RESULTS AND DISCUSSION

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Dietary Pattern of Low and High Income Groups

As has been indicated in 'Materials and Methods' dietary information was collected from a total of 153 pregnant women and 357 adult men and women in the high (HIG) and low (LIG) income groups totalling to 510 families. To know the diet pattern and consumption of various nutrients in this region, dietary intakes of these were calculated at random from 241 families.

The major components of the diets consumed in the region studied are shown in Table 9 and 10a. In Kerala, consumption of fish and other animal foods by non-vegetarians in the high income group accounted for the relatively high protein content of the diets consumed, whereas tapioca consumption accounted for the relatively low protein content of the poor people (Table 10b).

The amount of fat consumed and the food sources of fats such as fish, fresh coconut, coconut oil and milk contribute not only to differences in fat content but also with regard to PUFA and tochopherols (Table - 10b) between HIG and LIG group.

Table 9: The major components in the diet consumed

Region		Staple food	Other foods consumed		
			Regularly	Occasionally	Rarely
TRIVANDRUM					
HIG	V	Rice + Wheat (Red, parboiled variety)	Coconut/sesame oil, coconut(fresh) legumes, vegetables, milk.	Jackfruit	Fruits, Tapioca.
	NV	Rice + Wheat (Red parboiled variety)	Fish and other animal foods, milk, coconut (fresh) coconut oil.	Tapioca, legumes, vegetables, Jackgruit.	
LIG		Rice + Tapioca+ Wheat* (Red, parboiled)	Fish, coconut	Vegetables, green gram	Coconut oil, fruits (Jack and castor apples)

HIG - High income group
LIG - Low income group
V - Vegetarian
NV - Non-vegetarian.

* Subsidized from fair price shops.

Table 10a Mean per capita food consumption per day of the major foods

	High Income Group Non-vegetarian	High Income Group Vegetarian	Low Income group
	Mean with range in parentheses.		
1. Cereals (g/day):			
(a) Rice	290 (220-360)	250 (220-340)	240 (170-280)
(b) Tapioca	86 (40-150)	26 (12- 30)	300 (250-500)
(c) Wheat	52 (35- 80)	35 (25- 70)	25 (25- 40)
2. Pulses (g/day)	25 - 30	45 (35- 60)	10 - 20
3. Fish and animal foods (g/day)	40 - 80	--	20 - 40
4. Fat (g/day)	37 (25 - 60)	40 (30- 58)	22*
5. Milk (ml/day)	100 - 250	250	50

* includes fat from fresh coconut.

Table 10b Nutritive value of the diets consumed in high (HIG) and low (LIG) income groups

Region		Total calorie	Protein (g)	FAT Total (g)	FAT PUFA** (g)	FAT P/s***	Toco-pherol (mg)	Magne-sium (mg)
HIG								
	V	1850	43	40*	9.0	0.26	6-8	100-150
	NV	1800	46	37*	7.0	0.20	6	100-150
LIG		1580	30	22	1.43	0.30	4-5	100-150

* Due to high consumption of fresh coconut.

** PUFA - Poly unsaturated fatty acids.

*** P/S - Poly unsaturated fatty acids/saturated fatty acids.

V Vegetarian;

NV Non-vegetarians.

Earlier studies from this laboratory conducted at Kerala also suggested that the tocopherols and PUFA consumption of Keralites are lower than those at Baroda (Thomas, 1975).

As indicated earlier, Kerala's staple cereals are rice (parboiled red variety) and tapioca. However, the proportion of these vary in the low and high income groups. In the high income groups (vegetarian and non-vegetarian) tapioca is consumed rarely or occasionally and is prepared more as a delicacy in the form of special dishes and not as a staple, whereas in the low income group the amount of tapioca consumed is as much or more than that of rice. So in order to see the calorie contribution of these cereals to the total calorie content of the diet, the calorie content of the staple cereals of LIG and HIG was calculated (Table 11). It can be seen from this table that 26% of the total calories in LIG are from tapioca whereas in HIG the calorie contribution from tapioca is only 20% and 8% in HIG vegetarian and HIG non-vegetarian respectively.

Apart from the major differences in the proximate principles of the diet, the diet is also poor in magnesium mainly due to deficiency in the mineral content of the water (Table-10b). In Kerala, the water is soft and both the staples used, namely rice and tapioca are low in magnesium (Gopalan et al.,

Table 11 : Contribution of calories from tapioca to the total diet in high (HIG) and low (LIG) income groups in Trivandrum.

Income group	Total kilo-calories	Kilocalorie contributed from: Rice	Tapioca	Wheat	Other sources	Percent calories from: Rice	Tapi-oca	Wheat	Other sources
HIG (V) n = 108	1855 (1605–2305)	880 (595–1167)	43 (10–95)	123 (49–291)	809	47	2	7	44
HIG (NV) n = 61	1800 (1217–2490)	1000 (500–1700)	150 (9–850)	190 (35–420)	460	56	8	11	25
LIG n = 72 (NV)	1580 (1070–2170)	790 (80–1000)	419 (8–500)	144 (4–136)	227	50	26	9	15

Values in parentheses indicate ranges.

NV = Non-vegetarians

V = Vegetarians.

