5 (10)	27 (54)	18 (36)	50 (100)
6 month lactation	3 (8)	22 (61)	11 (31)	36 (100)
total	44	136	69	249

* within 24-48 h post-partum.

figures in parentheses are percentages in each group.

Table 60 : Frequency distribution for the urinary excretion of creatinine in different groups in Baroda.

	creatinine (mg) excretion per day			
	< 400	400-600	> 600	total
non-pregnant non-lactating	7 (29)	7 (29)	10 (42)	24 (100)
pregnant :				
trimester I	4 (14)	19 (68)	5 (18)	28 (100)
trimester II	7 (13)	41 (74)	7 (13)	55 (100)
trimester III	15 (26)	26 (46)	16 (28)	57 (100)
parturient*	17 (32)	19 (35)	18 (33)	54 (100)
6 months of lactation	8 (23)	17 (48)	10 (29)	35 (100)
total	58	129	66	253

* within 24-48 h postpartum.

figures in parentheses are percentages in each groups.

No differences from controls were found in either parturient or lactating women but in both, nitrogen excretions were significantly more than in late pregnancy. Also, the proportion of high values tended to be greater. This is consistent with the weight loss occurring in some individuals soon after delivery and reports of negative nitrogen balance during pregnancy (Jayalakshmi, Venkatachalam and Gopalan, 1959).

In contrast to the situation in women, collateral studies on rats suggest a similar increased efficiency of nitrogen utilization not only during pregnancy but also during lactation. Such continued adaptation may be a physiological necessity in view of the greater stress imposed by pregnancy and lactation in rats (Rajalakshmi and Ramakrishnan, 1969c) (Table 61).

A similar pattern was observed in Kerala during pregnancy, the decrease in nitrogen excretion being even more marked. But the pattern in parturient women was different, increases being found in both nitrogen and creatinine excretion. As already pointed out this is believed to be due to the greater amounts of fish and therefore of protein and creatinine in the hospital diet.

The data on the excretion of various nitrogenous constituents on pregnant and parturient women are presented in Tables 62 and the individual data for the same in Table 62a.

Table 61 : The nutritional stress of reproduction in rat and woman (Rajalakshmi and Ramakrishnan, 1969c).

	rat	woman
body weight (kg)	0.2 - 0.3	45 - 50
days of :		
gestation	21	270
lactation	21	180
weight (g) of ~~pregnancy~~ progeny :		
at birth	35 - 40	3500
at weaning	300 - 400	7000 - 8000
tissue (g) produced per day :		
prenatal	1.8 - 2.0	13
neonatal	12 - 14	20 - 22
tissue produced per day as percent of maternal weight :		
prenatal	1	0.027
neonatal	4 - 5	0.040

Table 62 : Urinary excretion of nitrogenous constituents in pregnant and parturient women in Kerala.

		total nitrogen (g)	nitrogen (g) excreted as					
			urea	ammonia	urea + ammonia	creati-nine	uric acid	undeter-mined
1		2	3	4	5	6	7	8
non-pregnant and non-lactating (n = 6)	m	3.7	2.3	0.35	2.7	0.17	0.09	0.78
	s.e.	0.73	0.57	0.08	0.57	0.02	0.01	0.2
	cv	49	61	58	52	35	22	67
pregnant : (n = 13)								
trimester III	m	2.4	1.5	0.21	1.7	0.18	0.11	0.45
	s.e.	0.31	0.24	0.03	0.26	0.01	0.01	0.04
	cv	46	56	59	55	22	28	34
parturient@ (n = 8)	m	5.4	3.7	0.37	4.0	0.24	0.18*	0.95
	s.e.	0.88	0.67	0.05	0.67	0.03	0.03	0.2
	cv	46	51	35	48	38	44	62

contd...

Table 62 : contd.

1	2	3	4	5	6	7	8
		% contribution to urinary nitrogen					
non-pregnant and non-lactating (n = 6)	m	62	10	72	5.0	2.8	20.3
	s.e.	4.30	2.40	4.00	0.65	0.39	3.90
	cv	17	59	14	32	34	47
pregnant : (n = 13)							
trimester III							
	m	60	8.5	68	8.1**	4.9***	19
	s.e.	2.10	0.83	1.90	0.50	0.33	1.60
	cv	13	35	10	22	25	31
parturient@ (n = 8)	m	67	7.3	74	4.6	3.4	17.7
	s.e.	2.80	0.92	3.10	0.42	0.21	2.70
	cv	12	36	12	26	18	43

m - mean, s.e. - standard error, cv - coefficient of variation.

@ within 24-48 h postpartum.

values marked with asterisk significantly different from control values, p less than 0.05 for *, 0.01 for ** and 0.001 for ***.

Table 62a : Individual values for the data of Table 62.

	total nitrogen (g)	nitrogen (g) excreted as					
		urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
1	2	3	4	5	6	7	8
non-pregnant and non-lactating							
69	3.6	1.7	0.69	2.3	0.12	0.11	1.0
70	2.1	1.4	0.17	1.6	0.09	0.08	0.38
71	2.7	1.8	0.45	2.3	0.18	0.06	0.24
72	7.3	5.1	0.39	5.5	0.23	0.09	1.56
73	3.3	1.7	0.19	1.9	0.20	0.11	1.1
74	3.3	2.4	0.19	2.6	0.22	0.12	0.39
mean	3.7	2.3	0.35	2.68	0.17	0.09	0.78
s.d.	1.8	1.4	0.20	1.4	0.06	0.02	0.52
range	2.1-7.3	1.4-5.1	0.17-0.69	1.6-5.5	0.09-0.23	0.06-0.12	0.38-1.56
pregnant :							
trimester III							
75	5.1	3.8	0.47	4.3	0.20	0.16	0.46
76	1.5	0.9	0.10	1.0	0.12	0.09	0.25
77	2.7	1.8	0.09	1.9	0.22	0.16	0.45
78	1.1	0.7	0.06	0.8	0.11	0.08	0.11
79	2.5	1.5	0.28	1.8	0.19	0.11	0.39
80	3.1	1.9	0.23	2.2	0.20	0.13	0.64

contd...

Table 62a : contd.

1	2	3	4	5	6	7	8
81	2.1	1.2	0.18	1.4	0.15	0.10	0.48
82	1.5	0.8	0.08	0.9	0.13	0.06	0.37
83	2.1	1.0	0.22	1.2	0.22	0.12	0.63
84	2.5	1.5	0.17	1.6	0.20	0.10	0.58
85	2.3	1.2	0.31	1.5	0.23	0.11	0.49
86	1.4	-	0.18	-	0.13	0.08	-
87	3.1	2.0	0.31	2.3	0.21	0.12	0.51
mean	2.4	1.5	0.21	1.7	0.18	0.11	0.45
s.d.	1.1	0.9	0.12	0.94	0.04	0.03	0.15
range	1.1-5.1	0.8-3.8)	0.06-0.47	0.8-4.3)	0.11-0.23	0.06-0.16	0.11-0.63
parturient :							
88	6.7	4.0	0.45	4.4	0.40	0.29	1.5
89	5.1	4.1	0.39	4.5	0.24	0.17	0.20
90	2.4	1.4	0.18	1.6	0.15	0.09	0.60
91	10.8	7.8	0.48	8.2	0.30	0.29	2.0
92	4.7	2.7	0.37	3.1	0.26	0.18	1.2
93	5.6	3.9	0.36	4.3	0.26	0.21	0.90
94	3.9	2.7	0.19	2.9	0.15	0.12	0.80
95	4.1	2.9	0.53	3.4	0.13	0.10	0.50
mean	5.4	3.97	0.37	4.0	0.24	0.18	0.95
s.d.	2.5	1.9	0.13	1.9	0.09	0.08	0.59
range	2.4-10.8	1.4-7.8	0.18-0.53	1.6-8.2	0.13-0.40	0.09-0.29	0.2-2.0

No significant differences were found in any of the nitrogenous constituents studied in pregnant women in Baroda either in absolute terms or in relation to total nitrogen as compared to controls except in the case of ammonia nitrogen (Tables 63 and 63a). Even this differences with regard to ammonia nitrogen was not found in the studies carried out in Kerala.

In conclusion, these studies suggested a decreased excretion of total nitrogen, creatinine and undetermined nitrogen in the elderly, a decrease in creatinine excretion in poor women, and a decrease in nitrogen excretion in pregnancy. The patterns in parturient and lactating women are not clear cut. On the whole, the percentage contribution of various nitrogenous constituents does not seem to be affected.

Table 63 : Urinary excretion of nitrogenous constituents in poor pregnant women in Baroda.

		total nitrogen (g)	nitrogen (g) excreted as					
			urea	ammonia	urea + ammonia	creati-nine	uric acid	undeter-mined
1		2	3	4	5	6	7	8
non-pregnant and non-lactating (n = 7)	m	4.2	2.5	0.26	2.8	0.20	0.08	1.13
	s.e.	0.45	0.37	0.02	0.39	0.02	0.01	0.25
	cv	29	40	15	37	20	38	59
pregnant : (n = 11) trimester III	m	3.9	2.6	0.36*	2.9	0.19	0.07	0.86
	s.e.	0.39	0.27	0.04	0.30	0.01	0.005	0.12
	cv	33	32	33	32	21	29	45

contd...

Table 63 : contd.

1	2	3	4	5	6	7	8
		% contribution to urinary nitrogen					
non-pregnant and non-lactating (n = 7)	m	60	6.3	66	5.2	2.1	27
	s.e.	4.3	0.44	4.4	0.64	0.23	4.5
	cv	19	19	18	33	30	44
pregnant : (n = 11)							
trimester III	m	63	9.0*	72	5.1	2.1	20.3
	s.e.	1.0	0.66	1.14	0.51	0.14	1.6
	cv	5	23	5	33	22	25

m- mean; s.e. - standard error, cv - coefficient of vafiation.
values marked with asterisk significantly different from non-pregnant and non-lactating women, p less than 0.05 for *.

Table 63a : Individual values for the data* of Table 63.

	total nitrogen (g)	nitrogen (g) excreted as					
		urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
pregnant : trimester III.							
58	4.8	3.1	0.43	3.5	0.20	0.08	0.99
59	5.5	3.6	0.49	4.1	0.26	0.08	1.1
60	6.0	3.7	0.49	4.2	0.17	0.10	1.5
61	4.4	2.9	0.23	3.1	0.21	0.08	0.98
62	5.0	3.2	0.47	3.7	0.22	0.07	1.0
63	2.2	1.4	0.18	1.6	0.12	0.06	0.45
64	3.7	2.1	0.35	2.5	0.16	0.07	1.0
65	2.8	1.9	0.22	2.1	0.19	0.07	0.43
66	2.7	-	-	-	0.13	0.06	-
67	3.9	2.3	0.40	2.7	0.21	0.10	0.88
68	2.3	1.5	0.31	1.8	0.21	0.06	0.22
mean	3.9	2.6	0.36	2.9	0.19	0.07	0.86
s.d.	1.3	0.84	0.12	0.94	0.04	0.02	0.39
range	2.2-6.0	1.4-3.7	0.18-0.49	1.6-4.2	0.12-0.26	0.06-0.10	0.22-1.5

* for the data of non-pregnant and non-lactating women, see Table 57a.

Studies on children and adolescents

As mentioned earlier, the studies on variations in the excretion of creatinine and other nitrogenous constituents in urine in relation to age, sex and plane of nutrition were extended to the growth period. Groups of boys and girls aged 4-7, 8-10, 11-12, and 13-to 15 years in the low and high income groups in urban Baroda were investigated. However, it was not possible to investigate 8-10 years old boys in the high income group due to the intervention of the vacation at the time of the studies. Additional data were obtained on boys and girls in urban Trivandrum (Kerala) belonging to the low income group.

The subjects were pupils in one or other of the local schools and investigated with the co-operation of the school authorities and the parents.

As mentioned earlier, 4 or 6 h. collections of urine were made in the case of 4-7 and 8-10 years old and 24 h. collections in the case of the rests. In two groups (11-12 and 13-15 years old boys in the low income group, Baroda) the collections were made over 3 consecutive days. These variations were necessitated by the exigencies of situation.

The heights and weights of the subjects investigated as compared to local norms are shown in Table 64.

Table 64 : Weights and heights of boys and girls in the low and high income group.

age group (yrs)	age (yrs)		weight (kg)		height (cm)		% local norms *				weight as % of Boston norms	
							weight		height			
	M	F	M	F	M	F	M	F	M	F	M	F
Low Income group												
4 - 7	5.5	5.6	14.0	13.9	100	101	100	103	101	102	70	70
8 - 10	9.4	9.1	19.9	19.1	121	120	99	101	103	104	64	65
11 - 12	11.6	12.3	22.3	24.2	128	131	93	93	101	100	60	58
13 - 15	13.5	14.5	27.4	32.9	140	143	93	94	101	100	60	66
High Income group												
4 - 7	6.0	5.5	20.3	18.0	115	113	112	105	104	101	94	91
8 - 10	-	10.0	-	27.2	-	136	-	100	-	101	-	85
11 - 12	11.9	11.9	32.3	31.1	137	142	108	99	99	98	85	79
13 - 15	14.5	14.4	40.3	41.9	155	155	101	102	102	102	79	85

M, male; F, female.

* for the respective income group.

It was realized in retrospect only at the time of presenting the thesis that some of the groups did not form representative samples with regard to weight.

In particular, the older children in the low income group showed more growth retardation than may be expected on the basis of local norms. The 4-7 and 11-12 years old boys in the high income group on the other hand, seemed to have a bigger body build than is generally the case. These differences make it very difficult to interpret the data and any suggestions which are ventured must be considered extremely tentative. When the physical stature of the different groups is compared to adult stature, it is found that girls approached the adult values at a faster rate than boys in both low and high income groups. But in both sexes adult values were reached at a slower rate in the low income group.

It was not possible to get detailed data on dietary intakes of the subjects studied in the present investigation. However, data have been obtained previously in this laboratory for similar groups of subjects and the same are shown in Tables 65 and 66.

The comparative data on creatinine excretion for different groups are presented in Tables 67 and 68 and individual data for the same are shown in Tables 69 and 70. In general, the

Table 65 : Dietary intakes of school boys and adolescents (Rajalakshmi, 1975).

age (yrs)	height (cm)	weight (kg)	consumption (g) per capita per day						
			cereals	pulses	leafy vege-tables	root and other vege-tables	sugar and jaggery	milk	fats and oils
School boys									
rural poor									
6 - 12	106-134	15-25	230	20	5	50-60	15	56	15
urban UPPER ~~poor~~ class									
6 - 12	112-136	18-27	225	45	10	150	30	300	30
10 - 13	126-150	26-40	225	65	5	150	30	350	50
Adolescents									
rural poor									
13 - 15	132-145	24-30	360	15	9	60	5	25	7
urban UPPER ~~poor~~ class									
13 - 15	134-166	24-56	250	70	5	200	30	350	60
15 - 17	168-174	55-62	350	75	5	200	30	350	75

Table 66 : Nutrients provided by the diets of school boys and adolescents (Rajalakshmi, 1975).

age (yrs)	amount per day						
	Calories	protein (g)	calcium (mg)	iron (mg)	carotene + vitamin A (µg)	thiamin (mg)	ribo-flavin (mg)
School boys							
rural poor							
6 - 12	1150	31	220	17	480 + 15	0.7	0.80
urban UPPER ~~poor~~ class							
6 - 12	1720	46	800	23	680 + 90	1.1	1.00
10 - 12	1900	50	855	20	570 + 160	1.3	1.10
Adolescents							
rural poor							
13 - 16	1400	46	166	25	680 + 11	1.6	0.50
urban UPPER ~~poor~~ class							
13 - 15	2150	54	910	25	670 + 160	1.6	1.2
15 - 17	2660	65	950	32	740 + 160	2.0	1.3

Table 67 : Urinary excretion of nitrogen and creatinine in boys in relation to socio-economic status.

age (yrs)		age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per			
							day	kg	cm	sq.m.
1		2	3	4	5	6	7	8	9	10
Low Income group (Baroda)										
4 - 7 (n = 21)	M	5.5	14	100	0.62	2.7	197	13.8	1.9	311
	s.e.	0.27	0.52	1.8	0.02	0.24	17	0.85	0.14	20
	cv	23	17	8	13	41	39	28	33	30
8 - 10 (n = 11)	M	9.5	20	121	0.83	3.9	329	16.5	2.7	395
	s.e.	0.30	0.80	2.1	0.02	0.24	21	0.74	0.15	19
	cv	10	13	6	9	21	22	15	18.5	16
11 - 12* (n = 14)	M	11.6	22	128	0.90	3.6	351	16.1	2.8	393
	s.e.	0.12	0.94	2.0	0.03	0.24	13	0.59	0.14	13
	cv	4	16	6	11	25	13	13	18	12
13 - 15* (n = 15)	M	13.5	27	140	1.05	4.8	443	15.8	3.1	426
	s.e.	0.19	1.10	2.0	0.03	0.36	38	0.85	0.23	26
	cv	16	15	6	10	29	33	21	29	23
Trivandrum										
13 - 15 (n = 16)	M	14.0	28	140	1.06	3.9	629	22.8	4.5	597
	s.e.	0.20	1.50	2.1	0.04	0.31	39	1.50	0.26	37
	cv	5	21	6	13	31	24	26	22	24

contd..

Table 67 : contd.

1		2	3	4	5	6	7	8	9	10
High Income group (Baroda)										
4-7 (n=10)	M	6.0	20	115	0.80	4.3	339	16.8	3.0	422
	s.e.	0.18	0.63	0.9	0.01	0.26	25	1.20	0.22	31
	cv	10	10	2	5	19	23	23	23	23
11-12 (h=6)	M	11.9	32	137	1.10	5.1	428	13.4	3.1	389
	s.e.	0.20	2.40	4.1	0.06	0.22	ø,24	0.67	0.12	14
	cv	4	18	8	13	11	14	12	9	9
13-15 (n=15)	M	14.5	40	155	1.33	5.8	749	18.8	4.8	563
	s.e.	0.23	1.90	2.7	0.04	0.46	42	0.95	0.25	27
	cv	6	18	7	13	31	22	20	20	19

M, mean; s.e. - standard error; cv - coefficient of variation.

* mean values based on values for 3 consecutive days.

Table 68 : Urinary excretion of nitrogen and creatinine in girls in relation to socioeconomic status.

age (yrs)		age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per			
							day	kg	cm	sq.m.
1		2	3	4	5	6	7	8	9	10
Low Income group (Baroda)										
4-7 (n=32)	M	5.6	14	101	0.62	2.2	174	12.6	1.7	276
	s.e.	0.21	0.38	1.4	0.01	0.15	11	0.75	0.11	17
	cv	22	15	8	11	38	36	33	35	33
8-10 (n=10)	M	9.1	19	120	0.81	3.0(8)	280	14.7	2.3	346
	s.e.	0.27	0.82	2.0	0.02	0.38	16	0.62	0.11	14
	cv	9	14	5	9	36	18	13	16	13
11-12 (n=20)	M	12.3	24	131	0.94	4.0(12)	361	15.0	2.8	388
	s.e.	0.11	0.83	1.4	0.02	0.24	23	0.88	0.16	21
	cv	4	16	5	10	21	29	26	26	25
13-15 (n =20)	M	14.5	33	143	1.15	3.9(10)	409	12.7	2.9	356
	s.e.	0.22	1.72	2.1	0.04	0.35	19	0.49	0.11	12
	cv	7	23	7	15	28	21	17	18	15
Trivandrum										
13-15 (n=16)	M	14.0	34	144	1.18	3.2	478	13.9	3.3	400
	s.e.	0.20	1.60	1.9	0.04	0.30	43	1.00	0.28	31
	cv	6	19	5	12	38	36	30	33	31

contd..

Table 68 : contd.

1		2	3	4	5	6	7	8	9	10
High Income group (Baroda)										
4-7 (n=4)	M	5.5	18	113	0.76	3.4	199	11.0	1.8	264
	s.e.	0.13	1.10	2.7	0.03	0.46	37	1.90	0.31	46
	cv	4	12	5	8	26	37	35	36	35
8-10 (n=14)	M	10.0	27	136	1.03	3.3	372	14.1	2.8	363
	s.e.	0.17	1.80	2.4	0.04	0.22	25	0.96	0.20	20
	cv	6	25	7	15	25	25	26	27	20
11-12 (n=21)	M	11.9	31	142	1.12	3.7	485	15.6	3.4	429
	s.e.	0.13	1.20	2.7	0.03	0.20	30	0.72	0.17	21
	cv	5	18	6	11	25	28	21	24	22
13-15 (n=29)	M	14.4	42	155	1.35	4.5	624	152	4.0	466
	s.e.	0.16	1.40	1.1	0.02	0.31	28	0.67	0.17	20
	cv	6	18	4	10	37	25	24	24	23

M, mean; s.e. - standard error; cv - coefficient of variation.
values in parentheses are the number of subjects.

Table 68a : Significance of differences between means of groups in Tables 67 and 68. (boys vs girls and LIG vs HIG).

age groups (years)	creatinine excretion per day	kg	cm	sq.m.	day	kg	cm	sq.m.
	p* less than							
Baroda	**Low Income Group (LIG)**			**Boys vs Girls**	**High Income Groups (HIG)**			
4 - 7	N.S.	N.S.	N.S.	N.S.	0.001	0.05	0.01	0.01
8 - 10	N.S.	N.S.	N.S.	N.S.	-	-	-	-
11 - 12	N.S.	N.S.	N.S.	N.S.	N.S.	0.05	N.S.	N.S.
13 - 15	N.S.	0.01	N.S.	N.S.	0.05	0.01	0.05	0.01
Trivandrum								
13 - 15	0.05	0.001	0.01	0.001	-	-	-	-
				LIG vs HIG				
Baroda	**Boys**				**Girls**			
4 - 7	0.01	N.S.	0.001	0.01	N.S.	N.S.	N.S.	N.S.
8 - 10	-	-	-	-	0.01	N.S.	0.05	N.S.
11 - 12	0.01	0.01	N.S.	N.S.	0.01	N.S.	0.05	N.S.
13 - 15	0.001	0.05	0.001	0.01	0.01	0.01	0.001	0.001

N.S. = not significant.

* on the basis of 't' values.

Table 68b : Significance of differences between means of different age groups in Tables 67 and 68.

age groups (years)	creatinine excretion per			
	day	kg	cm	sq.m.
Low Income Group (Boys)	p* less than			
Baroda				
4 - 7 ~ 8 - 10	0.001	0.05	0.01	0.01
8 - 10 ~ 11 - 12	N.S.	N.S.	N.S.	N.S.
11 - 12 ~ 13 - 15	0.05	N.S.	N.S.	N.S.
13 - 15				
Baroda vs Trivandrum	0.01	0.001	0.001	0.001
High Income Group (Boys)				
4 - 7 ~ 11 - 12	0.05	0.05	0.05	N.S.
11 - 12 ~ 13 - 15	0.001	0.001	0.001	0.001
Low Income Group (Girls)				
4 - 7 ~ 8 - 10	0.001	0.05	0.001	0.01
8- 10 ~ 11 - 12	0.01	N.S.	0.05	N.S.
11 - 12 ~ 13 - 15	N.S.	0.05	N.S.	N.S.
13 - 15				
Baroda vs Trivandrum	N.S.	N.S.	N.S.	N.S.
High Income Group (Girls)				
4 - 7 ~ 8 - 10	0.001	N.S.	0.05	N.S.
8 - 10 ~ 11 - 12	0.01	N.S.	0.05	0.05
11 - 12 ~ 13 - 15	0.01	N.S.	0.05	N.S.