1978; Ramakrishnan and Rajalakshmi, 1980). Although in Tamilnadu (neighbouring state) the staple diet is also rice, the side-dishes used are based on pulses, vegetables and tamarind, all of which are reasonably good sources of magnesium. In addition, the water there is hard and is likely to contain appreciable amounts of magnesium and calcium. The poor diets in this region thus provide approximately 100 - 150 mg/day of magnesium where as the recommended allowances is 300 - 400 mg/day for this mineral.

From Table - 10b, it is also clear that the tocopherol content of the diet is considerably low <9 mg because the fat used, if any, is coconut oil which is low in tocopherol. For example, the poor diet in Gujarat is based on wheat, bajra and rice and at least 15-20% of groundnut oil. Here LIG diets (Baroda) are estimated to provide, 10-15 mg of tocopherol. Similarly in Madurai also since the fat is either groundnut/or sesame oil (rarely) the tocopherol content is similar to that of Baroda.

Apart from differences in tapioca consumption, the diets of the three groups, namely LIG which is exclusively non-vegetarian and HIG which has both vegetarians and non-vegetarians, differ with regard to other food constituents as well. This can be seen from the day's menu in Table-12. In the LIG while consumption of fish is regular meat and eggs is rare.

TABLE-11: Typical meal pattern in different income groups - [illegible]

	HIGH INCOME GROUP		LOW INCOME GROUP
	Vegetarian	Non-vegetarian †	Non-vegetarian *
Early morning	Coffee/Black Coffee	Black Coffee/Tea	Black Coffee/Tea.
Morning	Idli/Dosai/Appam/Upma/ Chapati-Coffee/Milk	Omlette/Puttu with fruit, Dosai/Idli/ Appam-Coffee/milk.	Left-over rice steeped in water/rice conjee with chutney/fish.
Mid-morning	Coffee/Tea (OCC)	--	--
Noon	Rice, dal (Sambar) one or two vegetables, dahi (yogurt) papad.	Rice, usually fish or beef, dahi (yogurt) or vegetables with dal.	Rice, tapioca and fish or occasionally other animal foods, vegetables, dal.
Evening	Coffee/Tea, light snacks	Tea, light snacks	Black tea.
Night	Rice or conjee vegetable or pickle, other left-over lunch items. Tapioca rarely.	Rice and conjee, fish or coconut chutney, vegetables (mostly left over lunch items)	Conjee with green gram, tapioca, pickle or fish, left-over from lunch.

† Fish or other animal foods consumed thrice daily.

* Fish consumed daily with vegetables and beef very occasionally.

OCC - Occasional.

However, fish is generally not consumed on Sundays and during the spawning season. When fish is not available a side dish prepared from either coconuts or legumes is substituted. All these are prepared in the form of a special gravy and thus in LIG the amount of fish or coconut or legume is much less than in the upper class. Because of these unique features of the diet in Kerala region the actual food consumption was calculated for the different groups i.e. HIG vegetarian and non-vegetarian and LIG groups. These differences in types of food and amount consumed are evident from Table-13. In HIG the amount consumed for all the foods listed were comparatively higher than in the LIG. In HIG, the type of foods consumed includes meat, fish and eggs for the non-vegetarians, whereas the LIG nonvegetarians mostly consumed only fish, the quantity of which was comparatively less. Moreover, in the HIG, because of the growing awareness of the effects of saturated fats in the diets, in recent years people are slowly changing to the use of groundnut/or seasame oil. However, the old pattern still continues in most of the families, the effects of which will be discussed in a later section on adults (aging).

Thus in all the three groups (HIG (V., & N.V) and LIG) the dietary patterns are found to differ in some respect from those in the other. They differ from even the neighbouring

TABLE- 13: Frequency distribution for the amounts of critical foods consumed by high (HIG) and low (LIG) income groups

Food			N	None or negligible	Amount consumed per day (g) per head				
					< 10	10–25	26–50	51–100	> 100
					Per cent distribution with mean consumption (g) in parentheses.				
PULSES	HIG	V	108	0	-	1 (22)	80 (37)	19 (60)	-
		NV	61	5	13 (6)	44 (17)	36 (36)	2 (63)	-
	LIG		72	32	31 (6)	29 (16)	7 (34)	1 (83)	-
EGGS	HIG		61	54	10 (7)	13 (16)	23 (42)	-	-
	LIG		72	89	4 (7)	4 (14)	3 (40)	-	-
MEAT	HIG		61	52	10 (6)	16 (20)	14 (32)	7 (73)	1 (114)
	LIG		61	89	4 (3)	7 (21)	-	-	-
FISH	HIG		61	3	-	10 (22)	43 (38)	44 (77)	-
	LIG		61	3	4 (8)	19 (19)	45 (37)	29 (72)	-

V – Vegetarian – N.V – Non Vegetarian

N = Number of subjects.

TABLE-13 (Contd.)