N.S. = not significant.

* on the basis of 't' values.

Table 69 : Individual values for the data of Table 67.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per			
						day	kg	cm	sq.m.
1	2	3	4	5	6	7	8	9	10
Low Income Group (Boys)									
4 - 7 years									
83	4.5	15.0	103.2	0.66	2.6	198	13.2	1.9	300
84	4.0	13.0	94.5	0.58	3.0	154	11.9	1.6	266
85	4.75	13.5	99.1	0.61	2.6	132	9.8	1.3	216
86	4.0	11.5	89.7	0.53	1.4	117	10.2	1.3	221
87	4.0	10.0	82.6	0.47	2.9	113	11.8	1.4	240
88	4.0	11.5	88.1	0.52	1.1	102	8.9	1.2	196
89	4.1	12.0	95.3	0.56	2.3	211	17.6	2.2	377
90	4.3	11.5	95.5	0.55	1.6	182	15.8	1.9	331
91	5.0	13.5	93.4	0.58	2.6	139	10.3	1.5	240
92	5.3	13.0	99.3	0.60	2.7	135	10.4	1.4	225
93	5.0	13.5	98.2	0.60	1.2	132	9.8	1.3	220
94	5.0	12.5	95.5	0.57	1.9	109	8.7	1.1	191
95	6.0	14.0	98.2	0.61	1.7	269	19.2	2.7	440
96	6.25	14.0	106.0	0.65	3.5	224	16.0	2.1	347
97	6.1	16.5	110.7	0.71	3.1	194	11.8	1.8	273
98	6.5	16.0	110.5	0.70	5.5	296	18.5	2.7	423

contd..

Table 69 : contd.

1	2	3	4	5	6	7	8	9	10
99	6.75	15.0	103.5	0.65	3.2	212	14.1	2.0	326
100	6.8	17.5	108.5	0.73	3.2	280	16.0	2.6	384
101	7.45	17.0	109.0	0.72	3.2	355	20.8	3.3	493
102	7.3	20.0	115.5	0.80	5.0	329	16.5	2.9	411
103	7.5	13.5	106.0	0.64	2.7	260	19.4	2.5	409
mean	5.5	14.0	100.2	0.62	2.7	197	13.8	1.94	311
s.d.	1.3	2.4	8.4	0.08	1.1	77	3.9	0.63	92
range	4.0-7.5	10.20	83-116	0.47-0.80	1.1-5.5	102-355	8.7-20.8	1.1-3.3	191-493
8 - 10 years									
104	8.15	19.0	118.0	0.8	4.8	311	16.4	2.6	389
105	8.15	18.5	121.2	0.8	3.0	272	14.7	2.2	340
106	8.15	15.5	107.5	0.69	3.2	251	16.2	2.2	364
107	9.5	20.0	120.0	0.82	4.7	353	17.7	2.9	430
108	9.5	19.0	118.0	0.80	4.9	355	18.7	3.0	444
109	9.5	21.5	125.5	0.88	4.5	326	15.2	2.6	370
110	9.3	17.0	114.5	0.74	3.7	266	15.6	2.3	359
111	10.5	20.0	132.0	0.88	3.5	384	19.2	2.9	436
112	10.25	25.0	130.0	0.95	4.2	468	18.7	3.6	493
113	10.9	21.5	122.5	0.86	2.5	395	18.4	3.2	459
114	10.25	22.0	125.5	0.89	3.4	237	10.8	1.9	266

contd...

Table 69 : contd.

1	2	3	4	5	6	7	8	9	10
mean	9.5	19.9	121.3	0.83	3.85	329	16.5	2.7	395
s.d.	0.98	2.6	7.0	0.07	0.81	71	2.5	0.5	64
range	8.5-10.9	15.5-25	107-132	0.69-0.95	3.0-4.9	237-468	10.8-19.2	1.9-3.6	266-493
11-12 years									
115	11.0	23.0	127.2	0.9	4.1	382	16.6	3.0	424
116	11.0	16.5	117.8	0.75	2.7	306	18.5	2.6	408
117	11.0	18.5	125.0	0.82	2.1	252	13.6	2.0	307
118	11.0	20.5	121.0	0.84	2.9	340	16.6	2.8	404
119	11.15	20.0	126.0	0.85	4.9	295	14.8	2.3	347
120	11.5	23.0	138.5	0.97	2.5	320	13.9	2.3	330
121	11.9	24.0	129.5	0.94	4.2	414	17.3	3.2	440
122	11.5	28.0	136.6	1.04	4.9	417	14.9	4.1	401
123	12.0	18.0	120.0	0.79	4.2	373	20.7	3.1	472
124	12.0	28.5	143.4	1.08	3.4	395	13.9	2.8	366
125	12.0	24.0	123.3	0.85	2.9	367	17.7	3.0	437
126	12.0	24.5	135.2	0.97	3.9	356	14.5	2.6	366
127	12.0	20.5	123.0	0.84	3.8	373	18.2	3.0	440
128	12.0	22.5	129.8	0.91	4.5	327	14.5	2.5	359
mean	11.6	22.3	128.3	0.896	3.64	351	16.1	2.8	393
s.d.	0.46	3.5	7.6	0.095	0.90	47	2.2	0.51	48
range	11-12	16.5-28.5	118-143	0.75-1.08	2.1-4.9	252-417	13.6-20.7	2.0-4.1	307-472

contd...202

Table 69 : contd.

1	2	3	4	5	6	7	8	9	10
13-15 years									
129	13.0	26.0	137.3	1.02	3.4	308	11.8	2.3	302
130	13.0	27.5	137.0	1.03	6.8	535	19.4	3.9	519
131	13.0	22.0	133.0	0.92	4.0	366	16.6	2.8	397
132	13.0	21.0	128.5	0.88	3.6	362	17.2	2.8	336
133	13.0	28.5	139.2	1.06	6.4	451	15.8	3.2	425
134	13.0	22.0	126.8	0.89	3.3	241	11.0	1.9	270
135	13.0	26.0	137.0	1.02	3.4	297	11.4	2.2	292
136	13.0	28.0	140.0	1.06	5.1	453	13.8	3.2	427
137	13.0	26.5	141.1	1.03	3.5	413	15.6	2.9	401
138	14.0	25.0	141.0	1.01	5.9	428	17.1	3.0	423
139	14.0	34.0	148.2	1.21	4.8	622	18.3	4.2	514
140	14.0	28.5	148.5	1.08	7.1	4x74	16.7	3.3	517
141	14.0	30.0	146.7	1.14	3.4	403	13.5	2.8	354
142	15.0	36.5	156.5	1.29	6.5	851	23.3	5.5	658
143	15.0	29.0	143.0	1.09	4.3	434	15.0	3.1	398
mean	13.5	27.4	140.5	1.05	4.8	443	15.8	5.1	426
s.d.	0.74	4.2	7.8	0.11	1.4	147	3.3	0.9	99
range	13-15	21.0-36.5	127-157	0.88-1.29	3.3-7.1	241-851	11.0-23.3	1.9-5.5	270-658

contd...

Table 69 : contd.

1	2	3	4	5	6	7	8	9	10
Low Income Group (Trivandrum)									
13-15 years									
144	13.0	23.0	131.0	0.92	5.1	630	27.4	4.8	685
145	13.0	21.5	128.5	0.89	3.4	596	27.7	4.6	670
146	13.0	25.0	133.5	0.97	1.7	308	12.3	2.3	318
147	13.0	27.5	136.0	1.03	3.3	407	14.8	3.0	395
148	13.0	23.0	130.5	0.92	4.8	744	32.3	5.7	808
149	14.0	26.0	142.0	1.04	2.3	592	22.8	4.2	569
150	14.0	27.5	140.0	1.05	2.4	660	24.0	4.7	628
151	14.0	39.0	154.0	1.31	3.9	660	16.9	4.3	504
152	14.0	31.0	145.5	1.14	3.8	708	22.8	4.9	621
153	14.0	30.0	144.0	1.11	4.1	874	29.1	6.1	787
154	14.0	27.5	140.5	1.05	5.9	721	26.2	5.1	686
155	14.0	21.5	134.0	0.91	2.3	442	20.6	3.3	485
156	15.0	38.0	153.0	1.29	3.9	374	9.8	2.4	290
157	15.0	23.5	133.0	0.95	4.5	620	26.4	4.7	652
158	15.0	38.0	151.0	1.28	5.8	878	23.1	5.8	685
159	15.0	28.0	142.5	1.07	2.4	522	18.6	3.7	487
mean	14.0	28.0	140.0	1.06	3.9	629	22.8	4.5	597
s.d.	0.76	5.9	8.2	0.14	1.2	150	5.9	1.0	142
range	13-15	21.5-39.0	128-154	0.89-1.31	1.7-5.9	308-878	9.8-32.3	2.4-6.1	290-808

contd...

Table 69 : contd.

1	2	3	4	5	6	7	8	9	10
High Income Group (Baroda)									
4-7 years									
160	4.9	17.5	109.6	0.73	5.2	281	16.1	2.5	385
161	6.0	19.5	113.1	0.78	5.0	453	23.2	4.0	581
162	5.9	21.5	116.2	0.83	3.3	315	14.7	2.7	380
163	6.0	19.5	117.6	0.81	3.9	336	17.2	2.9	415
164	6.05	17.5	112.5	0.74	4.7	247	14.1	2.2	334
165	6.0	20.0	118.6	0.82	3.9	261	13.1	2.2	318
166	5.9	22.0	115.6	0.84	2.8	329	15.0	2.9	392
167	6.0	24.0	116.5	0.87	4.9	288	12.0	2.5	331
168	5.75	21.0	115.5	0.82	5.0	446	21.2	3.9	544
169	7.3	20.0	116.0	0.80	4.6	435	21.7	3.8	543
mean	5.98	20.3	115.0	0.80	4.33	339	16.8	2.96	422
s.d.	0.58	2.0	2.7	0.04	0.81	78	3.9	0.69	98
range	4.9-7.3	17.5-24.0	109-119	0.73-0.87	2.8-5.2	247-453	12.0-23.2	2.2-4.0	318-581
11-12 years									
170	11.4	30.5	142.1	1.1	5.2	416	13.5	3.0	378
171	11.5	30.5	126.2	1.01	5.1	416	13.6	3.3	412
172	11.6	35.5	150.0	1.24	4.8	479	13.4	3.2	386
173	11.9	28.0	129.0	1.0	5.7	327	12.0	2.6	337

contd...

Table 69 : contd.

1	2	3	4	5	6	7	8	9	10
174	12.3	26.5	130.0	0.98	4.2	433	16.3	3.3	441
175	12.6	42.5	146.0	1.3	5.6	495	11.6	3.4	380
mean	11.9	32.3	137.2	1.1	5.1	428	13.4	3.1	389
s.d.	0.5	5.9	10.1	0.14	0.54	59	1.65	0.29	35
range	11.4-12.6	26.5-42.5	126-146	0.98-1.3	4.2-5.6	327-495	11.6-16.3	2.6-3.4	337-441
13-15 years									
176	13.1	38.0	152.0	1.28	8.9	677	18.0	4.5	529
177	13.1	28.0	137.0	1.05	6.1	729	26.0	5.3	694
178	13.2	43.0	158.0	1.39	4.9	1014	24.0	6.4	729
179	13.8	38.0	148.0	1.25	5.8	906	24.0	6.1	724
180	13.9	40.0	152.0	1.30	4.8	550	13.0	3.3	396
181	14.1	38.0	150.0	1.26	6.4	686	18.0	4.6	543
182	14.4	37.0	158.0	1.30	5.2	602	16.0	3.8	463
183	14.5	41.0	160.0	1.37	4.8	568	14.0	3.6	414
184	14.6	44.0	153.0	1.36	4.9	784	18.0	5.2	576
185	14.8	25.0	134.0	0.97	3.3	523	21.0	3.9	538
186	15.3	45.0	163.0	1.45	3.8	699	16.0	4.2	482
187	15.4	41.0	157.0	1.35	8.8	859	21.0	5.5	636
188	15.5	49.0	170.0	1.55	5.5	848	17.0	5.0	547
189	15.6	53.0	170.0	1.60	8.9	1029	19.0	6.1	643
190	15.7	47.0	166.0	1.49	4.6	797	17.0	4.8	535
mean	14.5	40.3	155.0	1.33	5.8	749	18.8	4.8	563
s.d.	0.9	7.4	10.3	0.17	1.8	163	2.7	0.96	104
range	13.1-15.7	25-53	134-170	0.97-1.6	3.2-8.9	515-1029	16-26	3.3-6.4	396-729

Table 70 : Individual values for the data of Table 68.

subject no.	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	total nitrogen (g)	creatinine (mg) excretion per			
						day	kg	cm	sq.m.
1	2	3	4	5	6	7	8	9	10
Low Income Group (Baroda)									
4-7 years									
96	4.5	12.0	94.0	0.56	1.6	297	24.8	3.2	530
97	4.9	12.0	92.3	0.55	1.6	203	16.9	2.2	369
98	4.0	-	-	-	2.9	183	-	-	-
99	4.75	12.5	95.7	0.57	4.3	167	13.4	1.8	293
100	4.0	10.5	88.6	0.51	1.8	165	15.7	1.9	324
101	4.75	11.5	92.3	0.54	2.1	157	13.7	1.7	291
102	4.5	12.5	94.8	0.57	2.9	153	12.2	1.6	268
103	4.0	11.0	91.2	0.53	1.8	114	10.4	1.3	215
104	4.5	-	-	-	2.0	104	-	-	-
105	4.0	11.5	96.7	0.56	1.4	89	7.7	0.9	159
106	4.15	18.5	114.0	0.76	2.7	263	14.6	2.3	346
107	4.5	13.5	100.5	0.61	0.9	110	8.1	1.1	180
108	4.9	13.0	97.7	0.59	1.7	226	17.4	2.3	383
109	5.5	16.5	110.0	0.71	4.2	342	20.7	3.1	482
110	5.5	13.5	96.7	0.60	2.5	154	11.4	1.6	257
111	5.15	12.0	96.5	0.57	2.1	137	11.4	1.4	240

contd...

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
112	5.0	14.0	100.5	0.62	1.9	131	9.4	1.3	211
113	5.05	14.5	91.2	0.59	1.6	70	4.8	0.8	119
114	5.45	12.0	99.6	0.58	1.1	83	6.9	0.8	143
115	5.15	12.5	104.0	0.61	1.4	122	9.8	1.2	200
116	5.85	16.0	-	-	2.8	266	16.6	-	-
117	5.85	19.0	105.0	0.73	1.7	160	8.4	1.0	219
118	6.5	13.0	97.0	0.58	2.3	184	14.2	1.9	317
119	6.5	16.0	110.0	0.70	2.3	188	11.8	1.7	369
120	6.1	14.5	105.2	0.65	2.3	234	16.1	2.2	360
121	7.5	17.0	114.0	0.74	-	302	17.8	2.7	405
122	7.15	15.0	117.0	0.71	1.8	136	9.1	1.2	192
123	7.7	16.5	110.0	0.71	4.6	262	15.9	2.4	369
124	7.75	15.0	104.9	0.66	3.4	201	13.4	1.9	305
125	7.0	15.0	108.2	0.68	3.1	197	13.1	1.8	290
126	7.0	15.0	110.0	0.69	2.2	152	10.1	1.4	220
127	7.0	14.0	102.8	0.63	1.7	115	8.2	1.1	183
128	7.65	15.0	109	0.68	2.3	238	15.9	2.2	350
mean	5.6	13.9	101.0	0.62	2.2	174	12.6	1.68	276
s.d.	1.2	2.1	7.8	0.07	0.83	62	4.2	0.59	92
range	4.0-7.7	10.5-19.0	89-117	0.51-0.76	0.86-4.6	70-302	6.9-24.8	0.8-3.2	119-530

contd...

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
8-10 years									
129	8.5	20.0	120.0	0.82	3.4	351	17.6	2.94	428
130	8.8	16.5	117.3	0.75	1.7	278	16.8	2.57	371
131	8.8	17.0	118.2	0.76	3.3	238	14.0	2.01	313
132	8.5	19.5	119.0	0.81	2.5	248	12.7	2.08	306
133	8.1	16.0	109.0	0.70	2.1	228	14.3	2.03	326
134	8.5	18.0	119.5	0.79	2.3	306	17.0	2.60	384
135	9.9	17.0	113.0	0.73	-	196	11.5	1.70	268
136	10.0	23.5	127.0	0.91	4.7	314	13.3	2.50	345
137	10.5	22.0	131.0	0.91	-	328	14.9	2.50	360
138	10.0	21.5	124.0	0.87	4.4	312	14.5	2.50	360
mean	9.1	19.1	119.7	0.81	3.0	280	14.7	2.3	346
s.d.	0.84	2.6	6.4	0.07	1.1	50	1.97	0.36	45
range	8.1-10.5	16.0-23.5	109-131	0.7-0.91	1.7-4.4	196-351	11.5-17.6	1.7-2.9	268-428
11-12 years									
139	11.3	21.0	120.0	0.84	-	281	13.4	2.3	337
140	11.3	19.5	122.0	0.82	-	206	10.6	1.7	252
141	11.9	28.0	135.0	1.03	-	289	10.3	211	280
142	11.45	21.0	128.2	0.88	3.74	445	21.2	3.47	506
143	12.45	20.5	125.0	0.86	3.90	312	15.2	2.4	362

contd..

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
144	12.9	19.0	126.0	0.82	4.6	312	16.4	2.5	380
145	12.9	25.5	130.0	0.96	4.5	388	15.2	3.0	404
146	12.5	23.0	131.0	0.92	4.2	281	12.2	2.5	380
147	12.8	22.0	129.0	0.90	-	230	10.4	2.2	306
148	12.0	25.0	134.5	0.98	-	259	10.3	1.9	264
149	12.45	24.5	136.0	0.98	5.3	438	17.8	3.2	446
150	12.50	25.5	131.0	0.97	5.3	362	19.2	2.8	373
151	12.9	34.0	140.5	1.16	-	406	11.9	2.9	350
152	12.9	27.5	137.0	1.04	-	524	19.1	3.8	503
153	12.3	30.5	146.0	1.13	-	497	16.3	3.4	440
154	12.2	22.0	126.7	0.89	2.6	225	10.7	1.85	264
155	12.5	24.5	132.5	0.96	3.0	326	13.3	2.46	340
156	12.25	22.5	129.5	0.91	3.3	432	19.2	3.33	475
157	12.15	22.0	125.1	0.89	3.7	423	19.2	3.3	475
158	12.15	25.0	128.0	0.94	3.5	580	23.2	4.53	617
mean	12.3	24.1	130.5	0.94	3.99	361	15.0	2.78	388
s.d.	0.51	3.75	6.4	0.09	0.82	105	3.95	0.73	96
range	11.3-12.9	19-34	120-146	0.8-1.16	2.58-5.3	206-580	10.3-23.2	1.7-4.5	250-617

contd...

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
13-15 years									
159	13.15	22.0	129.5	0.90	2.44	352	16.0	2.71	391
160	13.15	21.0	127.7	0.87	2.06	241	11.5	1.88	277
161	13.15	24.0	133.6	0.96	4.00	392	16.3	2.93	408
162	13.50	23.5	130.5	0.93	-	358	15.2	2.70	368
163	13.00	26.5	134.0	1.00	-	357	13.5	2.70	354
164	13.80	31.5	144.0	1.14	-	338	10.7	2.40	297
165	13.55	28.0	138.5	1.05	-	352	12.6	2.50	335
166	14.15	28.0	129.6	1.00	4.78	418	14.9	3.20	418
167	14.25	28.0	141.5	1.07	-	363	13.0	2.60	339
168	14.90	42.0	155.0	1.35	5.30	548	13.0	3.50	406
169	14.3	42.0	142.0	1.28	-	497	11.8	3.50	388
170	14.0	43.0	156.5	1.38	4.50	378	8.7	2.40	274
171	15.55	32.5	144.0	1.16	-	430	13.2	3.00	371
172	15.25	43.5	156.5	1.38	-	520	12.0	3.30	280
173	15.55	34.5	148.5	1.22	4.6	591	14.2	3.30	403
174	15.60	44.5	149.0	1.35	4.9	438	9.8	2.90	324
175	15.55	39.5	149.5	1.29	-	570	14.4	3.80	444
176	15.55	34.5	145.0	1.20	3.4	298	8.6	2.10	249
177	15.60	36.5	144.5	1.22	-	465	12.7	3.20	281
178	15.50	32.5	150.5	1.20	3.20	358	11.0	2.40	298
mean	14.5	32.9	142.5	1.15	3.92	409	12.7	2.9	356
s.d.	1.0	7.7	9.2	0.17	1.1	86	2.2	0.50	55
range	13.0-15.6	21.0-44.5	129-157	0.87-1.38	2.1-5.3	241-570	8.6-16.0	1.9-3.8	249-444

contd...

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
13-15 years (Trivandrum)									
179	13.0	21.0	125.0	0.86	2.0	225	10.7	1.8	262
180	13.0	30.5	138.0	1.09	2.4	280	9.2	2.0	256
181	13,0	34.0	143.0	1.17	5.8	538	15.8	3.8	460
182	13.0	30.0	138.0	1.08	1.5	342	11.4	2.5	316
183	13.0	31.0	141.0	1.11	3.1	425	13.7	3.0	382
184	14.0	24.5	137.0	0.98	4.5	370	15.1	2.7	317
185	14.0	36.5	151.0	1.25	2.4	238	6.5	1.6	190
186	14.0	40.0	153.0	1.31	2.4	440	13.5	3.5	412
187	14.0	38.5	151.0	1.28	2.1	441	14.1	3.6	422
188	14.0	36.0	151.0	1.25	5.0	912	25.3	6.1	730
189	14.0	35.0	149.0	1.23	3.3	648	18.5	4.4	527
190	15.0	32.0	142.0	1.14	3.1	432	13.5	3.0	379
191	15.0	35.0	143.0	1.20	2.9	534	15.3	3.7	445
192	15.0	48.5	153.0	1.43	3.1	612	12.6	4.0	428
193	15.0	38.5	150.0	1.28	2.7	488	12.7	3.3	381
194	15.0	36.5	144.0	1.22	4.9	522	14.3	3.6	428
mean	14.0	34.2	144.0	1.18	3.2	478	13.9	3.3	400
s.d.	0.8	6.4	7.6	0.14	1.2	173	4.1	1.1	123
range	13-15	21-48.5	125-153	0.86-1.43	1.5-5.8	225-912	6.5-25.3	1.6-6.1	190-730

contd...

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
High Income Group (Baroda)									
4-7 years									
195	5.25	17.5	113.0	0.75	2.4	117	6.7	1.0	156
196	5.15	21.0	120.0	0.84	3.6	274	13.0	2.3	326
197	5.6	16.0	108.0	0.7	4.6	247	15.4	2.3	353
198	5.45	17.5	110.0	0.73	3.1	158	9.0	1.4	216
mean	5.5	18.0	113.0	0.76	3.4	199	11.0	1.80	264
s.d.	0.25	2.1	5.3	0.06	0.9	74	3.9	0.63	93
range	5.15-5.6	16-21	108-120	0.7-0.84	2.4-4.6	117-274	6.7-15.4	1.0-2.30	156-353
8-10 years									
199	10.75	40.0	156.7	1.34	3.7	529	13.2	3.4	393
200	10.25	40.5	147.6	1.3	4.3	545	13.5	3.7	419
201	10.5	20.0	128.5	0.86	3.5	330	16.5	2.6	354
202	10.8	27.2	144.2	1.08	2.8	470	17.3	3.3	435
203	10.5	29.0	138.2	1.07	2.5	268	9.2	1.9	250
204	10.5	26.0	136.9	1.02	3.1	343	13.2	2.5	336
205	9.75	28.2	134.3	1.03	3.4	387	13.7	2.9	375
206	9.0	27.4	130.3	0.99	2.4	257	9.4	2.0	259
207	9.75	21.0	127.0	0.88	3.3	351	16.7	2.8	399
208	10.0	31.0	138.2	1.1	2.7	331	10.7	4.5	301
209	10.0	26.5	133.3	1.0	5.1	373	14.1	2.0	373

contd...

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
210	9.0	19.5	129.7	0.86	4.6	432	22.1	3.3	502
211	9.0	18.5	122.0	0.81	2.9	320	17.3	2.6	395
212	10.0	26.0	137.2	1.01	2.6	267	10.3	2.0	264
mean	9.98	27.2	136.0	1.03	3.3	372	14.1	2.8	363
s.d.	0.64	6.7	9.0	0.15	0.83	92	3.6	0.76	73
range	9.0-10.8	18.5-40.0	122-157	0.81-1.34	2.4-5.1	257-545	9.2-22.1	1.9-4.5	259-502
11-12 years									
213	11.75	25.5	136.0	1.0	2.8	350	13.7	2.6	350
214	11.3	23.5	134.0	0.96	5.2	408	17.4	3.0	425
215	11.8	24.0	137.0	0.98	3.0	435	18.0	3.2	443
216	11.0	32.6	137.0	1.12	2.8	370	11.4	2.7	330
217	11.75	24.7	135.0	0.98	2.7	544	20.0	4.0	555
218	11.5	29.0	147.7	1.12	2.7	462	15.9	3.1	412
219	11.1	24.6	134.0	0.98	4.1	326	13.3	2.4	332
220	11.25	33.9	142.0	1.17	3.2	448	13.2	3.2	383
221	11.5	27.0	139.0	1.04	3.6	502	18.6	3.6	482
222	11.0	31.2	131.0	1.12	4.1	420	13.5	3.2	375
223	11.75	31.0	143.0	1.14	2.8	340	11.0	2.4	298
224	12.5	36.0	157.2	1.29	3.1	428	11.9	2.7	331
225	12.25	26.7	140.0	1.04	4.6	475	17.2	3.4	456
226	12.2	36.6	153.0	1.26	3.1	414	11.3	2.7	329
227	12.3	30.7	132.8	1.06	2.5	434	14.1	3.3	409

contd...

Table 60 : contd.

1	2	3	4	5	6	7	8	9	10
228	12.3	28.9	144.2	1.11	3.6	575	19.9	4.0	517
229	12.9	32.7	138.3	1.12	4.2	484	14.8	3.5	432
230	12.0	38.0	141.5	1.22	3.6	480	12.6	3.4	393
231	12.3	41.0	152.8	1.33	5.7	877	21.4	5.7	659
232	12.8	42.6	156.3	1.37	4.6	792	18.6	5.1	578
233	12.25	33.5	148.2	1.28	4.5	625	18.7	4.2	520
mean	11.9	31.1	142.0	1.12	3.7	485	15.7	3.4	429
s.d.	0.58	5.6	7.9	0.12	0.91	138	3.3	0.8	95
range	11.0-12.9	23.5-43.0	133-157	0.96-1.37	2.5-5.7	370-877	11.0-21.4	2.4-5.7	298-578
13-15 years									
234	13.0	38.8	160.5	1.35	4.8	635	16.4	4.0	470
235	13.25	40.0	156.5	1.34	5.4	547	13.7	3.5	4.8
236	13.55	46.4	150.1	1.43	4.5	594	12.8	3.8	415
237	13.6	37.0	154.8	1.28	5.1	627	17.0	4.1	490
238	13.1	37.5	150.7	1.27	2.3	445	11.9	3.0	350
239	13.8	34.0	148.2	1.21	2.7	472	18.9	3.2	390
240	13.9	40.0	146.5	1.27	3.4	457	11.4	3.1	360
241	13.5	32.3	143.3	1.16	4.1	486	15.1	3.4	418
242	13.9	33.0	146.2	1.18	3.5	435	13.2	3.0	369
243	13.8	30.6	153.5	1.17	3.4	604	19.7	4.0	576
244	13.9	53.5	151.0	1.47	3.9	547	10.2	3.6	372
245	14.3	41.3	157.5	1.36	2.6	584	14.1	3.7	429

contd...

Table 70 : contd.

1	2	3	4	5	6	7	8	9	10
246	14.8	42.0	157.5	1.37	3.9	721	17.2	4.6	526
247	14.25	63.1	155.5	1.61	2.3	588	9.3	3.8	365
248	14.2	39.4	153.2	1.32	4.8	643	16.3	4.1	487
249	14.0	49.3	162.1	1.43	2.8	451	9.2	2.9	315
250	14.55	39.4	154.5	1.33	4.0	750	19.0	4.9	564
251	14.1	48.8	162.7	1.5	4.2	592	12.1	3.6	395
252	14.55	49.0	163.7	1.51	4.0	849	17.1	5.2	562
253	14.2	45.5	154.3	1.4	6.5	546	12.0	3.5	390
254	15.0	47.5	156.4	1.45	5.3	665	14.0	4.3	458
255	15.5	47.3	157.2	1.43	6.9	982	20.7	6.3	687
256	15.0	51.0	164.2	1.54	4.7	773	15.2	4.7	501
257	15.3	33.1	159.9	1.25	3.8	561	17.0	3.5	449
258	15.8	33.1	159.9	1.25	4.2	600	19.9	4.1	529
259	15.5	45.5	155.5	1.41	8.9	869	19.1	5.6	616
260	15.75	41.5	151.0	1.30	8.6	997	24.0	6.6	766
261	15.9	29.8	140.0	1.08	2.7	449	15.1	3.2	416
262	15.7	44.5	162.3	1.44	5.8	626	14.1	3.9	434
mean	14.4	41.9	155.0	1.35	4.5	624	15.2	4.0	466
s.d.	0.87	7.7	6.1	0.13	1.66	153	3.6	0.94	105
range	13.0-15.9	29.8-63.1	140-164	1.1-1.61	2.3-8.9	435-997	9.2-24.0	2.9-6.6	315-766

variation between individuals was more in young children than in older boys and girls. This was also true of day to day variations.

By and large creatinine excretion was found to increase with age and to be more in boys than in girls and more in the high income group than in the low income group. However, there were several anomalies. The difference between boys aged 8-10 and 11-12 years in the low income group was not all that clear cut perhaps because the latter were not quite representative of their group. Similarly, the differences between boys and girls in the 4-7 years old in the high income group are probably exaggerated because of the greater than expected body weights of the boys. The lack of appreciable difference between boys and girls in the low income group is consistent with expectation that at this age (4-7 years), sex differences are not all that appreciable. In any case, age and sex differences seem to be less evident in the low income group than in the high income groups (Table 71). This is also true of heights and weights and might be because of the greater susceptibility of males to a low plane of nutrition which would tend to minimise sex differences.

In the high income group the sex differences are less evident in the 11-12 years groups and this cannot be accounted for in terms of sampling differences in body weight. It is

Table 71 : The values for boys and girls as per cent of adult values.

age (yrs)	creatinine (mg) excretion in 24 h urine							
	day		kg		cm		sq.m.	
	M	F	M	F	M	F	M	F
Low Income Group								
adult	948	500	21	13	6.1	3.4	676	396
1 - 3	21	35	values as % of adult value					
4 - 7	21	35	66	97	31	50	46	70
8 - 10	35	56	79	113	44	68	58	87
11 - 12	37	72	77	115	46	82	58	98
13 - 15	47	82	75	98	51	85	63	90
High Income Group								
adults	1076	718	21	15.1	6.2	4.6	666	500
			values as % of adult values					
4 - 7	32	28	80	73	48	38	63	53
8 - 10	-	52	-	93	-	61	-	73
11 - 12	40	68	64	103	50	74	58	86
13 - 15	70	87	90	101	77	87	84	93

Table 71a : Values for creatinine in boys and girls in the Low Income Group as per cent of those in the High Income Group.

age (yrs)	creatinine excretion per							
	day		kg		cm		sq.m.	
	M	F	M	F	M	F	M	F
	Low Income Group values as % of High Income Groups							
4 - 7	55	87	82	114	63	95	73	104
8 - 10	-	75	-	104	-	83	-	95
11 - 12	82	74	120	96	90	82	101	90
13 - 15	59	66	84	83	64	73	76	76

M, male; F, female.

Table 71b : Values for creatinine in Low and High Income Group girls as per cent of those in the boys.

age (yrs)	creatinine excretion per							
	day		kg		cm		sq.m.	
	LIG	HIG	LIG	HIG	LIG	HIG	LIG	HIG
	girls values as % of boys values							
4 - 7	88	56	91	65	88	59	89	62
8 - 10	85	-	89	-	86	-	88	-
11 - 12	103	113	93	116	100	110	99	110
13 - 15	92	83	80	81	94	83	84	83

LIG, low income group; HIG, high income group.

possible that the more rapid prepubertal growth 'spurt' in girls during this period accounts for this. More extensive studies are needed on this point.

A similar pattern of increase with age is suggested when the data on girls are considered in terms of creatinine weight or height coefficients, but data on boys are less clear cut and this must be presumed to be partly due to sampling differences and partly due to differences in growth rate and endogenous metabolism.

As mentioned at the beginning, comparative studies were made on boys and girls aged 13-15 years in urban Trivandrum (Kerala) belonging to low income group. Six hour collections of urine were made in these studies, The values when extrapolated for 24 h. and compared with corresponding age groups in Baroda studies, Creatinine excretion both in absolute terms and in relation to body size was more in Trivandrum than in Baroda, but the differences were significant only in the case of boys. Sex differences in Trivandrum were more clear cut. This might be because of more careful sampling procedures as all the boys and girls in a large school were measured for height and weight and stratified samples taken for these investigations.

The literature values for different groups are shown in Tables 72 and 73. It can be seen from the same that creatinine

Table 72 : Values reported for creatinine excretion for boys of different ages in the West.

investigator	age (yrs)	weight (kg)	height (cm)	surface area (sq.m.)	creatinine (mg) excretion per			
					day	kg	cm	sq.m.
Clark et al (1951)	4-7	20.7	116	0.81	438	21.1	3.8	537
Stearns (1958)	-	-	-	-	-	20.5	-	-
Clark et al (1951)	8-10	33.0	139	1.14	757	22.9	5.4	663
Stearns (1958)	8-10	-	-	-	-	22.4	-	-
Nagakawa et al (1961)	10	26.6	134	1.01	621	23.4	4.7	615
Nagakawa et al (1962)	10	26.6	132	0.99	634	24.0	4.8	640
Nagakawa et al (1961)	11	29.8	138	1.07	742	24.4	5.4	693
Zorab (1969)	11-12	-	-	-	481	-	-	-
Nagakawa et al (1962)	11-12	29.1	139	1.07	730	25.1	5.3	682
Nagakawa et al (1963)	11-12	32.8	143	1.15	861	26.2	6.0	749
Nagakawa et al (1964)	11-12	33.3	146	1.17	911	27.6	6.2	773
Zorab (1969)	13-15	-	-	-	722	-	-	-
Clark et al (1951)	13-15	53.0	162	1.56	1285	24.1	7.9	820
Novak (1963)	12.5-14.5	50.6	160	1.51	1270	25.3	7.9	841

Table 73 : Values reported for creatinine excretion in different age groups.

investigator	age (yrs)	sex	weight (kg)	height (cm)	surface area (sq.m.)	creatinine (mg) excretion per			
						day	kg	cm	sq.m.
Clark et al (1951)	4-7	F	20.1	115	0.80	441	21.7	3.8	545
Macy (1947)	4-7	M + F	19.8	113	0.78	460	23.2	4.1	590
Ritchey et al (1973)	7-9	F	28.8	132	1.03	536	18.7	4.1	520
Macy (1947)	8-10	M + F	28.8	134	1.04	683	23.7	5.1	657
Clark et al (1951)	9	F	28.1	134	1.04	593	21.1	4.4	570
Clark et al (1951)	11	F	36.1	146	1.22	797	22.1	5.5	652
Zorab (1969)	11-12	F	-	-	-	362	-	-	-
Macy (1947)	11-12	M + F	38.8	149	1.27	900	23.1	6.1	709
Zorab (1969)	-	-	-	-	-	393	-	-	-
Dakshyani and Ramanamurthy (1964)	13-15	F	40.5	147	1.29	721	17.8	4.9	558
Novak (1963)	12.5-14.5	F	45.7	157	1.43	1040	23.0	6.6	727
Clark et al (1951)	13-15	F	49.0	158	1.49	1058	21.5	6.7	710

M, male; F, female.

excretion in the subjects studied were less than that of reported values.

In conclusion, creatinine excretion showed the expected variation with age, sex and plane of nutrition in spite of some anomalies suspected to have arisen because of faulty sampling.

The data on total nitrogen and other nitrogenous constituents present essentially the same picture as that of creatinine (Tables 74, 75 and 76). Again, sex differences were evident in the low income group.

The possibility that differences in endogenous metabolism, if any, account for this is suggested by the differences in the contribution of urea nitrogen. However, no consistent differences were observed with regard to the percentage contribution of various nitrogenous metabolites to total nitrogen (Tables 77 and 78).

No systematic studies on nitrogenous constituents excretion at different ages appear to have been reported. However, the nitrogen values reported for preadolescent boys (Nakagawa et al, 1962, 1963 and 1964) and girls (James, 1960; Howat et al, 1975) and adolescent boys and girls (Oomen, 1967) were more than those obtained in the present study.

It must be pointed out that the above discussion based on the excretion of creatinine does not take into account that

Table 74 : Urinary excretion of various nitrogenous constituents in boys in relation to socio-economic status.

age (yrs)		total nitrogen (g)	nitrogen (g) excreted as						
			urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined**
1		2	3	4	5	6	7	8	9
Low Income Group (Baroda)									
4 - 7 (n = 21)	M	2.7	1.8	0.22	2.03	0.07	0.06(13)	-	0.49(13)
	s.e.	0.24	0.20	0.04	0.21	0.010	0.010	-	0.06
	cv	41	50	74	45	41	31	-	40
8 - 10 (n = 11)	M	3.9	2.4(10)	0.16	2.58(10)	0.12	-	-	-
	s.e.	0.24	0.23	0.01	0.24	0.010	-	-	-
	cv	21	30	34	28	26	-	-	-
11 - 12* (n = 14)	M	3.6	2.3	0.31	2.60	0.13	0.06(10)	0.13(10)	0.68(10)
	s.e.	0.24	0.18	0.03	0.19	0.005	0.005	0.015	0.08
	cv	25	30	32	28	15	25	34	35
13 - 15* (n = 15)	M	4.8	3.3	0.41	3.68	0.16	0.08	0.16(10)	0.80
	s.e.	0.36	0.26	0.03	0.29	0.010	0.005	0.016	0.11
	cv	29	30	32	30	24	26	32	51

contd..

Table 74 : contd.

1		2	3	4	5	6	7	8	9
Trivandrum									
13 - 15 (n = 16)	M	3.9	2.4	0.30	2.60	0.23	0.10	-	0.92
	s.e.	0.31	0.22	0.04	0.27	0.020	0.010	-	0.08
	cv	31	37	46	39	26	40	-	33
High Income Group (Baroda)									
4 - 7 (n = 10)	M	4.3	2.9	0.22	3.17	0.13	-	-	-
	s.e.	0.26	0.21	0.02	0.22	0.010	-	-	-
	cv	19	22	32	22	23	-	-	-
11 - 12 (n = 6)	M	5.1	3.2	0.28	3.52	0.16	0.09	-	1.34
	s.e.	0.22	0.16	0.04	0.16	0.010	0.010	-	0.10
	cv	11	12	31	11	13	23	-	18
13 - 15 (n = 15)	M	5.8	4.0	0.45	4.40	0.28	0.10	-	1.00
	s.e.	0.47	0.30	0.04	0.31	0.020	0.010	-	0.19
	cv	31	29	33	28	22	20	-	72

M, mean; s.e. - standard error; cv - coefficient of variation.

* mean values based on 3 consecutive days.

** including values for amino nitrogen.

values in parentheses are the number of subjects.

Table 75 : Urinary excretion of various nitrogenous constituents in girls in relation to socio-economic status.

age (yrs)		total nitrogen (g)	nitrogen (g) excreted as					
			urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined*
1		2	3	4	5	6	7	8
Low Income Group (Baroda)								
4 - 7 (n = 32)	M	2.2	1.5	0.16	1.74	0.07	0.06	0.38
	s.e.	0.15	0.11	0.01	0.12	0.004	0.004	0.005
	cv	38	40	43	39	31	33	63
8 - 10 (n = 9)	M	3.0	2.2	0.18	2.24	0.10	-	-
	s.e.	0.39	0.33	0.01	0.31	0.006	-	-
	cv	36	45	44	40	17	-	-
11 - 12 (n = 20)	M	4.0(11)	3.0(14)	0.26(19)	3.22(14)	0.13(20)	0.06(6)	0.57(6)
	s.e.	0.25	0.26	0.02	0.27	0.010	0.004	0.07
	cv	21	33	38	31	30	17	30
13 - 15 (n = 20)	M	3.9(10)	3.3	0.25	3.60	0.15	0.07(10)	0.63(10)
	s.e.	0.34	0.20	0.02	0.21	0.007	0.006	0.08
	cv	28	27	32	26	20	31	46
Trivandrum								
13 - 15 (n = 16)	M	3.2	2.0	0.25	2.20	0.18	0.10	0.69
	s.e.	0.30	0.25	0.04	0.26	0.015	0.010	0.06
	cv	38	50	69	47	34	38	32

contd...

Table 75 : contd.

1		2	3	4	5	6	7	8
High Income Group (Baroda)								
4 - 7 (n = 4)	M	3.4	2.4	0.13	2.53	0.07	-	-
	s.e.	0.46	0.37	0.02	0.37	0.015	-	-
	cv	27	31	23	29	41	-	-
8--10 (n = 14)	M	3.3	2.4	0.22	2.62	0.14	0.09(5)	0.32(5)
	s.e.	0.22	0.23	0.03	0.27	0.010	0.013	0.08
	cv	25	35	51	35	22	34	56
11 - 12 (n = 21)	M	3.7	2.7(18)	0.26(18)	3.00(18)	0.18	- -	-
	s.e.	0.20	0.17	0.03	0.18	0.010	-	-
	cv	25	26	50	25	28	-	-
13 - 15 (n = 29)	M	4.5	3.1(24)	0.26(23)	3.36(22)	0.23	-	-
	s.e.	0.31	0.22	0.02	0.24	0.010	-	-
	cv	37	36	39	34	26	-	-

M, mean; s.e. - standard error; cv - coefficient of variation.
values in parentheses are number of subjects.
* including values for amino nitrogen.

Table 75a : Significance of differences between means of groups in Tables 74 and 75.
(Boys vs Girls)

age group (years)	total nitrogen (g)	nitrogen excreted as						
		urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined
Low Income Group (Baroda)					p* less than			
4 - 7	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	-	N.S.
8 - 10	N.S.	N.S.	N.S.	N.S.	N.S.	-	-	-
11 - 12	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
13 - 15	N.S.	N.S.	0.001	N.S.	N.S.	N.S.	N.S.	N.S.
Trivandrum								
13 - 15	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	-	Ø.05
High Income Group (Bafoda)								
4 - 7	0.01	N.S.	0.01	N.S.	0.001	-	-	-
11 - 12	0.001	0.05	N.S.	0.05	N.S.	-	-	-
13 - 15	0.05	0.05	0.001	0.05	0.05	-	-	-

N.S. = not significant

* on the basis of 't' values.

Table 75b : Significance of differences between means of groups in Tables 74 and 75.
(LIG vs HIG)

age group (years)	total nitrogen (g)	nitrogen excreted as					
		urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
Boys				p* less than			
4 - 7	0.001	0.001	N.S.	0.001	0.001	-	-
11 - 12	0.001	0.001	N.S.	0.05	0;01	0.05	0.001
13 - 15	N.S.	N.S.	N.S.	N.S.	0.001	N.S.	N.S.
Girls							
4 - 7	0.001	0.05	N.S.	N.S.	N.S.	-	-
8 - 10	N.S.	N.S.	N.S.	N.S.	0.01	-	-
11 - 12	N.S.	N.S.	N.S.	N.S.	0.01	-	-
13 - 15	N.S.	N.S.	N.S.	N.S.	0.001	-	-

N.S. = not significant.

* on the basis of 't' values.

Table 75c : Significance of differences between means of different age groups in Table 74.

age group (years)	total nitrogen (g)	nitrogen excreted as						
		urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined
Low Income Group					p* less than			
Baroda								
4 - 7 ~ 8 - 10	0.01	N.S.	N.S.	N.S.	0.001	-	-	-
8 - 10 ~ 11 - 12	N.S.	N.S.	0.001	N.S.	N.S.	-	-	-
11 - 12 ~ 13 - 15	0.01	0.01	0.05	0.01	0.05	N.S.	N.S.	N.S.
13 - 15								
Baroda ~ TVM	N.S.	0.05	0.05	0.05	0.01	N.S.	-	N.S.
High Income Group								
4 - 7 ~ 11 - 12	0.05	N.S.	N.S.	N.S.	0.05	-	--	-
11 - 12 ~ 13 - 15	N.S.	0.05	0.01	0.05	0.001	N.S.	-	N.S.

N.S. = not significant.

* on the basis of 't' values.

TVM, Trivandrum

Table 75d : Significance of differences between means of different age groups in Table 75.

age group (years)	total nitrogen (g)	nitrogen excreted as					
		urea	ammonia	urea + ammonia	creati-nine	uric acid	undeter-mined
Low Income Group				p* less than			
4 - 7 ~ 8 - 10	0.001	N.S.	N.S.	N.S.	0.001	-	-
8 - 10 ~ 11 - 12	0.05	N.S.	0.001	0.05	0.01	-	-
11 - 12 ~ 13 - 15	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
13 - 15							
Baroda ~ TVM	N.S.	0.001	N.S.	0.001	N.S.	N.S.	N.S.
High Income Group							
4 - 7 ~ 8 -- 10	N.S.	N.S.	0.05	N.S.	0.001	-	-
8 - 10 ~ 11 - 12	N.S.	N.S.	N.S.	N.S.	0.01	-	-
11 - 12 ~ 13 - 15	0.05	N.S.	N.S.	N.S.	0.01	-	-

N.S. = not significant.

* on the basis of 't' values.