Food			N	None or Negli-gible	Amount consumed per day (g) per head				
					< 10	10-25	26-50	51-100	>100
SUGAR	HIG	V	108	-	-	-	82 (37)	18 (55)	-
		NV	61	2	-	25 (19)	57 (39)	7 (83)	-
	LIG		61	11	14 (5)	42 (16)	26 (35)	7 (58)	-
MILK	HIG	V	108	-	-	-	-	97 (100)	93 (241)
		NV	61	8	-	1 (11)	10 (42)	25 (75)	56 (250)
	LIG		61	61	3 (8)	3 (20)	10 (36)	10 (80)	13 (196)
COCONUT OIL	HIG	V	108	-	14 (8)	86 (16)	-	-	-
		NV	68	-	2 (9)	53 (17)	42 (30)	3 (61)	-
	LIG		71	-	14 (8)	65 (16)	21 (28)	-	-

NV - Nonvegetarians; V - Vegetarians, N - Number of subjects.

HIG - High income Group; LIG - Low Income Group.

Tamilnadu, where tapioca is hardly consumed and the consumption of polished rice is the usual pattern. In the upper classes legumes and fish are consumed to a less extent. Also the oil consumed is groundnut/or sesame oil. Thus the dietary patterns in Kerala are such as to lead us to expect some difference in the nutritional/or biochemical status of Keralites and people in other regions (e.g. changes in biochemical profile specially serum lipids and magnesium and vitamin E duing pregnancy and in aging populations) and between vegetarians and non-vegetarians of the same region.

P A R T - I

Studies on pregnant and parturient women

A: General information on diets and blood hemoglobin:

As mentioned earlier although poor women in this country and elsewhere show by and large, a successful gestation performance (Bagchi and Bose, 1962; Rajalakshmi and Ramakrishnan, 1969; Jensen et al., 1975), a poor plane of nutrition of the mother during pregnancy may influence her gestation performance and the outcome of pregnancy by affecting physiological responses of the mother and her pregnant state and thus jeopardise the optimal growth of the fetus in-utero (Winick, 1969; 1976; Duffus, 1971; NIN Ann. Report, 1972; Rajalakshmi et al., 1978; 1980; Iyengar, 1984). It also results in inadequate preparation for lactation (Hytten and Leitch, 1971; Draper, 1980).

The successful outcome of pregnancy depends on the amounts of hormones secreted at different stages of pregnancy altering the rates of degradation and excretion of various substances. The reorganisation of the normal female endocrine system is to a large extent initiated by the emerging endocrine functions of the placenta. Hormones produced by the co-operative effort of the placenta, fetal adrenals and liver appropriate the role of the maternal endocrine organs. Thus, the fetus is directly involved in the maintenance of pregnancy, the important feature of which is the assurance of an adequate nutrient supply (Naismith, 1980). The mothers of prematures and small for dates may be the ones who fail to show the expected physiological and biochemical responses to pregnancy.

The possibility of using biochemical indices which alter during pregnancy as indicators of satisfactory progress of gestation is currently engaging interest of many nutritionists and medical professionals (Metcoff, 1974; Metcoff et al., 1982, 1985; Iyengar, 1982; RAJALAKSHMI & RAMAN 1985 Shah and Rajalakshmi, 1984, 1987). The present studies are therefore concerned with the question of how selected parameters such as serum lipids (cholesterol, phospholipids and triglycerides), serum magnesium and serum vitamin E are influenced by pregnancy and to what extent this influence is modified by the overall plane of nutrition.

These studies were therefore carried out in Trivandrum with respect to serum lipids (Cholesterol, phospholipid and triglycerides) Vitamin E and magnesium status in pregnant and parturient women. Additional studies were carried out on mother-infant pairs for cholesterol levels in serum. Details of information about these subjects and their health status were recorded and described briefly.

The studies were carried out mainly on a cross-sectional basis in pregnant women and with respect to parturient women these were the ones who were admitted to the hospital well before delivery. Therefore the information of these women is available also before partus. Table - 14, gives the comparative general information about the subjects from HIG and LIG. As can be seen from the table, the mean maternal age, gestational age and parity are comparable in both the groups. Consistant with the several reports the average body weights of non-pregnant non-lactating (NPNL) women of HIG and LIG differed (HIG - 46.2 kg; LIG - 42.0 kg). With respect to the mean body weights during different stages of pregnancy, weight gains/or weight changes cannot be commented as the relative number requires to be considerably high to make such a comment. However, for those subjects that were studied both before and after delivery (Table -15) indicates that the loss in weight during delivery is more or less similar in both HIG and LIG and 50 per cent of this weight loss could be accounted for the weight of the infant.

The small differences in the weight losses (~500 g) though not significant are due to small differences in the birth weight, placental weight and other losses. It is not possible to know what was the exact weight gain of mothers during pregnancy and whether there was any change in the maternal weights after delivery from that of her non-pregnant

Table-14 : Pregnant and parturient women investigated in Trivandrum.

	(NPNL)† Non Pregnancy Non-lactating.		Weeks of gestation								Post-partum (PP)*		TOTAL	
			∠10 and 10 wks		10-20		20-30		30-40					
	HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG
1. No. of subjects	32	32	13	13	20	19	14	21	27	26	23	17	129	128
2. Mean gestational age (weeks)	-	-	7.7	8.4	14	14	25	25	38	37	-	-		
3. Mean maternal age (yrs)	27	29	28	28	26	28	28	25	26	29	-	-		
4. Parity (range)	-	-	Primi -5	2-6	Primi -5	1-6	Primi -3	1-3	Primi -3	1-4	Primi -3	1-4		
5. Mean body weight (kg)	46.5	42.0	46.0	41.2	46.6	40.5	48.2	43.3	55.50	45.90	49.5	40.4		

† NPNL : Women taken at random from the women on aging studies after carefully matching for age, weight and height.