TVM, Trivandrum

Table 76 : Individual values for the data of Table 74.

subject no.	total nitrogen (g)	nitrogen (g) excreted per day						
		urea	ammonia	urea + ammonia	uric acid	creati-nine	amino acid	undeter-mined
1	2	3	4	5	6	7	8	9
Low Income Group (Boys)								
4 - 7 years								
83	2.6	1.5	0.33	1.83	0.1	0.07	-	0.57
84	3.0	1.9	0.17	2.07	0.09	0.06	-	0.75
85	2.6	1.7	0.15	1.85	0.06	0.05	-	0.66
86	1.4	0.78	0.17	0.95	0.06	0.04	-	0.31
87	2.9	1.9	0.15	2.05	0.09	0.04	-	0.66
88	1.1	0.72	0.07	0.79	0.05	0.04	-	0.19
89	2.3	1.4	0.18	1.58	0.06	0.08	-	0.59
90	1.6	-	0.17	-	0.07	0.07	-	-
91	2.6	1.8	0.26	2.06	0.04	0.05	-	0.45
92	2.7	1.7	0.14	1.84	0.06	0.05	-	0.72
93	1.2	0.6	0.09	0.69	0.05	0.05	-	0.42
94	1.9	1.3	0.15	1.45	0.06	0.04	-	0.38
95	1.7	1.3	0.13	1.43	0.05	0.10	-	0.18
96	3.5	2.3	0.20	2.50	-	0.08	-	-
97	3.1	2.0	0.11	2.11	-	0.07	-	-
98	5.5	4.1	0.34	4.44	-	0.11	-	-

contd...

Table 76 : contd.

1	2	3	4	5	6	7	8	9
99	3.2	2.0	0.27	2.27	-	0.08	-	-
100	3.2	2.2	0.14	2.34	-	0.10	-	-
101	3.2	1.7	0.65	2.35	-	0.13	-	-
102	5.0	4.1	0.06	4.16	-	0.12	-	-
103	2.7	1.3	0.62	1.92	-	0.10	-	-
mean	2.7	1.8	0.22	2.03	0.06	0.07	-	0.49
s.d.	1.1	0.91	0.16	0.92	0.02	0.03	-	0.20
range	1.1-5.5	0.60-4.1	0.06-0.65	0.69-4.40	0.04-0.1	0.04-0.13	-	0.18-0.75
8-10 yrs								
104	4.8	-	0.09	-	-	0.12	-	-
105	3.0	2.1	0.22	2.32	-	0.1	-	-
106	3.2	2.1	0.15	2.25	-	0.09	-	-
107	4.7	3.4	0.1	3.5	-	0.13	-	-
108	4.9	3.7	0.22	3.92	-	0.13	-	-
109	4.5	-	0.17	-	-	0.12	-	-
110	3.7	2.4	0.16	2.56	-	0.1	-	-
111	3.5	2.3	0.18	2.48	-	0.14	-	-
112	4.2	2.4	0.25	2.65	-	0.17	-	-
113	2.5	1.4	0.1	1.5	-	0.15	-	-
114	3.4	1.9	0.12	2.02	-	0.09	-	-
mean	3.85	2.4	0.16	2.58	-	0.122	-	-
s.d.	0.81	0.72	0.05	0.73	-	0.03	-	-
range	2.5-4.9	1.4-3.7	0.1-0.25	1.5-3.92	-	0.09-0.17	-	-

contd...

Table 76 : contd.

1	2	3	4	5	6	7	8	9
11-12 yrs								
115	4.1	2.9	0.26	3.16	0.09	0.14	0.12	0.75
116	2.7	1.7	0.18	1.88	0.05	0.11	0.07	0.65
117	2.1	1.2	0.27	1.47	0.04	0.09	0.12	0.5
118	2.9	1.7	0.32	2.02	0.05	0.13	0.11	0.71
119	4.9	1.9	0.33	3.22	-	0.11	-	-
120	2.5	1.5	0.26	1.76	-	0.12	-	-
121	4.2	2.3	0.31	2.61	-	0.15	-	-
122	4.9	3.2	0.18	3.38	-	0.16	-	-
123	4.2	2.7	0.27	2.97	0.08	0.14	0.13	0.67
124	3.4	2.3	0.29	2.59	0.07	0.15	0.14	0.59
125	2.9	2.0	0.22	2.22	0.06	0.14	0.13	0.49
126	3.9	2.1	0.50	2.60	0.06	0.13	0.24	1.0
127	3.8	2.1	0.38	2.48	0.08	0.14	0.12	1.1
128	4.5	3.6	0.52	4.12	0.06	0.12	-	0.3
mean	3.64	2.3	0.31	2.6	0.064	0.13	0.131	0.68
s.d.	0.9	0.69	0.1	0.72	0.016	0.02	0.045	0.24
range	2.1-4.9	1.2-3.6	0.17-0.52	1.47-4.12	0.04-0.09	0.09-0.15	0.07-0.24	0.3-1.1

contd...

Table 76 : contd.

1	2	3	4	5	6	7	8	9
13-15 yrs								
129	3.4	2.3	0.32	2.62	0.08	0.11	0.12	0.60
130	6.8	4.3	0.44	4.74	0.11	0.2	0.21	0.95
131	4.0	2.8	0.37	3.17	0.08	0.14	0.19	0.61
132	3.6	2.3	0.29	2.59	0.09	0.13	0.13	0.72
133	6.4	3.9	0.56	4.46	0.10	0.17	0.24	1.7
134	3.3	1.9	0.28	2.18	0.07	0.09	0.13	1.0
135	3.4	2.1	0.30	2.40	0.05	0.11	0.12	0.84
136	5.1	3.6	0.57	4.17	0.05	0.17	-	0.64
137	3.5	2.6	0.32	2.92	0.06	0.15	-	0.34
138	5.9	4.4	0.37	4.77	0.07	0.16	0.08	0.86
139	4.8	3.6	0.67	4.27	0.08	0.23	-	0.59
140	7.1	5.5	0.57	6.07	0.08	0.18	-	0.78
141	3.4	2.7	0.31	3.01	0.05	0.15	-	0.25
142	6.5	4.0	0.44	4.44	0.10	0.32	0,16	1.65
143	4.3	3.2	0.34	3.54	0.09	0.16	0.19	0.51
mean	4.8	3.3	0.41	3.68	0.08	0.16	0.16	0.80
s.d.	1.4	1.0	0.13	1.12	0.02	0.04	0.05	0.41
range	3.3-7.1	1.9-5.5	0.28-0.67	2.18-6.07	0.05-0.11	0.11-0.32	0.08-0.24	0.25-1.7

contd...

Table 76 : contd.

1	2	3	4	5	6	7	8	9
Low Income Group (Trivandrum)								
13-15 yrs								
144	5.1	3.2	0.44	3.64	0.12	0.23	-	1.11
145	3.4	1.7	0.27	1.97	0.19	0.22	-	1.03
146	1.7	1.1	0.06	1.16	0.09	0.11	-	0.29
147	3.3	2.5	0.15	2.65	0.06	0.15	-	0.45
148	4.8	3.0	0.38	3.38	0.08	0.28	-	0.11
149	2.3	1.1	0.19	1.29	0.13	0.22	-	0.61
150	2.4	1.2	0.10	1.30	0.07	0.25	-	0.77
151	3.9	-	0.17	-	0.06	0.25	-	-
152	3.8	2.4	0.28	2.68	0.10	0.26	-	1.10
153	4.1	2.4	0.50	2.90	0.08	0.32	-	0.83
154	5.9	3.7	0.55	4.25	0.11	0.27	-	1.28
155	2.3	1.4	0.29	1.69	0.05	0.16	-	0.44
156	3.9	2.6	0.37	2.97	0.09	0.14	-	0.74
157	4.5	2.4	0.46	2.86	0.14	0.23	-	1.23
158	5.8	3.8	0.24	4.04	0.15	0.33	-	1.28
159	2.4	0.8	0.12	0.92	0.09	0.19	-	-
mean	3.9	2.4	0.30	2.6	0.10	0.23	-	0.92
s.d.	1.2	0.87	0.14	1.0	0.04	0.06	-	0.30
range	1.7-5.9	0.8-3.8	0.06-0.55	0.92-4.25	0.05-0.19	0.11-0.33	-	0.11-1.28

contd...

Table 76 : contd.

1	2	3	4	5	6	7	8	9
High Income Group								
4 - 7 yrs								
160	5.2	3.7	0.3	4.0	-	0.10	-	-
161	5.0	3.4	0.22	3.62	-	0.17	-	-
162	3.3	2.1	0.11	2.22	-	0.12	-	-
163	3.9	2.8	0.21	3.01	-	0.13	-	-
164	4.7	3.0	0.14	3.14	-	0.09	-	-
165	3.9	2.5	0.25	2.75	-	0.10	-	-
166	2.8	1.7	0.18	1.88	-	0.12	-	-
167	4.9	3.3	0.20	3.50	-	0.11	-	-
168	5.0	3.4	0.25	3.65	-	0.17	-	-
169	4.6	3.5	0.35	3.85	-	0.16	-	-
mean	4.33	2.94	0.22	3.17	-	0.127	-	-
s.d.	0.81	0.66	0.07	0.7	-	0.03	-	-
range	2.8-5.2	1.7-3.7	0.11-0.35	1.88-4.0	-	0.09-0.17	-	-
11-12 yrs								
170	5.2	3.2	0.45	3.65	0.08	0.15	-	1.3
171	5.1	3.3	0.32	3.62	0.07	0.15	-	1.3
172	4.8	2.7	0.26	2.96	0.10	0.18	-	1.5
173	5.7	3.7	0.24	3.94	0.11	0.13	-	1.5
174	4.2	2.9	0.23	3.13	0.06	0.16	-	0.9
175	5.6	3.6	0.21	3.81	0.11	0.18	-	1.5

contd...

Table 76 : contd.

1	2	3	4	5	6	7	8	9
mean	5.1	3.22	0.28	3.52	0.09	0.16	-	1.34
s.d.	0.54	0.39	0.09	0.39	0.02	0.02	-	0.24
range	4.2-5.7	2.7-3.7	0.21-0.45	2.96-3.94	0.06-0.11	0.13-0.18	-	0.9-1.5
13-15 yrs								
176	8.9	5.6	0.38	5.98	0.12	0.25	-	2.5
177	6.1	4.7	0.34	5.04	0.11	0.27	-	0.69
178	4.9	3.4	0.38	3.78	0.09	0.38	-	0.65
179	5.8	4.4	0.35	4.75	0.1	0.34	-	0.57
180	4.8	3.7	0.28	3.98	0.07	0.19	-	0.62
181	6.4	4.6	0.75	5.35	0.09	0.26	-	0.68
182	5.2	3.4	0.40	3.80	0.07	0.22	-	1.09
183	4.8	3.5	0.38	3.88	0.09	0.21	-	0.61
184	4.9	3.4	0.38	3.78	0.11	0.29	-	0.67
185	3.3	2.3	0.23	2.53	0.06	0.19	-	0.47
186	3.8	2.5	0.24	2.74	-	0.26	-	-
187	8.8	6.6	0.48	7.08	0.13	0.32	-	1.27
188	5.5	3.9	0.42	4.32	0.10	0.31	-	0.76
189	8.9	4.9	0.71	5.61	0.11	0.38	-	2.74
190	4.6	3.1	0.36	3.46	0.10	0.30	-	0.73
mean	5.75	3.99	0.45	4.4	0.1	0.28	-	1.0
s.d.	1.8	1.15	0.15	1.2	0.02	0.06	-	0.72
range	3.3-8.9	2.3-6.6	0.23-0.75	2.53-7.08	0.06-0.13	0.19-0.38	-	0.47-2.51

Table 76a : Individual values for the data of Table 75.

	total nitrogen (g)	urea	ammonia	urea + ammonia	uric acid	creati-nine	undeter-mined
1	2	3	4	5	6	7	8
Low Income Group (Baroda)							
4-7 yrs							
96	1.6	0.71	0.37	1.08	0.05	0.11	0.41
97	1.6	1.0	0.16	1.16	0.06	0.08	0.32
98	2.9	2.0	0.15	2.15	0.08	0.07	0.62
99	4.3	2.8	0.21	3.01	0.09	0.06	1.1
100	1.8	1.1	0.12	1.22	0.05	0.06	0.4
101	2.1	1.3	0.17	1.47	0.07	0.06	0.6
102	2.9	2.4	0.18	2.58	0.09	0.06	0.17
103	1.8	1.3	0.14	1.44	0.07	0.04	0.29
104	2.0	1.6	0.20	1.80	0;06	0.04	0.08
105	1.4	1.0	0.11	1.11	0.01	0.03	0.27
106	2.7	1.8	0.22	2.02	0.08	0.10	0.54
107	0.9	0.45	0.04	0.49	0.03	0.04	0.30
108	1.7	1.1	0.12	1.22	0.09	0.08	0.28
109	4.2	2.9	0.22	3.12	0.09	0.13	0.86
110	2.5	-	0.16	-	0.07	0.06	-
111	2.1	1.2	0.17	1.37	0.06	0.05	0.54
112	1.9	1.3	0.15	1.45	0.03	0.05	0.32

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
113	1.6	1.0	0.17	1.17	0.04	0.03	0.34
114	1.1	0.84	0.13	0.97	0.01	0.03	0.14
115	1.4	1.1	0.06	1.16	0.04	0.05	0.18
116	2.8	2.2	0.25	2.45	0.10	0.1	0.11
117	1.7	1.2	0.15	1.35	0.08	0.06	0.20
118	2.3	1.6	0.10	1.70	-	0.07	-
119	2.3	1.9	0.13	2.03	-	0.07	-
120	2.3	1.4	0.18	1.58	0.04	0.09	0.57
121	-	2.1	0.31	2.41	-	0.11	-
122	1.8	1.1	0.09	1.19	-	0.05	-
123	4.6	3.0	0.15	3.15	-	0.1	-
124	3.4	2.2	0.17	2.37	0.08	0.08	0.9
125	3.1	2.4	0.15	2.55	0.06	0.07	0.45
126	2.2	1.4	0.13	1.53	0.07	0.06	0.54
127	1.7	1.3	0.12	1.42	0.05	0.04	0.19
128	2.3	1.8	0.26	2.06	0.06	0.09	0.12
mean	2.2	1.5	0.16	1.74	0.06	0.065	0.382
s.d.	0.8	0.62	0.07	0.68	0.02	0.02	0.24
range	0.86-4.6	0.45-3.0	0.04-0.37	0.49-3.15	0.01-0.1	0.03-0.11	0.08-1.1

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
8-10 yrs							
129	3.4	-	-	-	-	0.13	-
130	1.7	0.82	0.35	1.17	-	0.10	-
131	3.3	1.9	0.17	2.07	-	0.09	-
132	2.5	1.4	0.10	1.50	-	0.09	-
133	2.1	1.7	0.13	1.83	-	0.09	-
134	2.3	1.7	0.10	1.80	-	0.11	-
135	-	2.4	0.15	2.55	-	0.07	-
136	4.7	3.1	0.18	3.28	-	0.11	-
137	-	3.5	0.24	3.74	-	0.12	-
138	4.4	3.7	0.20	3.90	-	0.12	-
mean	3.0	2.2	0.18	2.24	-	0.10	-
s.d.	1.1	1.0	0.08	0.89	-	0.018	-
range	1.7-4.7	0.82-3.7	0.1-0.35	1.17-3.90	-	0.07-0.13	-
11-12 yrs							
139	-	-	0.13	-	-	0.10	-
140	-	2.2	0.11	2.31	-	0.08	-
141	-	3.4	0.15	3.55	-	0.11	-
142	3.74	2.5	0.32	2.82	0.07	0.17	0.68
143	3.90	-	-	-	-	0.12	-
144	4.6	-	0.21	-	-	0.12	-

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
145	4.5	-	0.24	-	-	0.14	-
146	4.2	-	0.14	-	-	0.10	-
147	-	2.7	0.21	2.91	-	0.10	-
148	-	3.5	0.28	3.78	-	0.10	-
149	5.3	4.0	0.22	4.22	-	0.16	-
150	5.3	-	0.18	-	-	0.13	-
151	-	4.8	0.31	5.11	-	0.15	-
152	-	4.7	0.41	5.11	-	0.20	-
153	-	2.7	0.44	3.14	-	0.18	-
154	2.6	1.8	0.17	1.97	0.04	0.09	0.50
155	3.0	2.0	0.31	~~0.23~~ 2.30	0.05	0.12	0.50
156	3.3	2.0	0.37	2.37	0.07	0.16	0.61
157	3.7	2.3	0.34	2.64	0.05	0.16	0.81
158	3.5	2.5	0.39	2.89	0.08	0.22	0.31
mean	3.99	2.90	0.26	3.22	0.06	0.13	0.57
s.d.	0.82	0.99	0.10	1.01	0.01	0.04	0.17
range	2.6-5.3	1.8-4.8	0.11-0.44	1.97-5.11	0.04-0.08	0.08-0.22	0.31-0.81

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
13-15 yrs							
159	2.44	1.75	0.22	1.97	0.05	0.13	0.30
160	2.06	1.47	0.20	1.67	0.04	0.09	0.27
161	4.00	2.70	0.33	3.03	0.07	0.15	0.76
162	-	3.70	0.34	4.04	-	0.13	-
163	-	2.20	0.23	2.43	-	0.13	-
164	-	3.80	0.40	4.20	--	0.13	-
165	-	3.20	0.40	3.60	-	0.13	-
166	4.78	3.31	0.33	3.64	0.08	0.16	0.91
167	-	3.60	0.24	3.84	-	0.14	-
168	5.30	3.8	0.15	3.95	0.08	0.20	1.1
169	-	4.3	0.28	4.58	-	0.18	-
170	4.50	3.2	0.15	3.35	0.07	0.14	0.95
171	-	3.9	0.29	4.19	-	0.16	-
172	-	4.9	0.27	5.17	0.10	0.20	-
173	4.60	3.5	0.18	3.68	0.07	0.18	0.67
174	4.90	3.9	0.19	4.09	0.07	0.16	0.60
175	-	3.9	0.33	4.23	0.06	0.21	-
176	3.40	2.6	0.21	2.81	0.06	0.11	0.43

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
177	-	4.5	0.20	4.70	-	0.17	-
178	3.20	2.5	0.15	2.65	0.05	0.13	0.37
mean	3.9	3.3	0.25	3.59	0.065	0.152	0.63
s.d.	1.1	0.9	0.08	0.92	0.02	0.03	0.29
range	2.06-5.3	1.47-4.9	0.15-0.40	1.67-5.17	0.04-0.10	0.09-0.21	0.27-1.1
Trivandrum							
13-15 yrs							
179	2.0	1.1	0.08	1.18	0.06	0.08	0.72
180	2.4	1.4	0.17	1.57	0.06	0.10	0.62
181	5.8	4.3	0.33	4.63	0.16	0.20	0.76
182	1.5	0.8	0.06	0.86	0.08	0.13	0.43
183	3.1	2.1	0.16	2.26	0.08	0.16	0.59
184	4.5	3.1	0.08	3.18	0.10	0.14	1.10
185	2.4	1.6	0.24	1.84	0.07	0.09	0.44
186	2.4	1.4	0.13	1.43	0.08	0.20	0.61
187	2.1	1.1	0.31	1.41	0.10	0.20	0.39
188	5.0	3.2	0.58	3.78	0.14	0.34	0.80
189	3.3	1.8	0.22	2.02	0.14	0.24	0.87
190	3.1	1.7	0.08	1.78	0.09	0.16	1.00
191	2.9	1.9	0.30	2.20	0.16	0.20	0.37
192	3.1	1.4	0.64	2.04	0.12	0.23	0.70

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
193	2.7	1.4	0.34	1.74	0.11	0.18	0.70
194	4.9	3.3	0.21	3.51	0.15	0.19	1.00
mean	3.2	2.0	0.25	2.22	0.10	0.18	0.69
s.d.	1.2	0.99	0.17	1.0	0.04	0.06	0.22
range	1.5-5.8	0.8-4.3	0.06-0.64	0.86-4.63	0.06-0.16	0.08-0.34	0.37-1.10
High Income Group (Baroda)							
4-7 yrs							
195	2.4	1.7	0.08	1.78	-	0.04	-
196	3.6	2.4	0.16	2.56	-	0.10	-
197	4.6	3.4	0.14	3.54	-	0.09	-
198	3.1	2.1	0.14	2.24	-	0.06	-
mean	3.4	2.4	0.13	2.53	-	0.07	-
s.d.	0.93	0.74	0.03	0.75	--	0.03	-
range	2.4-4.6	1.7-3.4	0.08-0.16	1.78-3.54	-	0.04-0.10	-
8-10 yrs							
199	3.7	2.9	0.31	3.21	-	0.53	-
200	4.3	2.9	0.41	3.31	-	0.55	-
201	3.5	2.1	0.15	2.25	-	0.33	-
202	2.8	1.8	0.17	1.97	-	0.47	-

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
203	2.5	1.50	0.09	1.59	-	0.27	-
204	3.1	-	-	-	-	0.34	-
205	3.4	2.0	0.2	2.2	-	0.39	--
206	2.4	1.6	-	-	-	0.26	-
207	3.3	1.8	0.07	1.87	-	0.35	-
208	2.7	1.8	0.14	1.94	0.07	0.33	0.54
209	5.1	4.2	0.37	4.57	0.12	0.37	0.27
210	4.6	3.7	0.29	3.99	0.11	0.43	0.27
211	2.9	2.1	0.16	2.26	0.09	0.32	0.45
212	2.6	2.1	0.21	2.31	0.06	0.27	0.08
mean	3.34	2.35	0.215	2.62	0.09	0.14	0.32
s.d.	0.83	0.83	0.110	0.93	0.03	0.03	0.18
range	2.4-6.1	1.5-4.2	0.07-0.41	1.59-4.57	0.05-0.12	0.09-0.2	0.08-0.54
11-12 yrs							
213	2.8	2.4	0.17	2.57	-	0.13	-
214	5.2	3.6	0.45	4.05	-	0.15	-
215	3.0	2.3	0.29	2.59	-	0.16	-
216	2.8	2.0	0.17	2.17	-	0.14	-
217	2.7	-	-	-	-	0.2	-
218	2.7	-	-	-	-	0.17	-

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
219	4.7	2.7	0.26	2.96	-	0.12	-
220	3.2	2.5	-	-	-	0.17	-
221	3.6	2.3	0.30	2.60	-	0.16	-
222	4.1	3.0	0.40	3.40	-	0.16	-
223	2.8	2.2	0.20	2.40	-	0.13	-
224	3.1	2.2	0.36	2.56	-	0.16	-
225	4.6	3.9	0.07	3.97	-	0.18	-
226	3.1	2.3	0.27	2.57	-	0.15	-
227	2.5	1.7	0.17	1.87	-	0.16	-
228	3.6	3.0	0.11	3.11	-	0.21	-
229	4.2	2.4	0.33	2.73	-	0.18	-
230	3.6	-	-	-	-	0.18	-
231	5.7	4.3	0.55	4.85	-	0.33	-
232	4.6	3.4	0.22	3.62	-	0.29	-
233	4.5	2.9	0.16	3.06	-	0.23	-
mean	3.7	2.7	0.26	3.0	-	0.18	-
s.d.	0.91	0.70	0.13	0.76	-	0.05	-
range	2.5-5.8	1.7-4.3	0.07-0.55	1.97-4.85	-	0.13-0.29	-

contd...

Table 76a: contd.