* PP : Women were also studied studied pre-partum and are included in the previous group.

HIG - High Income Group.

LIG - Low Income Group.

Table 15: Maternal weight loss during parturition in relation to placental and infant birth weights in low (LIG) and high (HIG) income groups

Group	No. of subjects	Maternal weight (kg) Pre-partum	Post-partum	Maternal weight loss (kg) after delivary	Placental weight (kg)	Infant weight (kg)	Placenta + infant (kg)	Other losses* (kg)
				Mean ± S.E				
HIG	23	55.50±6.3	49.5+6.5	6.00±1.3	0.55±0.1	3.20±0.4	3.75±0.5	2.30±1.0
LIG	17	45.90±2.7	40.43±2.1	5.50±0.9	0.53±0.1	2.90±0.3	3.43±0.3	2.04±0.8

* This would include amniotic flud, blood loss which are reported to be of the order of 80 gms and 1250 g respectively and sweat loss.

weight because the subjects were contacted only after they visited the hospital for check up. One thing which is consistant with earlier observations from this department and elsewhere is that, in spite of considerable differences in the intake of food/or nutrients between HIG and LIG the pregnancy outcome is satisfactory as judged by birth weights of infants. (McGanity et al., 1954, 1955; Bagchi and Bose, 1962; Rajalakshmi and Ramakrishnan, 1969). In this connection it is well known that during pregnancy, the efficiency of utilising the nutrients increases considerably and specially during the last trimester of pregnancy. To mention a few, nitrogen retension (Mitchell, 1962; Venkatachalam, 1962; Thomson and Hytten, 1966; Rajalakshmi and Ramakrishnan, 1969). Calcium absorption (Shinolekar, 1970) iron absorption in normal and anemic (Apte and Iyengar, 1970) phosphorus and magnesium absorptions or retension (Coons and Blunt, 1930; Beaton, 1961; Caddell et al., 1973; Ashe et al, 1979) are the studies. Perhaps in women who thrive on marginally adequate nutrients the efficiency of utilization increases much more than those from HIG and such a possibility has been evidenced from earlier studies in this laboratory as well (Rajalakshmi, 1980).

To have an idea about the general health status of the subjects blood hemoglobin was also measured and are presented in Table - 16. By and large women from LIG group

TABLE-16 : Blood hemoglobin levels during different stages of gestation and post-partum in high (HIG) and low (LIG) income groups in Trivandrum.

	Non-pregnant	Weeks of gestation				Post-partum	
		10	11 - 20	21 - 30	31 - 40	Full-term cases (AGA)	Premature cases
	Blood hemoglobin (g/dl) mean ± s.e.						
HIG :							
No. of cases	34	13	14	14	22	21	-
Mean	11.8±0.12	11.7±0.23	11.3±0.27	11.4±0.17	11.2±0.16	11.8±0.18	
Range	(10.6-13.3)	(10.6-13.4)	(8.4-12.2)	(10.0-12.0)	(9.0-12.5)	(9.0-13.0)	
LIG :							
No. of cases	34	13	19	21	22	16	10*
Mean	11.3±0.08	10.9±0.20	10.5±0.22	10.7±0.13	10.1±0.20	10.8±0.17	9.4±0.45
Range	(9.0-12.5)	(9.7-12.8)	(8.0-11.9)	(9.5-11.9)	(7.5-11.7)	(10.0-12.3)	(7.0-11.0)

* Significant at P < 0.01 level compared to the preceding post-partum AGA mothers.

are known to have lower hemoglobin values compared to their age matched women from HIG. These differences on the average basis do not appear very large but often found to be due to greater number of women having blood hemoglobin values in the category of low and deficient norms (< 10.5 g/dl according to ICNND norms).

One of the physiological phenomenon of pregnancy is a progressive decline in the blood hemoglobin which is significant in the third trimester. This has been attributed to hemodilution. In the present study which is cross-sectional as mentioned earlier with wide intragroup variations and small sample size the average hemoglobin for non pregnant are 11.8 g/dl and 11.3 g/dl for HIG and LIG respectively. At term (30-40 weeks) it is 11.2 and 10.1 g/dl respectively and the values in between gestation periods are not very consistent. If one considers the difference between the non-pregnant and for those who are > 30 weeks of pregnancy the fall in hemoglobin is of 0.6 g/dl for HIG and 1.2 g/dl in LIG group and postpartum values returning to that of non pregnant values. A similar trend (Table 17) has been reported by National Institute of Nutrition (Annual Report, 1985-86). However when the values are arranged with two weeks intervals a lowest value was observed between 26-28 weeks of gestation. Since the interval in the present study was 10 weeks this trend might have been obscured.

Table - 17: Changes in Hemoglobin values (g/dl) in pregnant women

Study Group	Gestational age (Weeks)						
	10-12	14-16	18-20	22-24	26-28	30-32	34-38
Study I							
Overall basal	11.3 ± 1.62(16)	11.0± 1.33(26)	11.0± 1.30(17)	10.5± 1.74(11)	9.8± 0.87(11)	10.8± 0.50(3)	11.1± 0.90(7)
Iron supplemented	-	-	10.4± 1.03(7)	10.7± 1.57(11)	10.8± 1.74(10)	10.3± 1.34(11)	11.2± 1.12(14)
Study II							
Overall basal	11.7± 0.76(7)	10.8± 1.57(20)	10.5± 1.73(12)	10.3± 1.61(9)	8.7± 0.75(3)	-	-
Iron supplemented	-	10.4± 1.06(4)	10.3± 1.14(7)	11.1± 0.89(10)	10.0± 2.11(15)	10.2± 1.37(13)	11.1± 1.09(14)

Ref: NIN. Ann. Report (1985-86)
ICMR

However, in the present study the fall in hemoglobin fell short of significance and even in between the different intervals of pregnancy there appears to be fluctuation. These discrepancies between the present and other reports may partly be due to the fact that all subjects included in the study are taken from the outpatient clinic of the general hospital where routinely women are given iron-folic acid supplementation. Kerala being a state where the educational level and awareness is high even among the poor the health problems might have made them quite receptive and cooperative to such supplementary feeding programmes which are in implementation from the past 15 to 20 years. Infant mortality rate (IMR) is reported to be very low in this state (UNICEF, 1987). Such a cooperation was also observed when a collegue was imparting nutrition education to mothers in the rehabilitation ward (Pratapkumar, 1983). As a consequence of greater awareness a smaller incidence of anemia might be prevalent in these women. This might be due to the influence of (supplements) greater circulating iron on the hemoglobin of these mothers. However, the frequency distribution pattern does show that greater number of women in the low income group during the third trimester are falling into low and deficient hemoglobin category (Table 18). Also it is observed that this percentage is much lower in the present study than that reported by an earlier investigator (Dave, 1980) the low and deficient values during the

Table 18 : Percentage of low and deficient hemoglobin values according to ICNND norms*

	Period of gestation		
	First trimester	Second trimester	Third trimester
	Percent with low and deficient values with no. of subjects in parentheses.		
HIG	20 (16)	22 (17)	35 (30)
LIG	24 (18)	30 (23)	46 (33)

* ICNND norms. O'Neal et al., (1970)

3rd trimester being 46% and 59% respectively in the two studies in the low income group.

Thus in the present study women from LIG group were much better off with respect to their hemoglobin status compared to earlier studies from this region. The body weights although were smaller were not grossly under weight and are satisfactory.

Studies on serum lipid levels in pregnant and parturient women.

It is well-known that serum lipids rise during pregnancy (Hansen et al., 1964; Aurell and Cramer, 1966; Green, 1966; Taylor, 1972; Taylor and Akande, 1975; Morse et al, 1975; Punnonen, 1977; Darmandy and Postle, 1982; Knopp et al., 1982). At least a few studies suggest that the rise may be affected by plane of nutrition on the basis of social class differences found in this phenomenon (Ahrens et al, 1957; Brown et al, 1966; Dalderup et al, 1969; Spritz and Mitchell, 1969; Lewis et al, 1970; Taylor and Akande, 1975; Potter and Nestel, 1976; Mellies et al, 1978). It has also been found that a failure of increase in maternal serum lipids according to the expected rate may influence the lipid status of the neonate as judged by cord serum lipid levels (Vobecky et al, 1982).

In view of these observations it was considered to be of interest to investigate, to what extent the expected increase in serum lipids is achieved during pregnancy in the low income (LIG) women of this region whose intake of food energy and fat are low. Investigations were carried out between maternal and neonate's serum levels of cholesterol in relation to each other and in relation to gestational age and growth status of the new born.

The serum lipid levels during the different gestation periods and post-partum are presented in Table - 19. As can be observed the total lipids showed a small decrease in the initial stages of pregnancy with a progressive increase after 10 weeks till partus. The initial fall in total lipid can be attributed exclusively to a fall in the triglyceride fraction as cholesterol and phospholipids did not show a similar magnitude of fall. The pattern is consistent in both income groups. However, the low (LIG) income group consistently showed lower levels at all gestational periods.

For triglycerides, the values dropped at 10 weeks of gestation followed by a significant rise at each stage of pregnancy (Table - 19). The pattern was consistent in both the income groups. Though the values obtained for LIG were consistently lower than HIG at all the stages studied, they were significantly lower only at the later stages of pregnancy (30 - 40 weeks) (Table - 19).

A similar decrease in triglycerides in early pregnancy has been observed by a number of workers (Peters et al, 1951; Green et al, 1966; Darmandy et al, 1982). Some of the experimental work with animal models and humans showed that a fall in triglyceride levels in early pregnancy is due to the lipoprotein lipase activity (LPLA) and the post heparin

TABLE- 19 : Changes in serum lipids (mg/dl) with progress of gestation in high (HIG) and low (LIG) income groups