1	2	3	4	5	6	7	8
13-15 yrs							
234	4.8	3.7	0.29	3.99	-	0.24	-
235	5.4	3.6	0.22	3.82	-	0.2	-
236	4.5	3.2	0.13	3.33	-	0.22	-
237	5.1	3.3	0.43	3.73	-	0.23	-
238	2.3	1.5	0.16	1.66	-	0.17	-
239	2.7	-	-	-	-	0.18	-
240	3.4	-	-	-	-	0.17	-
241	4.1	2.3	0.35	2.65	-	0.18	-
242	3.5	2.0	0.18	2.18	-	0.16	-
243	3.4	2.4	0.32	2.72	-	0.22	-
244	3.9	2.3	0.31	2.61	-	0.2	-
245	2.6	1.8	-	-	-	0.22	-
246	3.9	3.0	0.28	3.28	-	0.27	
247	2.3	1.5	0.28	1.78	-	0.22	-
248	4.8	3.6	-	-	-	0.24	-
249	2.8	1.9	0.19	2.09	-	0.17	-
250	4.0	2.1	0.31	2.41	-	0.28	-
251	4.2	2.6	0.09	2.69	-	0.22	-
252	4.0	3.0	0.18	3.18	-	0.38	-

contd...

Table 76a : contd.

1	2	3	4	5	6	7	8
253	6.5	4.0	0.26	4.26	-	0.20	-
254	5.3	3.4	0.41	3.81	-	0.25	-
255	6.9	4.9	0.31	5.21	-	0.37	-
256	4.7	-	-	-	-	0.29	-
257	3.8	2.9	0.15	3.05	-	0.21	-
258	4.2	-	-	-	-	0.25	-
259	8.9	5.2	0.45	5.65	-	0.32	-
260	8.6	5.1	0.30	5.40	-	0.37	-
261	2.7	-	0.13	-	-	0.17	-
262	5.8	4.2	0.26	4.46	-	0.23	-
mean	4.5	3.1	0.26	3.36	-	0.23	-
s.d.	1.66	1.1	0.10	1.14	-	0.06	-
range	2.3-8.9	1.50-5.2	0.09-0.45	1.66-5.65	-	0.16-0.38	-

Table 77 : Contribution of various nitrogenous constituents to total nitrogen in Boys in relation to socio-economic status*.

age (yrs)		total nitrogen (g)	% contribution to total nitrogen						
			urea	ammonia	urea + ammonia	creatinine	uric acid	amino acid	undetermined*
1		2	3	4	5	6	7	8	9
Low Income Group (Baroda)									
4 - 7 (n = 21)	M	2.7	62	9.2	72	3.1	3.2(13)	-	23(13)
	s.e.	0.24	2.5	1.30	1.4	0.28	0.28		1.7
	cv	41	18	66	8	42	31	-	27
8 - 10 (n = 11)	M	3.9	64(10)	4.5	69(10)	3.2	-	-	-
	s.e.	0.24	2.0	0.49	2.4	0.29	-	-	-
	cv	21	11	38	11	31	-	-	-
11 - 12** (n = 14)	M	3.6	62	8.8	72	4.0	1.9(10)	4.1(10)	20(10)
	s.e.	0.24	1.9	0.86	1.9	0.24	0.10	0.38	2.0
	cv	25	12	36	10	22	17	29	31
13 - 15** (n = 15)	M	4.8	69	8.8	78	3.7	1.7	3.9(10)	16.5
	s.e.	0.36	1.8	0.47	2.0	0.21	0.11	0.29	1.7
	cv	29	10	20	10	22	26	27	41
Trivandrum									
13 - 15 (n = 16)	M	3.9	59	7.8	68	6.5	2.8	-	23.5
	s.e.	0.30	1.9	0.70	2.0	0.48	0.33	-	1.4
	cv	31	13	36	11	30	47	-	23

contd...

Table 77 : contd.

1		2	3	4	5	6	7	8	9
High Income Group (Baroda)									
4 - 7 (n = 10)	M	4.3	67	5.4	73	3.0	-	-	-
	s.e.	0.26	1.5	0.52	1.7	0.24	-	-	-
	cv	19	7	31	8	25	-	-	-
11 - 12 (n = 6)	M	5.1	63	5.6	69	3.2	1.7	-	26
	s.e.	0.22	1.8	0.70	1.8	0.29	0.12	-	1.4
	cv	11	7	31	6.0	18	18	-	13
13 - 15 (n = 15)	M	5.8	69	7.1	77	5.1	1.7	-	16
	s.e.	0.47	1.5	0.47	1.6	0.36	0.08	-	1.7
	cv	31	9	26	8	28	18	-	40

M - mean; s.e. - standard error; cv - coefficient of variation.

values in parentheses are number of subjects.

* including values for amino nitrogen.

** mean values based on values for 3 consecutive days.

Table 78 : Contribution of various nitrogenous constituents in Girls in relation to socio-economic status.

		TOTAL NITROGEN (g)	% contribution to total nitrogen					
			urea	ammonia	urea + ammonia	creati-nine	uric acid	undeter-mined*
1		2	3	4	5	6	7	8
Low Income Group (Baroda)								
4 - 7 (n = 32)	M	2.2	68	7.3	76	3.0	2.8	18.2
	s.e.	0.15	1.5	0.60	1.6	0.20	0.19	1.5
	cv	38	13	46	12	37	35	43
8 - 10 (n = 9)	M	3.0	66	6.9	74	3.8	-	-
	s.e.	0.39	4.4	1.9	4.2	0.38	-	-
	cv	36	20	84	15	32	-	-
11 - 12 (n = 20)	M	4.0(11)	70(8)	6.8(9)	76(7)	3.6(13)	1.8(6)	17.2(6)
	s.e.	0.25	1.9	1.0	1.6	0.31	0.12	1.8
	cv	21	8	44	5	32	17	26
13 - 15 (n = 10)	M	3.9	73	5.8	79	3.8	1.6	15.5
	s.e.	0.34	1.25	0.80	1.2	0.21	0.06	1.2
	cv	28	6	43	5	18	12	25
Trivandrum								
13 - 15 (n = 16)	M	3.2	60	7.9	68	5.9	3.4	23
	s.e.	0.30	2.0	1.3	1.8	0.52	0.25	1.7
	cv	38	13	65	10	36	29	29

contd...

Table 78 : contd.

1		2	3	4	5	6	7	8
High Income Group (Baroda)								
4 - 7 (n = 4)	M	3.40	70	3.8	74	2.2	-	-
	s.e.	0.46	1.7	0.35	1.3	0.25	-	-
	cv	27	5	18	4	23	-	-
8 - 10 (n = 14)	M	3.34	69	6.0	75	4.1	2.5(5)	10.1(5)
	s.e.	0.22	2.6	0.57	5.3	0.24	0.14	3.3
	cv	25	13	33	15	22	12	73
11 - 12 (n = 21)	M	3.65	74(18)	7.1(18)	80(18)	5.0	-	-
	s.e.	0.20	1.8	0.68	1.8	0.24	-	-
	cv	25	10	39	9	22	-	-
13 - 15 (n = 29)	M	4.46	67(24)	6.8(23)	72(22)	5.6	-	-
	s.e.	0.31	1.5	0.71	1.6	0.24	-	-
	cv	37	11	50	10	25	-	-

M - mean; s.e. - standard error; cv - coefficient of variation.

values in parentheses are number of subjects.

* including values for amino nitrogen.

of creatine. In the first series of investigations on adults, the urine was analysed in a few subjects for creatine and the same found to be nil or negligible even in the women studied. So estimation of creatine was omitted in the studies on adults. Unfortunately, this omission continued in the studies on the younger age groups due to an oversight although some excretion of creatine may be expected. However, it is unlikely that the total picture would have been affected because of this. In this connection, the percentage of creatine to total creatinine (Creatine + creatinine) as calculated from the data of Clark et al (1951)is of the order of 41, 28, 23, 20, 13, 10 and 6% for subjects aged 5, 7, 9, 11, 13,15 and 16 years so that in the older age groups studied the omission would not have much difference. Further, it can also be argued that whereas creatine in urine is an index of the efficiency with which creatine is phosphorylated, it is creatinine which represents the turnover of creatine which is what these investigations were mainly concerned.

In conclusion, the present studies point to age and sex differences in the excretion of creatinine and other nitrogenous constituents, but more extensive data are needed before any conclusions can be drawn about the effects of these as well as the plane of nutrition, particularly, around puberty. Any changes in these parameters should be correlated with studies on the rates of growth and basal metabolism.

Studies on malnourished children

As mentioned earlier, studies were carried out on severely malnourished children (aged 3-6 years) at the time of admission with regard to urinary creatinine and other nitrogenous constituents. The children studied were those admitted for treatment at the Nutrition Rehabilitation Centre, Pediatrics Department, Trivandrum (Kerala) medical college hospital, with different degrees of protein and energy malnutrition. In addition, some of these children were investigated at varying intervals after discharge following dietary rehabilitation at Nutrition Rehabilitation Centre. Since this study suffers from lack of controls from the same region, the experiments were compared with age matched subjects of a similar socio-economic group from Baroda. This procedure is considered reasonable as extensive data obtained on the growth status of poor children in Baroda and similar data obtained by Dr. Soman in Kerala show them to be similar with regard to the same as judged by height and weight. Similarly, school boys and girls in Kerala were compared with those in Baroda. Also, it was possible to make 24 h. collections only in a few cases (Tables 79 and 80). For others, casual samples were collected and the values expressed in terms of amounts per deci litre.

Urinary creatinine and total nitrogen excretion in malnourished children were significantly lower than in controls

Table 79: Urinary excretion of creatinine in malnourished children before and after dietary rehabilitation.

subject no.	sex	age (months)	weight (kg)	height (cm)	total nitrogen (g)	creatinine (mg) excretion per		
						day	kg	cm
malnourished								
202	M	48	8.6	79	0.67	55	6.3	0.7
265	F	42	7.9	80	0.96	55	7.0	0.7
mean		45	8.3	79.5	0.82	55	6.7	0.7
malnourished and rehabilitated*								
232	M	37	7.3	73	1.34	101	13.8	1.4
235	M	54	10.6	89	3.00	168	15.8	1.9
227	M	48	10.3	99	2.42	161	15.6	1.6
228	M	83	13.2	101	1.20	121	9.2	1.2
229	M	79	9.6	90	2.13	145	15.1	1.6
mean		60.2	10.2	90.4	2.00	139	13.9	1.5
s.d.		20	2.1	11.1	0.75	28	2.7	0.3
range		37-83	7.3-13.2	73-101	1.20-3.00	101-168	9.2-15.8	1.2-1.9

M, male; F, female.

* given a diet at the Nutrition Rehabilitation Centre for 2-4 weeks and studied at varying intervals after discharge.

Table 80 : Urinary excretion of various nitrogenous constituents in malnourished children before and after dietary rehabilitation.

subject no.	sex	total nitrogen (g)	nitrogen (g) excreted as					
			urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
malnourished								
202	M	0.67	0.29	0.07	0.36	0.02	0.03	0.26
265	F	0.96	0.56	0.07	0.63	0.02	0.04	0.27
mean		0.82	0.43	0.07	0.49	0.02	0.035	0.27
malnourished and rehabilitated*								
232	M	1.34	0.49	0.46	0.95	0.04	0.06	0.29
235	M	3.00	1.70	0.38	2.08	0.06	0.08	0.78
227	M	2.40	1.60	0.20	1.80	0.06	0.08	0.46
228	M	1.20	0.70	0.20	0.90	0.05	0.05	0.20
229	M	2.13	1.20	0.22	1.44	0.05	0.08	0.55
mean		2.00	1.14	0.29	1.43	0.05	0.07	0.46
s.d.		0.75	0.53	0.12	0.50	0.008	0.01	0.23
range		1.20-3.00	0.49-1.70	0.20-0.46	0.90-2.08	0.04-0.06	0.05-0.08	0.20-0.78

M, male; F, female.

* given a diet at the Nutrition Rehabilitation Centre for 2-4 weeks and studied at varying intervals after discharge.

(Table 81) and consistent with the observations made by other investigators (Edozein and Phillips, 1961; Vasant Gadkar et al, 1963; Schendel and Hansen, 1965; Ramakrishna Rao et al, 1973).

The values continued to be low in follow-up cases but were higher than at the time of admission.

The percentage contributions of urea nitrogen and creatinine nitrogen to total nitrogen were significantly lower in malnourished children, whereas the relative contributions of ammonia nitrogen and undetermined nitrogen were significantly higher as compared to controls (Table 82). The observations were consistent with those reported in literature (Table 83).

In summary, severe malnutrition in young children appears to be associated with changes in the plane of protein metabolism as might be expected. But even after rehabilitation, some of the differences appear to persist. This might be because of poor continued recovery following discharge or because of long term changes in protein turnover. The former possibility is suggested by the wide variation in the weight gains following discharge which varied from 12 to 400 % expected gains according to Boston norms (Table 84).

In this connection, collateral studies carried out by a co-investigator (Poonam, unpublished) also suggest that when animals are switched from a low protein to a high protein diet or vice-versa there may be some carry-over effects in turnover rates for protein.

Table 81 : Urinary excretion of various nitrogenous constituents in malnourished children before and after dietary rehabilitation.

		age (months)	weight (kg)	height (cm)	creatinine (mg/dl)	total nitrogen (mg/dl)	nitrogen (mg/dl) excreted as: urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
controls	m	56	13	97	43	589	405	46	452	16.0	16.0	121
(n = 56)	s.e.	1.6	0.3	1.0	2.5	47	34	4.5	38	0.9	1.1	12
	cv	21	17	8	44	60	62	74	62	44	47	68
malnourished												
A. n = 6-8	m	47	8.8	80	23**	296***	139***	50	188***	8.7	14.7	76**
	s.e.	2.7	0.5	2.4	6.1	28	19	13.0	27	2.3	1.7	11.0
	cv	16	16	9	73	25	33	64	35	74	32	34
B. n = 56	m	52	8.5	81	25***	360⊕***	-	-	-	-	-	-
	s.e.	1.7	0.3	0.9	2.0	33	-	-	-	-	-	-
	cv	25	24	8	60	46	-	-	-	-	-	-
malnourished and rehabilitated@												
n = 12 - 16	m	53	10.3	85	33*	525	295	65	361	12.2	15.9	116
	s.e.	3.9	0.6	2.8	3.1	80	59	6.6	63	1.2	1.6	22
	cv	28	21	13	38	58	74	39	65	39	39	63

M, mean; s.e. standard error; cv - coefficient of variation.

values marked with asterisk significantly different from controls; p less than 0.05 for *, 0.02 for ** and 0.001 for ***.

⊕ n = 25. @ given a diet at the Nutrition Rehabilitation Centre for 2-4 weeks and studied at varying intervals after discharge.

Table 81a : Individual values for the data of Table 81.

subject no.	age (months)	weight (kg)	height (cm)	creatinine (mg/dl)	total nitrogen (mg/dl)	nitrogen (mg/dl) excreted as					
						urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
A. malnourished											
males											
191	42	6.8	68	65	-	-	-	-	24.1	22.6	-
197	54	11.1	88	26	392	212	85	297	9.7	17.5	67
202	48	8.6	79	15	179	76	19	95	5.4	8.3	70
209	60	7.9	78	17	336	137	50	187	6.3	13.6	129
207	48	9.7	88	15	364	-	-	-	5.6	12.5	-
females											
265	42	7.9	80	14	235	136	18	154	5.0	10.3	66
266	36	7.3	74	20	286	110	92	202	7.4	18.8	58
267	42	9.7	82	16	280	160	33	193	5.9	14.3	67
mean	47	8.8	80	23	296	139	50	188	8.7	14.7	76
s.d.	7.7	1.4	6.8	17.2	74	46	32	66	6.4	4.7	26
range	36-60	6.8-11.1	68-88	14-65	179-392	76-212	18-92	95-297	5.0-24.1	8.3-22.6	58-129

contd...

Table 81a : contd.

subject no.	age (months)	weight (kg)	height (cm)	urinary excretion (mg/dl)	
				creatinine	total nitrogen
B. malnourished					
males					
191	42	6.8	68	65	-
192	42	5.9	72	35	-
193	36	7.4	78	14	-
194	42	-	-	25	-
195	36	9.2	84	40	428
196	36	10.5	88	46	652
197	54	11.1	88	26	392
198	54	8.5	80	12	-
199	54	7.3	76	25	-
200	48	8.5	79	23	-
201	52	9.7	-	8	170
202	48	8.6	79	15	179
203	48	7.4	78	8	144
204	48	10.2	87	16	154
205	48	10.5	81	16	-
206	48	8.5	74	30	-
207	48	9.7	88	15	364
208	48	11.0	83	60	-
209	60	8.9	78	17	336
210	62	9.0	86	32	294
211	60	6.7	78	48	-

contd...

Table 81a : contd.

subject no.	age (months)	weight (kg)	height (cm)	urinary excretion (mg/dl)	
				creatinine	total nitrogen
212	60	7.7	83	18	280
222	66	9.1	80	51	499
223	60	8.8	82	24	-
224	82	9.0	88	33	276
225	72	9.2	88	10	-
226	72	10.2	85	11	-
females					
262	42	-	-	35	619
263	36	6.0	69	24	279
264	42	7.0	76	12	591
265	42	7.9	80	14	235
266	36	7.3	74	20	286
267	42	9.7	82	16	280
268	36	8.5	82	77	641
269	36	7.4	77	4	-
270	39	6.9	81	14	-
271	42	7.7	76	54	-
272	36	9.9	81	20	-
273	36	9.5	72	18	-
274	54	8.5	81	21	-
275	48	6.1	62	28	347

contd...

Table 81a : contd.

subject no.	age (months)	weight (kg)	height (cm)	urinary excretion (mg/dl)	
				creatinine	total nitrogen
276	54	8.0	~~81~~ 79	~~2~~16	-
277	54	6.2	76	17	-
278	48	8.2	80	20	509
279	48	8.0	70	7	-
280	54	8.6	75	35	-
281	61	8.3	88	29	-
282	60	6.2	72	7	169
283	62	11.1	86	19	-
284	60	9.2	82	24	242
285	79	8.2	80	19	-
286	72	7.0	77	17	-
287	74	8.2	90	34	626
288	72	11.8	98	35	-
289	72	11.2	90	25	-
290	73	13.5	99	20	-
mean	52	8.5	81	25	360
s.d.	13	2.0	6.6	15	166
range	36-82	5.9-13.5	68-99	4-77	144-652

Table 81a : contd.

subject no.	age (months)	weight (kg)	height (cm)	creatinine (mg/dl)	total nitrogen (mg/dl)	nitrogen (mg/dl) excreted as: urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
malnourished and rehabilitated											
males											
227	48	10.3	99	36	543	358	45	403	13.4	18.8	108
228	83	13.2	101	25	210	143	41	184	9.3	9.7	-
229	79	9.6	90	35	510	292	52	344	12.8	17.8	135
230	32	8.6	71	27	213	126	36	162	10.0	13.8	27
231	39	11.5	87	30	453	313	56	369	10.9	8.8	64
232	37	7.3	73	17	218	89	75	164	6.1	9.5	38
233	43	-	-	19	-	97	32	129	7.1	7.8	-
234	60	14.5	99	50	655	-	46	-	18.6	22.1	-
235	54	10.6	89	24	431	247	55	302	8.9	10.8	109
236	51	10.5	80	50	784	491	91	582	18.6	29.1	154
females											
291	54	9.2	77	26	610	368	91	459	9.5	20.1	121
292	61	9.6	80	60	1400	934	116	1050	22.3	20.1	308
293	60	13.0	89	33	392	117	101	218	12.1	12.2	149
294	42	6.6	66	39	482	270	74	344	14.1	22.1	102
295	30	8.6	78	16	-	-	-	-	5.8	-	-
296	66	12.0	93	38	454	287	60	347	13.9	15.7	78
mean	53	10.3	85	33	525	295	65	361	12.2	15.9	116
s.d.	15	2.2	10.8	12.6	302	219	26	236	4.7	6.2	73
range	30-83	6.6-14.5	66-101	16-60	210-1400	89-934	32-116	129-1050	5.8-22.3	7.8-29.1	27-308

Table 82 : Contribution of various nitrogenous constituents to total nitrogen in malnourished children before and after dietary rehabilitation.

		total nitrogen (mg/dl)	% contribution to total nitrogen					
			urea	ammonia	urea + ammonia	creatinine	uric acid	undetermined
controls (n = 56)	m	589	65	7.9	74	3.0	2.9	19.9
	s.e.	47	1.50	0.45	0.99	0.15	0.14	1.07
	cv	60	17	43	10	37	34	37
malnourished (n = 8)	m	296***	49***	16.5*	65*	2.2**	4.7	27.7*
	s.e.	28	3.55	3.67	3.63	0.19	0.38	3.80
	cv	25	18	54	14	22	21	33
malnourished and rehabilitated@ (n = 16)	m	525	58*	15.0***	74	2.8	3.5	26
	s.e.	80	3.05	1.97	2.06	0.24	0.32	5.09
	cv	58	19	49	10	32	34	67

m, mean; s.e. standard error; cv - coefficient of variation.

values marked with asterisk significantly different from controls, p less than 0.05 for *, 0.01 for ** and 0.001 for ***.

@ given a diet at the Nutrition Rehabilitation Centre for 2-4 weeks and studied at varying intervals after discharge.

Table 83 : Contribution of various nitrogenous constituents to total nitrogen reported by other investigators.

investogators	total nitrogen (g)	% contribution to nitrogen						
		urea	ammonia	creatinine	creatine	uric acid	amino acid	undetermined
kwashiorkor								
Edozein and Phillips (1961)	3.80 *	41	20	3.8	2.5	6.8	25.0	-
Vasant Gadkar et al (1963)	0.67	51	16.8	2.6	2.1	-	8.6	22
Shendel and Hansen (1965)	0.75	41	21	2.8	3.3	2.5	4.9	23
Ramakrishna Rao et al (1973)	1.9	44	13.8	2.5	1.3	-	5.4	33
marasmus								
Vinodini Reddy et al (1963)	1.20	66	16.8	1.9	1.6	-	8.2	6.0

* Values per litre of urine

Table 84 : Weight gains of malnourished children subjected to dietary rehabilitation as compared to expected gains.

no.	weight (kg)		weight gain(kg)	expected* gain (kg)	$\frac{A}{B}$ x 100
	I	II	II - I (A)	(B)	
I	3.0	5.5	2.5	3.4	74
II	4.0	4.3	0.3	0.3	100
III	3.4	4.3	0.9	1.5	60
IV	4.1	6.8	2.7	3.1	87
V	4.1	5.4	1.3	3.0	43
VI	4.7	6.0	1.3	1.1	118
VII	7.5	9.6	2.1	1.8	117
VIII	7.1	7.3	0.2	0.8	25
IX	7.5	10.5	3.0	1.9	158
X	9.3	9.5	0.2	1.7	12
XI	8.4	10.0	1.6	1.6	100
XII	5.6	6.9	0.3	0.8	37
XIII	6.5	8.0	1.5	1.2	125
XIV	7.1	7.8	0.7	1.8	39
XV	8.7	9.5	0.8	0.6	133
XVI	9.4	12.5	3.1	1.9	163
XVII	9.2	10.8	1.6	0.4	400
XVIII	10.4	11.3	0.9	0.6	150
XIX	7.9	8.3	0.4	0.5	80
XX	6.4	8.3	1.9	1.9	100
XXI	10.5	11.0	0.5	0.6	83
XXII	14.4	16.0	1.6	3.2	50
XXIII	15.0	15.8	0.8	2.5	32
XXIV	16.5	19.5	3.0	1.1	273

I, at the time of discharge; II, at the time of follow up.
* on the basis of Boston norms for the corresponding ages.

Studies on nitrogen metabolism in rats in relation to the plane of nutrition

As mentioned earlier, experiments were carried out on rats in order to study, under more controlled conditions, the influence of protein status and undernutrition on creatinine exdretion. For this purpose studies were made of nitrogen and creatinine excretion in groups of animals fed diets varying in protein (0, 4, 5 or 20% protein) or food energy content (100, 50, or 33% of voluntary intakes). The carcass was also analysed for fat, nitrogen and creatine as creatinine.

In a second experiment in which groups of animals were fed 20, 10 or 5% protein, studies were made of food and fecal nitrogen in addition to urine nitrogen, creatinine and creatine but no analyses were made of the carcass.

As mentioned earlier, weanling albino rats were used in both experiments.

The results of the two experiments are presented in Table 85. The high protein animals in the two experiments differed presumably because of differences in growth rate and body weight. These in turn were probably due to differences in the period of treatment and environmental conditions. However, the low protein animals in the two experiments were essentially similar. This is perhaps not surprising as within group differences are often minimised by dietary restrictions and deficiencies.

Table 85 : Nitrogen metabolism in nutritional deficiency.

	no.of animals	body weight@ (g)	food intake g/day	nitrogen (mg/day) content			$\frac{B}{A}$ x 100	apparent digestibility	% nitrogen retained
				food A	feces B	urine			
% dietary protein				mean ± s.e. / cv					
				Experiment II, male and female rats were treated for 8 weeks					
20	4-6	208±15.0 / 18	12.6±1.6 / 32	403±53 / 32	48±4.2 / 20	84±19.4 / 51	11±1.7 / 31	0.88±0.01 / 3	79±4.9 / 13
10	6	158±9.2* / 14	14.1±1.0 / 18	226±16** / 18	23±2.5*** / 27	50±7.1 / 35	10±0.9 / 21	0.90±0.008 / 2	75±2.0 / 6
5	12	60±4.3*** / 25	4.1±0.4*** / 34	33±3.3*** / 34	5.4±0.6*** / 36	8±0.8*** / 32	17±1.7* / 34	0.83±0.02* / 7	69±2.5 / 13
				Experiment I, male rats were treated for 4-6 weeks					
20	10	126±7.7 / 19	9.1±0.4 / 14	292±12 / 13	-	62±5.9 / 30	-	-	-
5	7	62±1.1*** / 5	5.8±0.15*** / 7	47±1.2***q / 7	-	10±1.4*** / 36	-	-	-
4	5-7	45±3.4*** / 20	4.9±0.2*** / 11	31±1.3*** / 11	-	4.5±0.7*** / 34	-	-	-
% food restriction @@									
50	11	78±2.6*** / 11	4.6±0.15*** / 11	146±4.9*** / 11	-	43±4.2* / 32	-	-	-
67	4	68±5.3*** / 16	3.6±0.4*** / 20	114±11.3*** / 20	-	34±6.0** / 36	-	-	-

values marked with asterisk significantly different from controls. p less than 0.05 for *, 0.02 for ** and 0.001 for ***.

@ initial body weights ranged from 37-53 g.

@@ 50% and 33% of the ad lib. food intake of animals fed 20% protein diet.

Table 85a : Individual values for the data of Table 85.

animal no.	sex	body weight (g)	food intake g/day	nitrogen (mg/day) content			$\frac{B}{A}$ x 100	apparent digesti-bility	% nitrogen retained
				food (A)	feces (B)	urine			
1	2	3	4	5	6	7	8	9	10
20% protein			Experiment II, 8 weeks treatment,						
43	M	255	17.3	554	48.3	108	8.7	0.91	79
44	M	227	14.3	458	38.7	129	8.4	0.91	69
45	M	223	15.0	480	62.8	-	-	0.87	-
46	F	172	8.0	256	40.8	18.	15.9	0.84	92
47	F	156	7.3	234	145*	64	62.0*	0.38*	28*
48	F	214	13.7	438	48.3	101	11.0	0.89	74
mean	2 3	2080	1236	4030	48.0	84	11	0.88	79
s.d.		37	4.0	129	9.4	44	3.4	0.03	99
range		156-255	7.3-17.3	234-554	38.7-62.8	18-129	8.4-15.9	0.84-0.91	69-92
10% protein									
49	F	150	10.6	170	19.3	30.8	11.4	0.89	79
50	F	134	11.6	186	16.9	34.1	9.1	0.91	75
51	F	134	15.0	240	16.4	45.8	6.8	0.93	80
52	M	175	14.6	234	29.0	56.0	12.4	0.88	73
53	M	189	16.6	266	24.2	79.1	9.1	0.91	67
54	M	168	16.3	261	30.9	53.8	11.8	0.88	77

contd...

Table 85a : contd.

1	2	3	4	5	6	7	8	9	10
mean	♀	158	14.1	226	22.8	49.9	10.1	0.90	75
s.d.		23	2.5	40	6.2	17.5	02.1	0.02	4.8
range		134-189	10.6-16.6	170-266	16.4-30.9	30.8-79.1	6.8-12.4	0.88-0.93	67-80
5% protein									
55	M	61	6.3	50.4	5.8	12.0	11.5	0.88	74
56	M	78	5.3	42.4	5.3	7.7	12.5	0.88	77
57	M	69	5.3	42.4	5.3	11.2	12.5	0.88	70
58	M	83	5.6	44.0	8.0	12.2	18.2	0.82	67
59	M	66	3.0	24.0	22.9	7.7	12.1	0.88	62
60	M	63	4.6	37.0	4.3	8.3	11.6	0.88	73
61	M	76	3.6	29	8.3	7.8	28.6	0.71	63
62	F	44	3.3	26.4	3.5	8.0	13.1	0.88	65
63	F	51	5.0	40.0	8.2	5.4	20.6	0.80	83
64	F	42	3.0	24.0	5.7	4.2	23.8	0.76	77
65	F	49	3.0	24.0	4.1	6.8	17.1	0.83	66
66	F	40	1.6	12.8	2.9	5.0	22.6	0.77	50
mean		60	4.1	33.0	5.4	8.0	17.0	0.83	69
s.d.		14.8	1.4	11.3	2.0	2.6	5.8	0.06	9.7
range		40-83	1.6-6.3	12.8-50.4	2.9-8.3	4.2-12.0	11.5-28.6	0.71-0.88	50-83

contd...

Table 85a : contd.

animal no.	period of treatment (weeks)	body weight (g)	food intake g/day	nitrogen (mg/day) content	
				food	urine
20% protein		Experiment I, male rats			
1	5	140	10.3	323	61.3
2	5	160	11.0	352	67.2
3	5	160	10.5	336	83.0
4	5	101	7.0	227	45.4
5	4	100	8.0	256	79.0
6	4	102	9.8	314	41.3
7	4	109	9.1	291	56.0
8	4	118	8.6	275	92.0
9	6	119	8.4	269	37.4
10	6	148	8.7	278	52.2
mean		126	9.1	292	62.0
s.d.		24	±1.3	39	18.5
range		100-160	7.0-11.0	227-352	37.4-83.0
5% protein					
11	5	64.5	5.6	44.8	8.5
12	5	65	5.9	47.2	9.9
13	5	62	5.9	47.2	14.9
14	5	60	5.9	47.2	16.0

contd...

Table 85a : contd.

1	2	3	4	5	6
15	6	65	6.1	49.0	8.6
16	6	62	6.3	50.4	8.3
17	6	57	5.1	40.8	5.8
mean		62	5.8	46.7	10.3
s.d.		3.0	0.4	3.1	3.7
range		57-65	5.1-6.3	40.8-50.4	5.8-16.0
4% protein					
18	5	31	4.3	27.5	4.9
19	5	49	4.5	28.8	4.4
20	5	47	4.3	27.5	6.7
21	4	36	5.4	34.5	-
22	4	43	5.1	32.6	-
23	6	53	5.5	35.2	4.1
24	6	56	5.3	33.9	2.5
mean		45	4.9	31.4	4.5
s.d.		9	0.5	3.4	1.5
range		31-56	4.3-5.5	27.5-35.2	2.5-6.7
50% food restriction					
28	5	86	5.1	163	38.3
29	5	84	4.6	147	34.7
30	5	90	5.3	170	50.0

contd...

Table 85a : contd.

1	2	3	4	5	6
31	5	85	5.2	166	18.3
32	5	67.5	3.7	118	37.8
33	4	63	4.1	131	40.3
34	4	80	4.9	157	74.0
35	4	74	4.6	147	50.4
36	4	70	4.2	134	42.0
37	6	80	4.3	137	48.5
38	6	80	4.3	137	34.2
mean		78	4.6	146	42.6
s.d.		8.5	0.5	16.3	13.8
range		63-90	3.7-5.3	118-160	18.3-74.0
67% food restriction					
39	5	68.5	3.4	109	31.8
40	5	68.0	3.5	112	27.4
41	6	54	2.8	89	23.6
42	6	80	4.5	144	51.3
mean		67.6	3.6	114	33.5
s.d.		10.6	0.7	22.7	12.0
range		54-80	2.8-4.5	89-144	23.6-51.3

* not included in calculating mean.

The data on food intakes and weight gain are presented in Fig. 2 and 3. Food intakes were compared with expected rate of basal metabolism under normal conditions (Table 86). It is obvious from the data that in undernourished animals the food intake is far less than what is required for maintaining the normal rate of growth suggesting a marked reduction in basal metabolism in these animals. As much as 40% reduction in basal metabolism was found in human studies (Keys et al, 1950) and an appreciable reduction was found in the previous studies on rats in this laboratory (Ramachandran, unpublished).

Creatinine excretion seems to vary both with the protein content of the diet and with undernutrition but these differences are abolished in the undernourished animals when the values are considered in terms of either body weight or surface area (Table 87). With a low protein diet, the same was true when creatinine excretion was considered per sq.m. of body surface but on a body weight basis the creatinine coefficient was higher. The groups fed a protein-free diet, however, showed no such increase. Das and Waterlow (1974) have reported an increase in creatinine-weight coefficient with a protein-free diet but this observation appears to have been made on only one animal. In the present study the individual values for the group fed the protein-free diet

FIG. 2.
EFFECT OF PROTEIN DEFICIENCY
ON FOOD INTAKE IN THE RAT

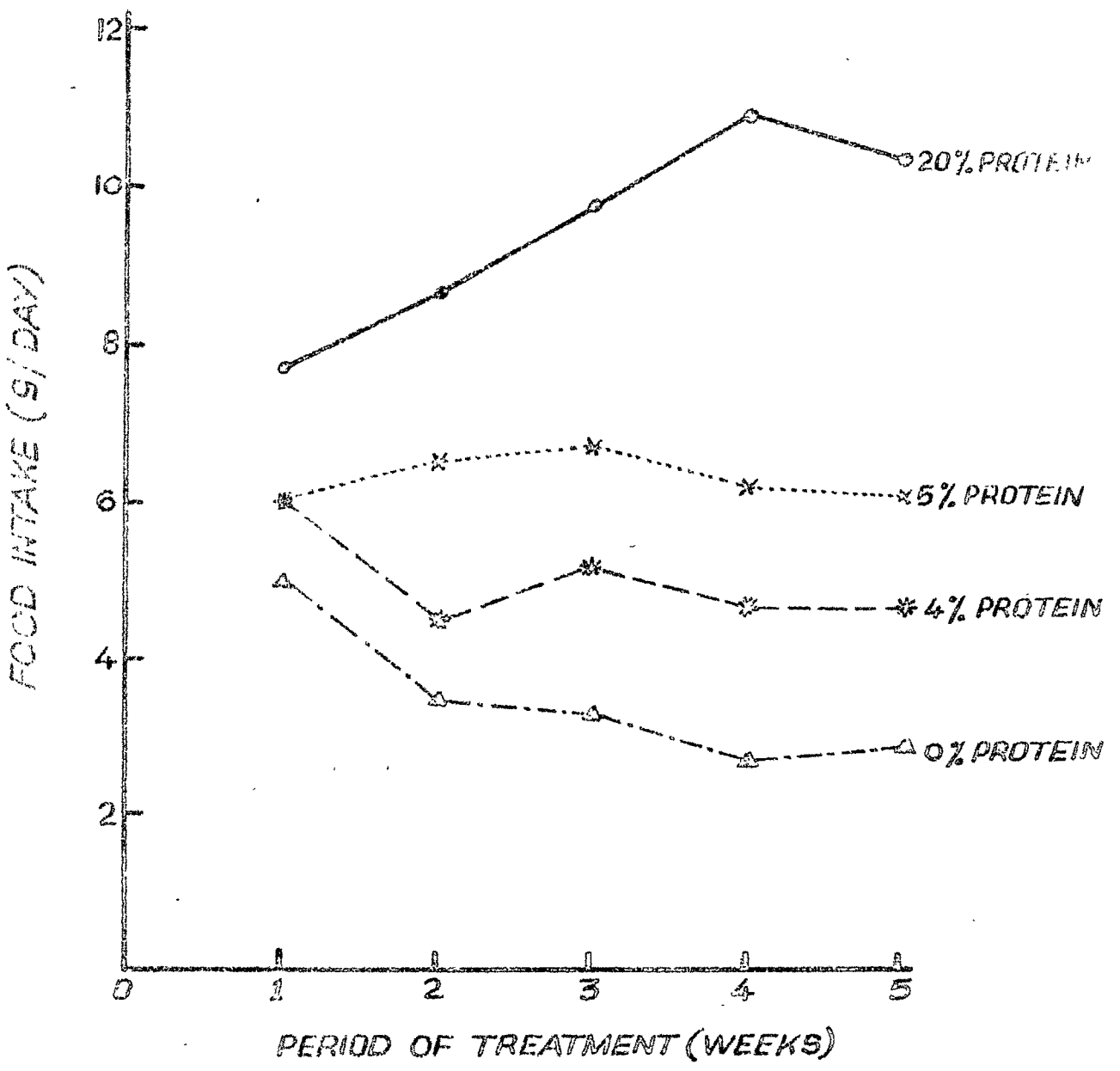

FIG. 3

EFFECT OF PROTEIN DEFICIENCY OR FOOD RESTRICTION ON GROWTH OF RATS.

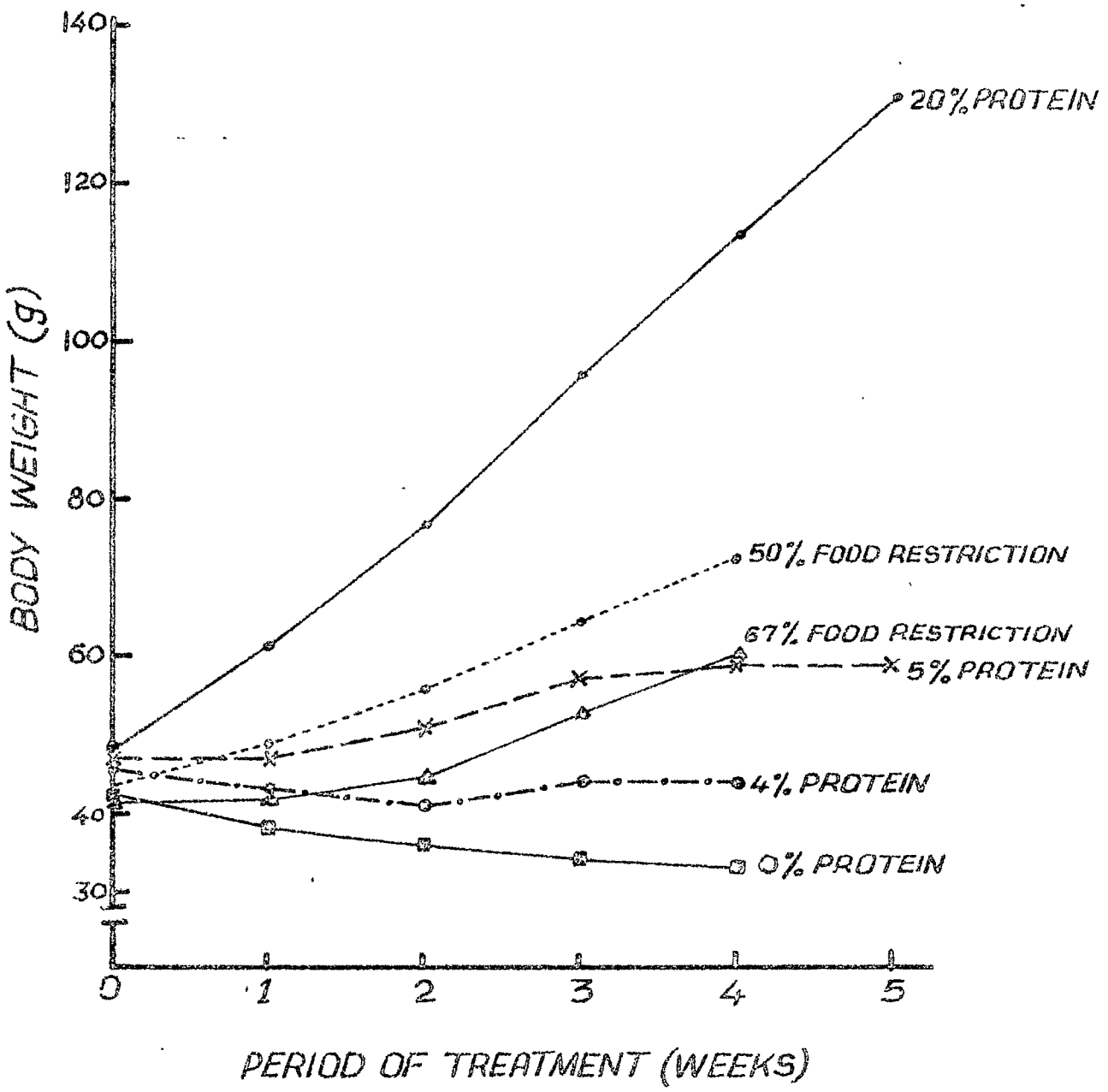

Table 86 : Estimated calories available for basal metabolism in undernourished and control rats.

	control	food restriction*	
	20% protein	50%	67%
body weight (g)	114	73	60
weight gain (g) per day[1]	2.6	1.1	1.0
food intake (g) per day	11	5.6	3.8
food calories[2]	45.1	23	15.6
available calories[3]	40.6	20.7	14.0
calories needed for :			
tissue gain[4]	5.2	2.2	2.0
activity[5]	2.3	1.5	1.2
BMR calories available	33.3	17	10.8

* 50% and 33% of the ad lib. food intake of animals fed 20% protein diet.

1. on the basis of values for the 4th week of treatment.
2. 1g. of food provided 4.1 calories.
3. assuming 90% availability.
4. assuming that one gram of tissue gain during growth represents 2 calories.
5. allowing 2 calories per 100g body weight.

Table 87 : Creatinine excretion in rats during protein deficiency and undernutrition.

	experiment	sex	no.of animals	period of treatment (weeks)	body weight (g)	surface area (sq.m.)	creatinine (mg) excretion per day	creatinine (mg) excretion per kg	creatinine (mg) excretion per sq.m.
% dietary protein							mean ± s.e. CV		
20	II	M+F	6	8	208±15 18	0.035±0.002 11	4.8±0.37 19	24±2.1 22	138±11 19
10	II	M+F	6	8	158±9.2* 14	0.029±0.001 10	4.1±0.40 24	26±1.9 19	141±11 19
5	II	M+F	12	8	60±4.3*** 25	0.015±0.0008 20	2.3±0.22*** 33	39±3.1** 28	152±12 28
5	I	M	7	5-6	62±1.1*** 5	0.016±0.0002 3	2.4±0.20*** 23	39±3.6** 25	152±14 24
4	I	M	7	4-6	45±3.4*** 20	0.013±0.0007 16	1.7±0.22*** 34	47±8.1* 46	152±21 37
0	I	M	3	4-5	32±2.7*** 14	0.010±0.0006 10	0.98±0.22*** 40	30±5.1 29	96±18 33
20	I	M	10	4-6	126±7.7 19	0.025±0.001 12	2.6±0.25 30	22±2.8 41	106±12 37
% food restriction@									
50	I	M	11	4-6	78±2.6*** 11	0.018±0.0003 6	1.6±0.19** 40	22±2.6 42	87±11 41
67	I	M	3	5-6	72±3.9*** 9	0.017±0.0006 6	1.8±0.42 40	25±4.8 34	102±21 36

M, male; F, female

values marked with asterisk significantly different from controls, p less than 0.05 for *, 0.01 for ** and 0.001 for ***.

@ 50% and 33% of the ad lib. food intake of animals fed 20% protein diet.

Table 87a : Individual values for the data of Table 87.

animal no.	body weight (g)	surface area (sq.m.)	creatinine (mg) excretion per		
			day	kg	sq.m.
1	2	3	4	5	6
20% protein :	Experiment II, male and female rats were treated for 8 weeks				
43	255	0.040	5.1	19.8	126
44	227	0.037	5.0	22.0	134
45	223	0.037	4.9	22.0	133
46	172	0.031	3.1	18.0	100
47	156	0.029	5.1	32.6	176
48	214	0.036	5.8	26.9	161
mean	208	0.035	4.8	24.0	138
s.d.	37	0.004	0.9	5.3	26.8
range	156-255	0.029-0.040	3.1-5.8	18.0-32.6	100-176
10% protein					
49	150	0.028	4.4	29.2	155
50	134	0.026	4.0	30.1	154
51	134	0.026	2.8	20.5	105
52	175	0.031	3.4	19.4	109
53	189	0.033	5.5	29.2	168
54	168	0.031	4.6	27.5	152
mean	158	0.029	4.1	25.9	141
s.d.	23	0.003	1.0	4.8	27
range	134-189	0.026-0.033	2.8-5.5	19.4-30.1	105-168

contd...

Table 87a : contd.

1	2	3	4	5	6
5% protein					
55	61	0.016	3.1	50.0	157
56	78	0.018	2.9	36.5	156
57	69	0.017	2.1	30.4	125
58	83	0.019	3.2	38.0	166
59	66	0.016	1.5	22.3	90
60	63	0.016	3.6	57.0	228
61	76	0.018	2.5	32.2	136
62	44	0.013	2.1	48.3	170
63	51	0.014	2.0	39.4	146
64	42	0.012	1.2	27.9	97
65	49	0.013	2.6	53.4	196
66	40	0.012	1.3	33.0	113
mean	60	0.015	2.3	39.0	152
s.d.	14.8	0.003	0.8	10.9	42
range	40-83	0.012-0.019	1.2-3.6	22.3-57.0	90-228
20% protein	Experiment I, male rats were treated for 4-6 weeks				
1	140	0.027	2.8	19.8	103
2	160	0.030	1.6	10.0	54
3	160	0.030	1.4	8.4	45
4	101	0.022	2.4	23.6	110

contd...

Table 87a : contd.

1	2	3	4	5	6
5	100	0.022	3.3	33.3	155
6	102	0.022	2.9	28.8	135
7	109	0.023	2.6	23.9	114
8	118	0.024	4.0	33.6	164
9	119	0.024	2.4	20.5	101
10	148	0.028	2.2	14.9	79
mean	126	0.025	2.6	21.7	106
s.d.	24	0.003	0.77	8.8	39
range	100-160	0.022-0.030	1.4-4.0	8.4-33.6	45-164
5% protein					
11	65	0.016	2.5	38.1	153
12	65	0.016	2.6	40.5	162
13	62	0.016	2.7	43.1	170
14	60	0.015	3.0	50.0	196
15	65	0.016	1.7	25.5	102
16	62	0.016	1.6	25.8	102
17	57	0.015	2.7	46.7	179
mean	62	0.016	2.4	38.5	152
s.d.	3.0	0.0005	0.54	9.6	37
range	57-65	0.015-0.016	1.6-3.0	25.5-50.0	102-196

contd...