		Non-pregnant	Weeks of gestation				Post-partum
			∠10	10-20	20-30	30-40	
			Mean ± S.E.; 'n' (above) and range (below) in parantheses				
TOTAL LIPID*	HIG	485 ± 13.5 (31) (377 - 616)	471 ± 15.3 (12) (382 - 561)	521 ± 11.9 (19) (450 - 645)	555 ± 23.5 (12) (458 - 699)	726 ± 22.7 (25) (512 - 948)	642 ± 18.5 (23) (491 - 801)
	LIG	475 ± 17.4 (28) (399 - 638)	456 ± 14.2 (12) (382 - 525)	480 ± 16.9 (18) (362 - 656)	541 ± 13.9 (21) (419 - 657)	652 ± 13.9 (26) (422 - 920)	598 ± 21.2 (17) (472 - 765)
TRIGLYCERIDE	HIG	116 ± 3.2 (31) (73 - 150)	90 ± 4.7^{+++} (12) (60 - 125)	118 ± 4.9^{+++} (19) (68 - 182)	136 ± 4.29 (12) (75 - 160)	197 ± 7.3 (25) (146 - 290)	130 ± 4.6 (22)
	LIG	109 ± 6.4 (28) (79 - 123)	77 ± 5.2^{+++} (13) (51 - 110)	96 ± 4.3^{+++} (18) (64 - 120)	138 ± 3.2^{+++} (21) (120 - 168)	174 ± 7.4** (26) (141 - 308)	114 ± 3.6 (16) (90 - 140)
PHOSPHOLIPIDS	HIG	190 ± 6.4 (32) (172 - 259)	190 ± 6.2 (13) (171 - 220)	203 ± 6.9 (20) (171 - 291)	215 ± 10.2^{+++} (13) (162 - 293)	265 ± 8.7^{+++} (27) (187 - 371)	258 ± 9.6 (22) (184 - 378)
	LIG	186 ± 6.0 (32) (145 - 230)	196 ± 8.4 (12) (150 - 250)	196 ± 7.3 (18) (140 - 267)	202 ± 7.1^{+++} (21) (157 - 278)	244 ± 9.9^{+++} (26) (168 - 350)	244 ± 11.5 (16) (180 - 320)

lypolytic activity (PHLA) (Pritchard et al, 1968; Hamosh, 1970; Knopp et al, 1973). It has also been shown that this fall helps in the initial fat storage in adipose tissue by enhancing the conversion of glucose into adipose tissue triglyceride fatty acid and diminished release of free fatty acids (Hamosh et al, 1970; Knopp et al, 1973). Studies by Gillespie (1950) and Hytten (1954b) showed an increase in weights of uterus and mammary gland volumes which might also require additional energy for tissue building. Thus this initial fall is a metabolic adaptation as a maternal preparation for the later catabolic events in adipose tissue.

After 10 weeks of gestation a significant rise in triglycerides is evident in both the groups (Table -19). These findings are consistent with longitudinal as well as cross-sectional studies (Horwitt et al, 1975; Latner, 1975; Morse et al., 1975; Montes and Knopp, 1977; Punnenon, 1977; Katiyar et al, 1978; Knopp et al., 1982; Darmandy et al, 1982). However, the period when peak values are attained varies according to different investigators. A progressive rise during pregnancy in serum triglycerides has been observed from the third month onwards, the values at term being about one-third times higher than those at three months. Katiyar et al (1978) found peak lipemia to occur between 31-33 weeks of gestation. Morse et al, (1975) found the peak occuring at 35 - 38 weeks of gestation. These differences may be due to the plane of nutrition.

Conflicting views are presented regarding the hyper trigly-ceridemia of pregnancy in fed state and hence was studied by a number of workers. Scow and Chernic (1964), Bierman et al, (1966) suggested prior intolerance to dietary fat and dimi-nished triglyceride removal. On the other hand Otway and Robinson (1968) Baron and Stein (1968) suggested accumulation of endogenous triglyceride due to increased entry and or dimi-nished removal. Childs et al, (1981) showed an unimpaired de-livery of exogenous fat to oxidizing tissues which maximise glucose availability for fetal growth. A few other investiga-tors showed saturation of hepatic clearing mechanism. (Redgrave, 1970; Cooper and YU, 1978). Noel et al, (1979) and Swift et al (1979) reported a stimulation of lipoproteins in the d $\angle$ 1.019 range.

Fain and Scow (1966), Knopp et al. (1973), Knopp (1975) Childs et al., (1981) however pointed to a biphasic pattern of pregnancy which prepares the mother with a largest reserve that may meet later energy needs. It is suggested that such a need would arise during stress of acute starvation which is not uncommon during late pregnancy even if the mother is in a fed state. Such lipogenic mechanism serves in diverting inges-ted fuel away from maternal tissue and helps retaining them in fetal circulation for transplacental transfer. In this conne-ction, it can be pointed out from the studies of Chang et al, 1977 and Elphick et al (1978) that maternal intravenous fat emulsion theraphy at term might benefit growth retarded babies. However a note of caution is suggested that the use of fat emulsion during pregnancy be restricted to the upper daily limit of 20% of the calories normally derived from dietary fats (Hellar, 1972). Thus even exogenous fat from diet could be diverted to the fetus when mother has low reserves of fat depots.

At all stages, values for LIG were lower than HIG and a greater number of women had triglyceride levels less than 150 mg/dl even at the gestational period of 30-40 weeks (Table - 20). This indicates that in LIG the rise is of a smaller magnitude and may be these are the women who require special attention to their diet to overcome any stress of energy deficit to avoid fetal distress.