Table 87a : contd.

1	2	3	4	5	6
4% protein					
18	31	0.001	2.7	87.7	275
19	49	0.013	1.5	31.2	114
20	47	0.013	1.6	34.0	123
21	56	0.011	1.4	40.0	132
22	43	0.012	1.6	37.9	133
23	53	0.014	0.8	66.0	158
24	56	0.015	1.9	32.7	127
mean	45	0.013	1.7	47.1	152
s.d.	3.4	0.002	0.57	21.5	56
range	31-56	0.001-0.015	0.8-2.7	32.7-87.7	114-275
0%					
25	27	0.009	0.6	23.6	70
26	34	0.011	0.9	26.5	86
27	35	0.011	1.4	40.0	131
mean	32	0.01	0.98	30.0	96
s.d.	4.6	0.001	0.39	8.8	32
range	27-35	0.009-0.011	0.9-1.4	23.6-40.0	70-131

contd...

Table 87a : contd.

1	2	3	4	5	6
50% food restriction					
28	86	0.020	0.9	10.3	45
29	84	0.019	1.2	14.3	63
30	90	0.020	1.5	16.9	76
31	85	0.019	1.1	12.4	54
32	68	0.017	1.2	17.8	72
33	63	0.016	1.7	27.4	107
34	80	0.019	3.1	38.8	166
35	74	0.018	2.1	28.4	119
36	70	0.017	1.8	26.1	108
37	80	0.019	1.6	20.0	86
38	80	0.019	1.1	13.2	57
mean	78	0.019	1.6	20.5	87
s.d.	8.5	0.001	0.63	8.7	36
range	63-90	0.016-0.020	0.9-3.1	10.3-38.8	45-166
67% food restriction					
39	69	0.017	1.0	15.0	62
40	68	0.017	1.9	27.4	111
42	80	0.019	2.5	31.2	134
mean	72	0.017	1.8	24.5	102
s.d.	6.8	0.001	0.73	8.4	37
range	68-80	0.017-0.019	1.0-2.5	15.0-31.2	62-134

were 24, 27 and 40 mg/kg with one animal showing an apparently higher coefficient than the controls.

An essentially similar picture was obtained when the values were considered in terms of fat free body mass (Table 88). Because of the difficulties in getting complete urine collections, the question arises regarding the reliability of the values obtained for creatinine excretion. The percentage of creatine to total creatinine (creatine to creatinine) was significantly higher in rats fed low protein diet, but in absolute terms creatine excretion failed to reach the level of significance (Table 89). The values obtained in this study compare with that of Nakagawa et al (1974). (Table 90). The values from other reports are not comparable since age (Chinn, 1966; Kumar et al, 1959; Nischiza et al, 1977; Sitren and Fisher, 1977), diets (Milner et al, 1974; Hsu and Anthony, 1975; Everett and Apagar, 1977) and period of treatments (Das and Waterlow, 1974; Kumar et al, 1959; Chinn, 1966) were different from that of present study.

However, some underestimation is possible on the basis of the data obtained on nitrogen balance in the second experiment in which the amount of nitrogen retained seemed more than what would be expected on the basis of body weight gain. However, a careful analysis of nitrogen balance data in relation to

Table 88 : Creatinine in relation to body composition in protein deficiency and undernutrition.

	no. of animals	fat free body weight (g)	creatinine (mg)		per 100 g of fat free weight		creatine turnover $\frac{A}{B}$ X 100
			urinary (A)	carcass (B)	urinary creatinine (mg)	carcass creatinine (mg)	
% dietary protein				mean $\pm$ s.e. CV			
20	4	105±10 / 19	2.4±0.4 / 34	164±13.8 / 17	2.4±0.57 / 48	156±4.6 / 6	1.5±0.37 / 50
5	3-4	54±1.3*** / 5	2.4±0.2 / 20	87±5.7*** / 11	4.3±0.47 / 22	158±6.5 / 8	2.6±0.43 / 29
4	4-5	38±2.8*** / 17	1.6±0.31 / 43	48.3±7.1*** / 33	4.6±1.2 / 60	143±4.1 / 6	3.9±1.0 / 59
0	2	28±2.5*** / 8	0.8±0.14*** / 24	34.3±3.4*** / 14	2.6±0.25 / 13	128±23 / 25	2.3±0.62 / 39
% food restriction@							
50	5	72±3.6 / 11	1.4±0.15 / 24	106±1.0 / 2	1.9±0.25 / 29	149±7.2 / 11	1.3±0.12 / 22
67	2-3	59±4.5 / 13	1.5±0.42 / 41	78±8.1 / 18	2.3±0.71 / 43	132±9.4 / 12	1.9±0.78 / 58

values marked with asterisk significantly different from controls, p less than 0.001 for ***.

@ 50% and 33% of the ad lib. food intake of animals fed 20% protein diet.

Table 88a : Individual values for the data of Table 88.

	fat free body weight (g)	creatinine (mg)		per 100 g fat free weight		creatine turnover $\frac{A}{B}$ X 100
		urinary (A)	carcass (B)	urinary creatinine (mg)	carcass creatinine (mg)	
1	2	3	4	5	6	7
20% protein						
3	133.6	1.4	194.0	1.0	146	0.7
4	94.8	2.4	150	2.5	158	1.6
5	87.1	3.3	133	3.8	152	2.5
6	105.5	2.4	178	2.3	168	1.3
mean	105.3	2.4	164	2.4	156	1.5
s.d.	20.0	0.81	28	1.14	9.3	0.75
range	87.1-133.6	1.4-3.3	133-194	1.0-3.8	146-168	0.7-2.5
5% protein						
11	58.2	2.5	97	4.2	167	2.5
12	54.0	2.6	119	4.9	143	3.4
13	52.2	2.7	-	5.1	-	-
16	53.0	1.6	87	3.0	164	1.9
mean	54.4	2.4	87.1	4.3	158	2.6
s.d.	2.6	0.47	9.8	0.95	13	0.75
range	52.2-58.2	1.6-2.7	87-119	3.0-5.1	143-167	1.9-3.4

contd...

Table 88a : contd.

1	2	3	4	5	6	7
4% protein						
18	29.5	2.7	39.0	9.2	132	7.0
19	42.0	1.5	27.9	3.6	66*	5.5
20	40.4	1.6	58.0	4.0	143	2.8
21	33.6	1.4	48.4	4.3	144	3.0
23	44.9	0.8	68.4	1.8	152	1.2
mean	38.1	1.6	48.3	4.6	143	3.9
s.d.	6.3	0.69	15.8	2.8	8.2	2.3
range	29.5-44.9	0.8-2.7	27.9-68.4	1.8-9.2	132-152	1.2-7.0
0% protein						
25	25.8	0.6	37.6	2.4	146	1.7
26	30.8	0.9	31.0	2.9	101	2.9
mean	28.3	0.8	34.3	2.6	128	2.3
s.d.	3.5	0.19	4.7	0.35	32	0.86
range	25.6-30.8	0.6-0.9	31.0-37.6	2.4-2.9	101-146	1.7-2.9
50% food restriction						
28	76.4	0.9	105.8	1.2	138	0.8
30	81.9	1.5	109.6	1.9	134	1.4
32	66.5	1.2	103.5	1.8	156	1.2
33	61.2	1.7	105.9	2.7	173	1.5

contd...

Table 88a : contd.

1	2	3	4	5	6	7
37	75.0	1.6	106.2	2.1	142	1.4
mean	72.2	1.4	106.2	1.9	149	1.3
s.d.	8.3	0.33	2.2	0.56	16	0.27
range	61.2-81.9	0.9-1.7	103.5-109.6	1.2-2.7	134-173	0.8-1.5
67% food restriction						
39	65.4	1.0	93.9	1.6	144	1.1
40	61.5	1.9	69.3	3.0	113	2.7
41	50.3	-	69.5	-	138	-
mean	59.0	1.45	77.6	2.3	132	1.9
s.d.	7.8	0.59	14.1	1.0	16.3	1.1
range	50.3-65.4	1.0-1.9	69.3-93.9	1.6-3.0	113-144	1.1-2.7

Table 89 : Urinary excretion of creatine and creatinine in protein deficiency in rats.

	% dietary protein		
	20	10	5
	mean ± s.e. / cv		
creatine (mg)	1.7 ± 0.44 / 58	1.35 ± 0.28 / 46	2.4 ± 0.52 / 75
creatinine (mg)	4.8 ± 0.37 / 19	4.1 ± 0.40 / 24	2.3 ± 0.22*** / 33
creatine / creatinine	0.36 ± 0.08 / 50	0.36 ± 0.09 / 59	1.0 ± 0.18*** / 61
creatine as % of creatine + creatinine	25.0 ± 4.6 / 42	25.0 ± 4.5 / 40	46.0 ± 4.8*** / 37
creatine + creatinine N as % total nitrogen	3.7 ± 1.0 / 62	4.3 ± 0.79 / 41	19.8 ± 1.4*** / 24

values marked with asterisk significantly different from controls, p less than 0.001 for ***.

Table 89a : Individual values for the data of Table 89.

animal no.	urinary excretion of		creatine / creatinine	$\frac{A}{A+B} \times 100$
	creatine (mg) A	creatinine (mg) B	A/B	
1	2	3	4	5
20% protein				
43	2.82	5.06	0.56	36
44	2.35	5.0	0.47	32
45	-	4.9	-	-
46	0.79	3.1	0.26	20
47	2.0	5.1	0.39	28
48	0.56	5.8	0.10	9
mean	1.70	4.8	0.36	24.6
s.d.	0.99	0.9	0.18	10.4
range	0.56-2.82	3.1-5.8	0.10-0.56	9-36
10% protein				
49	0.82	4.38	0.42	29
50	0.66	4.03	0.16	14
51	1.90	2.76	0.69	40
52	0.70	3.4	0.21	19
53	1.69	5.52	0.31	23
54	-	4.63	-	-
mean	1.35	4.12	0.36	25
s.d.	0.62	0.97	0.21	10
range	0.66-1.90	2.76-5.52	0.16-0.69	14-40

contd...

Table 89a : contd.

1	2	3	4	5
5% protein				
55	4.7	3.05	1.54	61
56	3.56	2.85	1.25	56
57	3.9	2.1	1.86	65
58	6.21	3.15	1.97	66
59	2.29	1.47	1.56	61
60	1.51	3.6	0.42	30
61	0.36	2.45	0.15	13
62	1.76	2.13	0.83	45
63	1.53	2.01	0.76	43
64	0.43	1.17	0.37	27
65	1.65	2.63	0.63	39
66	0.97	1.32	0.74	42
mean	2.4	2.33	1.0	46
s.d.	1.8	0.76	0.61	16.8
range	0.36-6.21	1.17-3.6	0.15-1.86	13-65

Table 90 : Reported values for creatinine excretion in rats with variations in dietary protein.

investigator	period of treatment (weeks)	% dietary protein			
		10	18	27	36
		creatinine (mg/day)			
Nakagawa et al (1974)	1-2	1.69	1.49	1.57	1.62
"	5	3.02	3.8	4.02	4.2
"	13	5.37	6.25	6.2	6.3
"	18-22	6.25	6.25	6.6	6.9
present study	8	4.12	4.82*	-	-
		creatinine (mg/kg)			
Nakagawa et al (1974)	1-2	23.6	22.3	23.4	23.2
"	5	23.0	27.2	27.9	29.8
"	13	23.7	26.6	26.4	26.5
"	18-22	24.9	24.9	25.4	26.3
present study	8	26	24.0*	-	-

* 20% protein

expected retention on the basis of body weight does not suggest differences in the degree of underestimation. Therefore, it is reasonable to conclude that although the absolute values may be in error, the comparative picture obtained might still be valid.

The data obtained on the nitrogen balance studies suggest an apparent digestibility of 83% in the low protein group and 88% in other two groups. This is consistent with the expectation, on the basis of the increased endogenous losses through intestinal route in protein deficiency (Platt et al, 1964). In this connection, Araya and his associates (Araya, Araya and Tagle, 1974) reported a correlation between endogenous loss and dry weight of the diet on one hand and metabolic weight in $Kg^{0.73}$ on the other hand. With these kinds of relationships the endogenous loss expected to be relatively low in low protein diets. When the equation given by them is applied to the present data the values derived for endogeous losses for low (5%) and high (20%) protein animals are 22% and 6% of dietary nitrogen.

The data on carcass composition were shown in Tables 91 and 92. No change in percent moisture content was observed with protein deficiency consistent with observations made by Widdowson and McCance (1957). This contrasts with the situation in children in whom edema is common feature of severe protein deficiency. However, it is well known that the

Table 91 : Composition of carcass of protein-deficient and undernourished rats.

	no. of animals	carcass composition				
		fresh weight (g)	dry weight (g)	moisture (g)	fat (g)	protein (g)
% dietary protein :				mean ± s.e. cv		
20	4	120 ± 14.0 23	42.2 ± 6.5 31	77.8 ± 7.8 20	14.6 ± 4.2 58	19.2 ± 1.7 17
5	4	64 ± 0.7*** 2	23.0 ± 0.9* 8	40.0 ± 1.5*** 7	8.7 ± 1.7 25	9.2 ± 0.8*** 11
4	5	43 ± 4.2*** 22	14.5 ± 2.1** 33	28.7 ± 2.1*** 16	5.4 ± 1.3 52	6.4 ± 1.1*** 39
0	2	30 ± 3.8*** 17	6.9 ± 1.9*** 39	23.4 ± 1.9*** 11	1.9 ± 1.2* 89	3.3 ± 0.25*** 11
% food restriction@						
50	5	77 ± 5.2* 15	22.3 ± 2.0* 20	53.8 ± 2.9* 12	4.1 ± 1.2* 67	12.4 ± 1.1** 19
67	3	64 ± 4.7** 13	19.3 ± 1.3** 12	44.2 ± 4.0** 16	4.4 ± 0.9* 34	10.3 ± 0.5*** 8

values marked with asterisk significantly different from controls, p less than 0.05 for *, 0.01 for ** and 0.001 for ***.

@ 50% and 33% of the ad lib. foods intake of animals fed 20% protein diet.

Table 91a : Individual values for the data of Table 91.

animal no.	carcass composition				
	fresh weight (g)	dry weight (g)	moisture (g)	fat (g)	protein (g)
1	2	3	4	5	6
20% protein					
3	160	60.5	99.5	26.4	21.5
4	101	30.4	70.6	6.5	14.4
5	100	37.0	63.0	12.4	19.4
9	119	40.8	78.2	13.2	21.5
mean	120	42.2	77.8	14.6	19.2
s.d.	29	13.0	15.7	8.4	3.4
range	100-160	30.4-60.5	63.0-99.5	6.5-26.4	14.4-21.5
5% protein					
11	65	21.0	43.5	6.0	9.3
12	65	23.9	41.1	10.4	8.1
13	62	25.0	37.0	10.5	8.0
15	65	22.1	38.5	8.0	11.5
mean	64	23.0	40.0	8.7	9.2
s.d.	1.5	1.8	2.9	2.2	1.6
range	62-65	21.0-25.0	37.0-43.5	6.0-10.5	8.0-9.3

contd...

Table 91a : contd.

1	2	3	4	5	6
4% protein					
18	31	8.0	23.0	2.3	3.3
19	49	16.3	32.7	6.9	5.2
20	47	17.0	30.0	6.8	6.2
21	36	11.2	24.8	2.5	6.9
23	53	20.1	32.9	8.4	10.1
mean	43	14.5	28.7	5.4	6.4
s.d.	9.3	4.8	4.6	2.8	2.5
range	31-53	8.0-20.1	23.0-32.9	2.3-8.4	3.3-10.1
0% protein					
25	27	5.0	21.5	0.7	3.0
26	34	8.8	25.2	3.1	3.5
mean	30.0	6.9	23.4	1.9	3.3
s.d.	5.3	2.7	2.6	1.7	0.35
range	27-36	5.0-8.8	21.5-25.2	0.7-3.1	3.0-3.5
50% food restriction					
28	86	23.0	57.0	3.7	11.0
30	90	28.4	61.6	7.9	11.7
32	68	17.7	49.8	1.3	9.8
33	63	18.1	44.9	2.0	13.8
37	80	24.3	55.7	5.4	15.8

contd...

Table 91a : contd.

1	2	3	4	5	6
mean	77	22.3	53.8	4.1	12.4
s.d.	11.7	4.5	6.5	2.7	2.4
range	63-90	17.7-28.4	44.9-61.6	1.3-7.9	9.8-15.8
67% food restriction					
39	69	18.5	50.0	3.4	10.0
40	68.	21.9	46.1	6.1	9.8
41	54	17.6	36.4	3.6	11.2
mean	64	19.3	44.2	4.4	10.3
s.d.	8.2	2.3	7.0	1.5	0.8
range	54-69	17.6-21.9	36.4-50.0	3.4-6.1	9.8-11.2

Table 92 : Composition of carcass of protein-deficient and undernourished rats.

	no. of animals	fresh weight (carcass) (g)	values as % of carcass weight			
			dry weight	moisture	fat	protein
% dietary protein				mean ± s.e. / cv		
20	4	120 ± 14.0 / 23	34.8 ± 1.7 / 10	65.0 ± 1.7 / 5	11.6 ± 2.1 / 36	16.3 ± 1.4 / 18
5	4	64 ± 0.7*** / 2	35.9 ± 1.6 / 9	62.6 ± 1.9 / 6	13.6 ± 1.7 / 26	14.4 ± 1.2 / 17
4	5	43 ± 4.2*** / 22	32.8 ± 2.1 / 14	67.1 ± 2.1 / 7	11.7 ± 1.9 / 36	14.6 ± 1.9 / 29
0	2	30 ± 3.8*** / 17	22.4 ± 3.5** / 22	77.5 ± 3.5** / 6	5.9 ± 3.3 / 79	10.8 ± 0.5** / 7
% food restriction@						
50	5	77 ± 5.2* / 15	28.7 ± 1.1** / 8	69.9 ± 1.3* / 4	5.0 ± 1.3* / 56	16.4 ± 1.8 / 25
67	3	64 ± 4.7** / 13	30.6 ± 1.8 / 10	69.4 ± 1.8 / 4	6.9 ± 1.1 / 29	16.6 ± 2.1 / 22

values marked with asterisk significantly different from controls, p less than 0.05 for *, 0.01 for ** and 0.001 for ***.

@ 50% and 33% of the ad lib. food intake of animals fed 20% protein diet.

clinical syndromes of protein deficiency with edema is not readily induced in rats, presumably because of reduced food intakes as the symptoms are induced when they are force-fed (Theophilus and Barnes, 1974). An increase in moisture content was found with undernutrition which was rather unexpected as generally undernutrition was associated with a reduced body size but no appreciable change in parameters such as blood hemoglobin and serum protein.

In other studies in the department protein deficiency but not undernutrition was associated with an increased moisture content in the bone (Upadhyaya, 1974; Dave, 1976).

In children, the presence of edema is taken as an index of protein deficiency, rather than plain undernutrition. However weight loss during dietary rehabilitation was found occasionally both in supplementary feeding programmes, organized for moderate undernutrition in a village near Baroda. Water retention with out localised edema at the extremities may go undetected in such cases.

The fat content of the body was reduced both with complete protein deprivation and undernutrition. This is consistent with expectation. The decrease in protein content with protein deficiency and not with undernutrition is as expected.

As already mentioned, creatinine content of fat-free body weight was not affected with a low protein diet but decreased with a protein-free diet although the differences fails to reach the significance because of the small number of observations. These observations suggest that creatinine content is reduced only under condition of tissue breakdown. Creatinine excretion was considered in relation to carcass creatinine and expressed as per cent of the latter. These studies suggest a higher turnover of creatine in the low protein animals (Table 88). This is consistent with the higher creatinine coefficient in the present studies.

Regarding the percentage contribution of various nitrogen constituents to total nitrogen (Tables 93 and 94) the contribution of urea and ammonia nitrogen was decreased with protein deficiency, whereas the reverse was found in the case of creatinine, uric acid and undetermined nitrogen. These are consistent with expectation as urea and ammonia nitrogen are derived primarily from dietary nitrogen whereas the other constituents are more influenced by endogenous metabolism.

No significant differences were found with food restriction either at the 50% or 67% levels.

In conclusion, both protein deficiency and undernutrition resulted in a decreased excretion of creatinine, but the differences were abolished when the values were considered in

Table 93 : Nitrogenous constituents in urine in protein-deficient and undernourished rats.

	experiment$	no.of animals	total nitrogen (mg)	nitrogen (mg) excreted as				
				urea + ammonia	creatinine	creatine	uric acid	undetermined
% dietary protein						mean ± s.e. CV		
20	I	10	62±5.9 / 30	51.6±5.1 / 31	0.95±0.09 / 30	-	0.25±0.04 / 54	8.6±2.5 / 91
	II	5-6	84±19.4 / 52	-	1.79±0.13 / 18	0.54±0.14 / 59	-	-
10	II	5-6	50±7.1 / 35	-	1.53±0.15 / 24	0.43±0.09 / 46	-	-
5	I	7	10±1.4*** / 36	7.3 &1.14*** / 38	0.88±0.08 / 23	-	0.06±0.009*** / 43	2.8±0.29* / 25
	II	12	8±0.8*** / 32	-	0.87±0.08*** / 33	0.77±0.17 / 75	-	-
4	I	3-7	4.5±0.7*** / 34	2.5±0.8*** / 56	0.62±0.08* / 34	-	0.04±0.004*** / 29	2.1±0.29* / 23
% food restriction@								
50	I	11	43±4.2* / 32	32.1±2.4** / 25	0.58±0.07** / 40	-	0.17±0.020 / 36	9.8±2.5 / 85
67	I	3-4	34±6.0** / 36	31.0±5.1* / 29	0.67±0.16 / 40	-	0.08±0.017** / 41	5.1±2.2 / 74

$ details same as for Table 95.

values marked with asterisk ~~with~~ significantly different from controls, p less than 0.05 for *, 0.01 for ** and 0.001 for ***.

@ 50% and 33% of the ad lib. food intake of animals fed 20% protein diet.

Table 93a : Individual values for the data of Table 93.

animal no.	total nitrogen (mg)	nitrogen (mg) excreted as			
		urea + ammonia	creatinine	uric acid	undetermined
1	2	3	4	5	6
20% protein : Experiment I					
1	61.3	53.4	1.03	0.20	6.7
2	67.2	58.5	0.59	0.32	7.8
3	83.0	78.0	0.50	0.47	4.0
4	45.4	34.7	0.88	0.16	9.7
5	79.0	74.6	1.24	0.30	2.9
6	41.3	38.0	1.09	0.18	2.0
7	56.0	40.6	0.96	0.22	14.2
8	92.0	61.9	1.47	0.45	28.2
9	37.4	34.0	0.91	0.11	2.4
10	52.2	42.4	0.82	0.08	8.9
mean	62.0	51.6	0.95	0.25	8.6
s.d.	18.5	16.2	0.29	0.13	7.8
range	37.4-83.0	34.0-78.0	0.50-1.47	0.08-0.47	200-28.2
5% protein					
11	8.5	5.7	0.91	0.04	1.8
12	9.9	5.6	0.98	0.07	3.2
13	14.9	10.7	0.99	0.10	3.1
14	16.0	11.1	1.11	0.08	3.7
15	8.6	5.1	0.62	0.03	2.9
16	8.3	5.6	0.59	0.04	2.1
17	5.8	-	0.99	0.05	-
mean	10.3	7.3	0.88	0.06	2.8
s.d.	3.7	2.8	0.20	0.02	0.71
range	5.8-16.0	5.1-11.1	0.59-1.11	0.03-0.10	1.8-3.7

contd...