The phospholipid fraction and cholesterol show a slightly different trend from that of triglycerides by a gradual increase in serum levels through the different gestation periods. (Table 19). The increase is significant at term. In HIG and LIG the trend in increase during the different stages is similar and the difference between the income groups is also maintained and this is significant at term.

TABLE - 20 Distribution of triglyceride levels (mg/dl) at different stages of gestation in high and low income groups.

	Serum triglyceride level (mg/dl)						Total no. of subjects	
	<100		100-150		150			
	HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG
	% distribution							
Non-pregnant:	19	25	79	75	3	-	31	28
Weeks of gestation:								
<10	67	92	8	33	-	-	12	13
10 - 20	16	56	79	44	5	-	18	18
20 - 30	-	-	86	86	14	14	12	21
30 - 40	-	-	8	31	92	69	25	26
Post partum	9	19	68	81	23	-	22	16

Regarding the changes in serum cholesterol Darmandy et al, (1982) noted a small initial fall at 8 weeks of gestation in a longitudinal study. As pointed above this fall could not be observed partly this being a cross sectional study on pregnant women from the out patient clinic of the maternity hospital who generally visit for confirmation of pregnancy around 8-10 weeks for Medical termination of Pregnancy (MTP).

The levels of maternal serum cholesterol and phospholipids are in the range of those reported by others (Mendez et al, 1959; Kaplan and Lee, 1966; Kessal and Narayan, 1966; Zee, 1967; Dave, 1980; Knopp et al, 1982; Darmandy et al, 1982).

The hyperlipidemia of pregnancy is characterised by a 2-4 fold rise in plasma triglycerides and a 10% to 50% rise in plasma cholesterol at term (Knopp et al, 1973, 1978, Warth et al, 1975). This physiologic hyper lipidemia in pregnancy is specially significant from several stand points. (1) The increase in plasma total triglycerides and VLDL triglycerides may enhance the availability of essential and nonessential triglyceride fatty acids for placental transfer to the fetus (Elphick et al, 1978; Humphrey et al, 1980; Childs et al, 1981) as mentioned previously. (2) The total cholesterol and VLDL and HDL lipoprotein cholesterol fractions may increase the supply of cholesterol needed for placental progestiron synthesis

(Knopp et al, 1981; Carr et al, 1980; Knopp et al 1981 (Abst) and transplacental cholesterol transfer to the fetus (Pitkin et al., 1972; Lin et al, 1977). Khamasi, et al (1972) have shown that there is a good placental transfer of free cholesterol but not estrified cholesterol. At mid-term 60-70% of the cholesterol is of maternal origin and at birth 80-85% is of fetal origin. Placenta is a partial barrier to dietary cholesterol. (3) The hyperlipidemia may also serve as a maternal lipid homeostasis to an extent that a mild prelipemia becomes clinically detectable like that of gestational diabetes.

Carr et al., (1980) concluded from their study that low density lipoprotein are the important source of cholesterol for steroid biosynthesis in the human fetal adrenal. ACTH stimulates LDL degradation thereby ensuring continuous supply of cholesterol to meet the large demands for precursor which results from the high rate of steroid synthesis by human fetal adrenals.

As mentioned earlier, the rise in cholesterol was observed in both HIG as well as LIG with LIG having lower values than HIG. The differences in serum cholesterol levels between the two groups at different stages of gestation were associated with wide variations in each and overlapping of the ranges, suggesting that the lower values in the LIG may be due to a greater proportion of subjects not achieving the expected increase in pregnancy. The values for the two groups (Table - 21) show that initially in the LIG 48% of the non-pregnant women had cholesterol levels less than 175 mg/dl whereas 63% of the non-pregnant HIG women had levels between 175 - 225 mg/dl range. Thus, initially in both LIG and HIG, women falling in the above 225 mg/dl range was very small. But in HIG, with progress of gestation and with increase in cholesterol levels, most of the women including those who had levels less than 175 mg/dl range, shifted over to higher levels by mid-gestation itself and even increased to 225 mg/dl levels by the end of gestation period. In the LIG, 12% women had levels less than 175 mg/dl by the end of gestation as compared to none in the HIG.

A question arises about the consequences of failure to achieve the expected rise for the progeny. Knopp et al., (1982) in their study showed racial differences in whole plasma and lipoprotein concentrations of pregnant women. In their study the level of hyper cholesterelemia of pregnancy is posed as a risk of heart diseases whereas in developing countries it is the low levels of cholesterol that might cause a risk as has been pointed earlier.

In this connection a significant correlation between maternal cholesterol levels and fetal growth was found in the extensive studies carried out in Baroda (Shah 1986). Further

TABLE- 21 : Distribution of serum cholesterol levels (mg/dl) at different stages of gestation in high (HIG) and low (LIG) income groups.

		Serum cholesterol level (mg/dl)						No. of subjects in	
		<175		175 - 225		> 225			
		HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG
		% distribution							
Non - pregnant		28	48	63	45	10	7	32	32
Weeks of gestation	< 10	15	54	77	46	8	-	13	13
	10-20	20	47	55	37	25	16	20	19
	20-30	7	24	57	48	36	29	14	21
	30-40	-	12	19	15	81	73	27	26
Post-partum		-	-	13	18	87	82	23	17

investigations in this regard on lipoprotein fractions might show differences in the pattern for normal premature and growth retarded fetuses.