Table 93a : contd.

1	2	3	4	5	6
4% protein					
18	4.9	1.3	1.01	0.04	2.6
19	4.4	2.2	0.57	0.03	1.6
20	6.7	4.0	0.59	0.06	2.1
21	-	-	0.53	0.05	-
22	-	-	0.60	0.05	-
23	4.1	-	0.30	0.03	-
24	2.5	-	0.69	0.03	-
mean	4.5	2.5	0.62	0.04	2.1
s.d.	1.5	1.4	0.21	0.012	0.5
range	2.5-6.7	1.3-4.0	0.30-1.01	0.03-0.06	1.6-2.6
50% food restriction					
28	38.3	34.1	0.33	0.14	3.7
29	34.7	32.2	0.45	0.15	1.9
30	50.0	42.1	0.56	0.19	7.1
31	18.3	16.3	0.39	0.10	1.5
32	37.8	32.8	0.45	0.15	4.4
33	40.3	23.9	0.62	0.15	15.6
34	74.0	41.9	1.15	0.19	30.8
35	50.4	37.0	0.78	0.30	12.4
36	42.0	30.3	0.68	0.23	10.8
37	48.5	38.2	0.59	0.14	9.6
38	34.2	23.8	0.39	0.08	9.9
mean	42.6	32.1	0.58	0.17	9.8
s.d.	13.8	8.1	0.23	0.06	8.3
range	18.3-74.0	16.3-42.1	0.33-1.15	0.08-0.30	1.9-30.8

contd...

Table 93a : contd.

1	2	3	4	5	6
67% food restriction					
39	31.8	28.6	0.38	0.04	2.8
40	27.4	23.5	0.69	0.09	3.1
41	23.6	-	-	-	-
42	51.3	40.8	0.93	0.10	9.5
mean	33.5	30.9	0.67	0.08	5.1
s.d.	12.0	8.9	0.27	0.03	2.2
range	23.6-51.3	23.5-40.8	0.38-0.93	0.04-0.10	2.8-9.5

	total nitrogen (mg)	nitrogen (mg) excreted as	
		creatinine	creatine
20% protein: Experiment II			
43	108	1.88	0.90
44	129	1.86	0.75
45	-	1.82	-
46	18	1.15	0.25
47	64	1.89	0.64
48	101	2.14	0.18
mean	84	1.79	0.54
s.d.	44	0.33	0.32
range	18-129	1.15-2.14	0.18-0.90
10% protein			
49	30.8	1.62	0.58
50	34.1	1.50	0.21
51	45.8	1.02	0.61
52	56.0	1.26	0.22

contd...

Table 93a : contd.

1	2	3	4
53	79.2	2.05	0.54
54	53.8	1.72	-
mean	49.9	1.53	0.23
s.d.	17.5	0.36	0.2
range	30.8-79.1	1.02-2.05	0.21-0.61
5% protein			
55	12.0	1.13	1.50
56	7.7	1.06	1.14
57	11.2	0.78	1.25
58	12.2	1.17	1.98
59	7.7	0.55	0.73
60	8.3	1.34	0.48
61	7.8	0.91	0.12
62	8.0	0.79	0.56
63	5.4	0.75	0.49
64	4.2	0.43	0.14
65	6.8	0.98	0.53
66	5.0	0.49	0.31
mean	8.0	0.87	0.77
s.d.	2.6	0.29	0.58
range	4.2-12.0	0.43-1.34	0.12-1.98

Table 94 : Contribution of various nitrogenous constituents to total nitrogen in urine in protein-deficient and undernourished rats.

diet	experiment	no. of animals	total nitrogen (mg)	% contribution to total nitrogen				
				urea + ammonia	creatinine	creatine	uric acid	undetermined
						mean ± s.e. / cv		
% dietary protein								
20	I	9-10	62±5.9 / 30	85±3.0 / 11	1.66±0.19 / 36	-	0.39±0.04 / 30	14.3±3.3 / 72
	II	5-6	84±19.4 / 52	-	2.9 ±0.88 / 67	0.79±0.20 / 57	-	-
10	II	6	50±7.1 / 35	-	3.31±0.51 / 37	0.98±0.27 / 62	-	-
5	I	6-7	10±1.4*** / 36	65±2.6*** / 10	9.34±1.41*** / 40	-	0.55±0.05 / 25	25.6±2.0** / 19
	II	12	8±0.8*** / 32	-	11.1±0.84*** / 26	8.74±1.3*** / 50	-	-
4	I	3-5	4.5±0.7*** / 34	45±9.8** / 38	10.4±2.9*** / 62	-	0.89±0.14*** / 35	40.0±6.4** / 28
% food restriction@								
50	I	11	43±4.2* / 32	77±3.6 / 15	1.39±0.11 / 26	-	0.41±0.04 / 30	20.8±3.7 / 59
67	I	3-4	34±6.0** / 36	85±3.1 / 6	1.85±0.39 / 37	-	0.23±0.06 / 48	12.9±2.9 / 40

° details same as for Table 85.

values marked with asterisk significantly different from controls, p less than 0.05 for *, 0.01 for ** and 0.001 for ***.

@ 50% and 33% of the ad lib. food intake of animals fed 20% protein diet.

relation to body surface area. Creatinine excretion per kg of body weight was increased in protein deficiency and there was a decrease in apparent digestibility suggesting an increase in endogenous losses of nitrogen.

The data on body composition suggested no increase in moisture with protein deprivation as well as with undernutrition, but protein content was reduced only in the former condition. Creatinine content was not affected.

Protein deficiency was associated with a decrease in the proportionate excretion of urea and ammonia and an increase in the case of the other components studied, a finding consistent with the greater contribution of the former to exogenous metabolism and of the latter to endogenous metabolism.

Creatine turnover seemed to be greater with a 4% protein diet.

The data on creatinine excretion fail to convey a clear cut picture. The data obtained with different degrees of protein deficiency suggest that surface area rather than body weight is the major determinant of the same as it is relatively invariant.

Nitrogen metabolism during starvation

As mentioned earlier, studies were carried out on fasting men and women. The Jains in this country (people practising 'Jainism') observe total fasting for a period of 8 days in the month of August. This opportunity was utilized to carry out the present study. Some details regarding the subjects investigated are shown in Table 95. The studies were initiated two days before fasting and terminated 8 days after the conclusion of the fast.

The average weight loss in the subjects studied were found to be about 0.54 kg/day constituting about 10% of total weight loss for 8 days. However, the same varied from nil to 8 kg.

Two 12 h. urine samples were collected each day and analysed for different nitrogenous constituents. However, the wide day to day fluctuations in some of the values are made us doubt the reliability of the collections. The values are therefore, considered only in relative terms of contribution made by different metabolites to total nitrogen. This can not be attributed to 'cheating' as the fast was undertaken by a group at a temple. The group shared a common living space, had no privacy and were not expected to leave the temple. They were more or less under constant surveillance. There were also similar variations in day to day changes in weight.

Table 95 : Weight loss during eight days of starvation.

subject no.	sex	age (years)	weight (kg)	height (cm)	weight loss (kg)
237	M	40	67	167	5.0
238	M	42	73	158	0.0
239	M	27	69	166	4.0
240	M	30	56	159	7.5
241	M	17	45	161	3.0
242	M	25	42	166	3.0
243	M	45	38	148	6.0
244	M	52	43	164	1.0
297	F	36	54	151	8.0
298	F	40	42	154	5.5
mean		35.4	52.9	159.4	4.3
s.d.		10.5	12.9	6.7	2.6

M, male; F, female.

The data on nitrogenous constituents were shown in Table 96. Creatinine and urea nitrogen were found to decrease with the progress of fasting, whereas ammonia nitrogen showed the opposite trend. This is consistent with expectation as well as published reports (Table 97).

Although it has been suggested that acute starvation does not influence the level of creatinine excretion (Van Hoogenhuygze and Verploegh, 1905; Cathcart, 1907; Watanabe and Sassa, 1914; Junkersdorf and Liesenfeld, 1926) an analysis of the data even in the earlier studies suggests some reduction (e.g. Benedict, 1915). (See Table 9). This has been confirmed by several recent studies (Young et al, 1973; Peters et al, 1975; Spencer et al, 1966; Ohnaka, 1976). A more clear cut picture was seen with the progress of starvation in the literature cited.

Table 96 : Urinary excretion of nitrogenous constituents during starvation.

subject no.	mg/g nitrogen											
	creatinine				urea nitrogen				ammonia nitrogen			
days of fasting	1-2	3-4	5-6	7-8	1-2	3-4	5-6	7-8	1-2	3-4	5-6	7-8
237	124	115	96	83	707	833	557	490	122	123	153	184
238	372	95	155	116	840	703	657	558	65	32	37	38
239	152	106	109	101	695	597	497	502	99	99	197	217
240	182	124	117	60	777	645	432	498	57	112	225	223
241	157	171	177	173	689	606	610	520	55	47	53	72
242	120	94	131	124	620	565	502	715	102	66	65	85
243	163	117	105	79	684	650	668	358	81	33	58	51
244*	151	123	105	85	788	678	462	558	53	35	58	43
297	-	110	111	82	622	563	417	343	99	217	252	274
298	133	181	106	83	628	587	528	510	96	161	195	142
mean	173	114	121	99	705	643	533	505	83	93	129	133
s.d.	77	25	26	32	75	82	89	104	24	62	83	87

* subject did not take water throughout the period of starvation.

Table 97 : Comparative data on nitrogenous metabolites in urine during starvation.

investigator	no. of subjects	sex	period of starvation (days)	mg/g nitrogen							
				total nitrogen (g)		creatinine		urea nitrogen		ammonia nitrogen	
				initial	final	initial	final	initial	final	initial	final
present report	10	M+F	8	-	-	173	99	7.5	505	83	133
Adibi (1971)	6	M+F	6	12.5	9.8	154	137	840	714	-	-
Ghnaka (1976)	3	M	7	10.6	9.7	184	174	-	-	-	-
Young et al (1973)	3	M+F	20	11.5	5.6	165	303	878	642	-	-
Owen et al (1969)	4	M+F	35-42	-	4.7	-	374	-	332	-	418

The magnitude and duration of postprandial thermogenesis in adult men and women in relation to the composition of the meal.

The studies described hither to suggest low levels of creatinine excretion as compared to western values even in the relatively well-nourished upper class men and women who also showed a somewhat lower rate of basal metabolism. The food intakes were also lower than expected in many of the groups studied. This raises questions about the overall plane of nutrition and/or metabolism in these subjects.

It has been suggested that the ingestion of food constitutes a stimulus to metabolism on the basis of the increase in heat production following a meal (Seguin and Lavoisier, 1788). It has also been suggested that the magnitude of this stimulus varies with the composition of the meal (Runber, 1902) and is high with high protein diets (Lusk, 1930; Glickman, Mitchell, Lambert and Keeton, 1948; Buskirk, Sampietro and Welch, 1957). This stimulus has been labeled as the specific dynamic (SDA) action or effect of food and is estimated to be of the order of 6-10%. It has also been suggested that an increase in SDA may occur under conditions of surfeit feeding (Miller, Mumford and Stock, 1967; Stirling and Stock, 1968) although this has been questioned (Garrow and Hawes, 1972).

If this observation is valid, part of the adaptation to the plane of nutrition may be in the form of variations in specific dynamic action. This aspect was sought to be investigated along with the studies on basal metabolism. The present studies were undertaken on the increments in heat production following ingestion of a breakfast and/or lunch in adult men and women in apparently normal health.

As mentioned earlier, the subjects investigated were men and women postgraduates aged 20-22 years. In the first series of investigations, measurements of oxygen consumption were made before and at varying intervals after a standard breakfast consisting of 4 slices of bread served with an omlette and a cup of tea and providing 450 Calories and 16g protein.

In the second series of investigations similar measurements were made after a standard lunch consisting of Chapaties, rice, dal, curd and vegetables and providing 1000 Calories and 30g protein in the case of men and 600 Calories and 23g protein in the case of women.

In the third series of investigations the conditions were the same as those in the first, but serial determinations were made on a fresh group of subjects every hour for 4 hours.

The other conditions and details were same as described elsewhere.

In the first series high agreement was found between duplicate measurements, the product moment 'r' between the two being 0.961 for n-94. The two valuesvaried by more than 5% only in 19 pairs of measurements out of a total of 94. The mean values for duplicate measurements obtained in this series are shown in Tables 98 and 99. It can be seen from the same that the values obtained for BMR on two consecutive days also showed a high agreement. (The product moment 'r' between the two was 0.78 for n=26). On the other hand, the thermic response to a standard breakfast on two consecutive days showed a significant but much smaller correlation of 0.283 (n=13). In other words, the subjects showed a greater day to day variation in thermic response to a standard meal than in BMR.

The BMR varied between 32 to 44 Calories per square meter per hour in the case of men with a mean of 37.3. For women, the mean was 34.8 with a range of 26.2 to 43.7. These values are close to those reported by Banerjee (1972).

The increments in heat production following the meal must be attributed to the effects of the meal as no increases were found in fasting controls.

In the case of men the mean percentage increments in heat production at 1 and 2 hours after breakfast were of the order of 16 and 17, the values for two consecutive days being

Table 98 : Thermogenesis following a standard breakfast in men*.

subject no.	weight (kg)	height (cm)	surface area (sq.m.)	day	hours after breakfast				
					Cals/sq.m./h.			as % of initia/values	
					initial+	1	2	1	2
1	2	3	4	5	6	7	8	9	10
28	43	166	1.44	1	42.4	44.8	46.3	106	109
				2	38.5	42.4	44.4	110	115
29	47	168	1.50	1	34.4	43.0	45.9	125	133
				2	37.3	44.8	46.5	120	125
30	53	167	1.56	1	39.7	41.3	45.8	104	115
				2	40.0	45.8	46.3	114	116
31	49	159	1.47	1	38.6	46.2	49.1	120	127
				2	39.8	45.7	49.7	115	125
25	54	183	1.69	1	32.6	40.5	38.7	124	119
				2	32.6	36.6	-	112	-
26	57	173	1.66	1	36.0	44.5	43.5	124	121
				2	36.8	41.4	-	113	-
27	53	164	1.59	1	34.0	40.6	46.0	119	135
				2	33.5	38.9	-	116	-
38	52	167	1.57	1	39.4	45.0	41.6	114	105
				2	40.5	48.8	44.9	120	110

contd...

Table 98 : contd.

1	2	3	4	5	6	7	8	9	10
3	64	179	1.80	1	32.0	-	39.6	-	123
5	48	181	1.61	1	32.0	-	39.5	-	123
6	45	158	1.42	1	36.3	-	41.2	-	113
				2	37.6	-	41.2	-	109
10	55	170	1.70	1	36.4	-	38.4	-	106
				2	35.9	-	39.5	-	110
mean ±s.d.	52	170	1.58	1	36.2 ±3.2	43.2 ±2.1	43.0 ±3.4	116 ±7.7	119 ±9.4
				2	37.2 ±2.5	43.0 ±3.7	44.6 ±3.2	115 ±3.3	116 ±6.4
				fasting controls +					
35	59	180	1.70	1	39.0	42.0	42.0		108
				2	40.5		39.5		98
36	48	161	1.47	1	41.0		41.0		100
12	43	171	1.46	2	36.3		36.3		100
1	59	175	1.70	1	38.0		38.5		101
2	51	180	1.66	1	32.6		34.2		105
				2	31.1		31.1		100
mean				1+2	36.9		37.5		102
s.d.					3.5		3.6		3.3

* the subjects were aged 20-22 years. The breakfast provided 450 Calories and 16g protein.

\+ determined under nearly basal conditions.

Table 99 : Thermogenesis following a standard breakfast in women*.

subject no.	weight (kg)	height (cm)	surface area (sq.m.)	day	hours after breakfast				
					Cal./sq.m./h.			as % of initial value	
					initial	1	2	1	2
1	2	3	4	5	6	7	8	9	10
1	36	150	1.24	1	37.5	42.0	51.3	112	137
				2	36.1	44.4	55.9	123	155
4	61	162	1.64	1	32.0	36.7	40.1	115	125
				2	34.6	42.5	39.4	123	134
8	41	153	1.32	1	38.4	43.4	44.3	123	115
				2	39.1	68.0	52.8	175	135
3	51	167	1.56	1	32.8	36.4	43.0	111	131
				2	33.1	42.5	41.9	129	127
16	33	149	1.20	1	43.7	41.5	41.9	95	95
				2	40.1	47.3	40.9	118	102
17	42	152	1.33	1	36.2	38.8	41.4	107	114
				2	35.6	40.4	40.1	114	113
mean ± S.D	44	155	1.38	1	36.8 ± 3.9	39.8 ± 2.7	43.7 ± 3.6	109 ± 6.6	120 ± 13.4
S.E.				2	36.4 ± 2.4	47.6 ± 9.6	45.2 ± 6.6	130 ± 20.4	124 ± 17.3
				2+	35.9 ± 2.3	43.4 ± 2.3	43.6 ± 6.2	121 ± 4.5	122 ± 18.2

contd...

Table 99 : contd.

1	2	3	4	5	6	7	8	9	10
					fasting controls				
299	55	163	1.57	1	34.0		35.1		103
6	43	151	1.33	1	38.8		41.4		107
				2	40.1		40.7		101
7	45	152	1.38	1	29.9		31.1		104
				2	26.2		26.2		100
mean				1+2	33.8		34.9		103
s.d.					5.2		5.8		2.5

\+ omitting the value for GOS (8).

* details same as for Table 98.

practically identical. These were nearly the same as those of 16 and 19 derived from the data of Pittet et al (1974). A similar pattern was found in the women studied, but the day to day variations were much greater, this being particularly true of one subject who showed an unusually large increment on day 2 and another, who showed no increment, on day 1, perhaps because of a somewhat higher initial value. A similar lack of stimulation of thermogenesis was found in some of the subjects studied by Pittet et al (1974).

In this connection, at least for some subjects with a low tolerance for hunger, the fasting state could be associated with some degree of tension resulting in an elevated basal metabolic rate. It has also been suggested that an elevation of metabolism may occur in the fasting state, if this is associated with the breakdown of tissue protein and the use of protein as fuel. Further, the values for oxygen consumption which is taken as an index of heat production would also depend on factors such as fat breakdown and synthesis. The former may be expected to increase oxygen consumption, the Calorie value of a litre of oxygen used for burning fat as fuel being 4.686 as against 5.047 and 4.46 for carbohydrate and protein.

Since duplicate measurements gave practically identical values and since other measurements made at about the same time gave reasonable values, these deviations cannot be attributed to experimental error.

Since the values at 2 h. in the above series were still considerably above the basal values, a question arises regarding the duration of the thermic effect.

Thesecond series of investigations were undertaken in six subjects to ascertain the duration of thermogenesis as well as the influence on the same of the size of the meal (Table 100). In this series 1h. values could not be obtained for 2 subjects because of a temporary power failure. Among the other four, peak values occured at 2 h. in 3 cases and at 1 h. in one case. In one case the postprandial values were lower than the initial value. The values tended to taper off after 3 hours and had come down to initial levels in most cases at 4 hours. The percentage increments of 13 and 16 at 1 and 2 hours were similar to those in the first series. The observation that they were no greater on an average than those following breakfast suggested that they were not influenced by the calorie value of the meal ingested. In this series, also, unusually large increments were obtained in the case of one subject (no. 17).

In the third series, the investigations after breakfast were repeated with a fresh batch of subjects for a period of 4 hours (Table 101). The pattern and the percentage increments were essentially similar to thosein the previous two series. This series was also characterised by the absence of increase in heat-production in the case of one subject (no.2~47).

Table 100 : Increase in heat production following lunch*.

subject no.	sex	initial	hours after lunch										mean of 4 h. (%)
			Cal./sq.m./h,					as % of initial values					
			1	2	3	4	5	1	2	3	4	5	
29	M	43.6	-	42.5	35.7	-	-	-	97	82	-	-	90
28	M	35.6	-	48.6	43.9	36.8	33.2	-	136	123	103	93	121
299	F	30.7	35.0	36.2	33.9	30.7	-	114	118	110	100	-	111
17	F	33.6	37.4	40.5	59.9	48.6	41.1	111	121	178	145	132	139
31	M	44.9	55.8	49.1	48.0	44.9	-	124	109	107	100	-	110
35	M	42.5	42.5	48.3	47.3	46.3	-	100	114	111	109	-	109
mean		38.5	42.7	44.2	44.8	41.5	-	112	116	119	111	-	113
s.d.		5.4	8.0	4.8	8.6	6.6	-	8.6	11.8	29.3	17.1	-	14.7
		139.5	44.4	44.9	41.8	39.7	-	113	115	107	103	-	108
		5.4	8.6	4.9	5.8	6.3	-	9.8	12.7	13.4	3.6	-	10.1

* the same provided 600-1000 Calories and 23.3 g protein.

\+ omitting the values for PCS (No. 17).

Table 101 : Thermogenesis during 4 hours following a standard breakfast in men*.

subject no.	weight (kg)	height (cm)	surface area (sq.m.)	hours after breakfast: Cal./sq.m./h. initial	1	2	3	4	as % of initial value: 1	2	3	4	mean of 4 h. (Cal./sq.m./h.)
23	55	167	1.60	32.5	44.0	36.8	40.1	39.6	136	110	124	122	120
245	52	166	1.56	34.9	39.4	37.8	34.9	-	113	108	100	-	107
246	43	170	1.47	37.1	40.7	50.8	34.1	36.0	110	137	92	97	109
247	45	160	1.41	30.8	30.0	47.1	36.6	34.2	97	153	119	111	120
mean	48	166	1.51	33.8	38.5	43.1	36.4	36.6	114	127	109	111	114
s.d.				2.4	5.2	5.9	2.8	2.2	14.1	18.8	13.2	10.3	6.0

* details as for Table 98.

It is not possible to calculate the increment in terms of calories ingested as the duration of the thermogenesis was not ascertained. However, it would appear from both the second and third series, that the initial values are restored by 4 hours in most cases. On this basis, the total increment in heat production would be of the order of 6 and 3% of ingested calories in the case of breakfast and lunch respectively. This would correspond roughly to 5-6% of whole day intakes.

Alternatively, the average increment of 14% over basal metabolism during 4 h. after each meal can be considered to constitute an overall increment of 7-10% over BMR or 5-7% over total energy intake. This is in agreement with the estimate of 6% by Swift and Fisher (1964) but is less than 10% cited by Mitchell (1964).

In conclusion, the present studies show the increments in heat production as measured by oxygen consumption following a breakfast providing 450 Calories and 16g protein and a lunch providing 600-1000 Calories and 23-30g protein to be similar and to compare with the values obtained by Pittet et al (1974) using more refined techniques. No correlation was found between the rates of actual and expected body weight and the size of the increment in heat production.

These studies were carried out on relatively well-nourished subjects. Further studies are needed on subjects with a chronically low plane of nutrition to see if the size of the stimulus resulting from ingestion of food varies with the nutritional status.