Since cholesterol, phospholipids and triglycerides seem to show some differences in the pattern of change with the progress of gestation, the percentage contribution of different lipid fractions was determined at different stages (Table - 22). The proportions of cholesterol, phospholipids and triglycerides remained more or less constant with progress of gestation except for a greater contribution of triglyceride levels during 30-40 weeks. This may be due to a greater mobilization of depot triglycerides during this period (De Alvarez et al, 1967).

A decrease in serum lipids has been reported post-partum by a number of workers (Horwitt et al, 1975). In the present investigation, cholesterol and phospholipids did not show much change whereas a steep fall was found in triglyceride levels (Table - 19).

The results are consistent with reports that triglycerides decline more rapidly after delivery (Otway and Robinson, 1968; Robinson et al, 1975; Darmandy et al, 1982; Knopp et al, 1982). The decline in cholesterol and phospholipid to pre-pregnant levels is reported to be achieved with the complete

TABLE-22: **Percentage contribution of different lipid components during gestation and post-partum.**

Lipid component (mg/dl)	Non-pregnant	Weeks of gestation				Post partum
		10	10-20	20-30	30-40	
		% contribution of lipids				
	Mean $\pm$ S.E.; with range in parentheses					
CHOLESTEROL	37.6±0.40 (31.7-43.0)	40.5±0.7 (36.0-46.1)	39.0±0.5 (31.0-44.7)	37.1±0.6 (31.2-43.2)	36.3±0.5 (29.3-54.9)	39.6±0.5 (33.1-46.4)
PHOSPHOLIPID	39.8±0.5 (33.6-47.4)	39.4±0.5 (34.2-45.6)	41.0±0.9 (36.2-54.9)	37.5±0.5 (29.3-41.3)	36.7±0.4 (33.6-42.6)	40.3±0.4 (36.7-45.7)
TRIGLYCERIDE	23.0±0.7 (15.5-30.1)	21.4±0.6 (14.1-28.1)	21.4±0.7 (10.2-25.0)	24.5±0.7 (17.5-32.9)	27.6±0.7 (20.9-39.6)	19.9±0.4 (16.0-24.0)

involution of the uterus and this is expected to occur at 6 weeks (Mendez et al, 1959). The decline was reported to be dependent on the breast feeding of their infants (Darmandy et al, 1982). However, according to some investigators this might take longer on the basis of the finding that cholesterol and phospholipids take 6 months post-partum to reach near non-pregnant level (Peters et al, 1951; Oliver and Boyd, 1955; Mendez et al, 1959; Smith et al, 1959; Otway and Robinson, 1968; Morse et al, 1975; Katiyar et al, 1978). The differences might be due to differences in the duration of lactation as well as post-partum amenorrhea. In this connection, lactation is reported to accelerate the involution of the uterus (Mitchell, 1964) and changes in prolactin levels. Hypoglyceridemia after delivery is interpreted to be due to the increased uptake of triglycerides and fatty acids by mammary tissue for the production of milk (Scow et al., 1964; Otway and Robinson, 1968).

In conclusion, the three major serum lipid components showed the expected increase with the progress of gestation, but for some fall in triglycerides in very early pregnancy. However, an appreciable proportion in the LIG failed to achieve this increase raising the question whether these are the women who are at risk of fetal loss, fetal growth retardation and prematurity as these lipid components are essential for various metabolic processes such as increase in steroid hormones and placental transfer of fatty acids to the fetus, not to mention the need for the acquisition of some adipose reserves during pregnancy which can enable the pregnant women to withstand the stress with regard to post partum changes. While levels of cholesterol and phospholipids remained the same, a significant fall after delivery in triglycerides is suggested.

As has been observed that an appreciable proportion of the Low income (LIG) group did not show significant change in the cholesterol values at term the cholesterol values being comparable to those of non-pregnant women - the question arises regarding the implications of this on the outcome of pregnancy. Hence simultaneously with the above investigation a preliminary study was carried out on maternal and infant serum cholesterol levels in relation to gestational age and weight of the infant. In other words comparisons were made of maternal and infant serum cholesterol levels in the three categories namely infants of full term, weights appropriate for gestational age (AGA), small for gestational age (SGA), and premature infants.

The results are presented in table - 23 which show the maternal and infant levels of serum cholesterol. The differences that were found between HIG and LIG at term were

Table 23 : Serum cholesterol (mg/dl) levels of mothers and infants in relation to age and growth status

	AGA				SGA				Prematures			
	'n'	GA	Mother Post-Partum	Infant	'n'	GA	Mother Post-Partum	Infant	'n'	GA	Mother Post-Partum	Infant
	Serum cholesterol (mg/dl) mean ± S.E. with range in parentheses											
HIG	10	39	257±14.5 (207-346)	122±5.6 (88-130)	-	-	-	-	-	-	-	-
LIG	33	39	232±6.16	97±3.29	12	37	206±6.28 (182-252)	80±3.74 (65-95)	22	33	207±5.05 (142-250)	78±2.31 (57-109)

AGA - Appropriate for gestational age.

SGA - Small for gestational age.

'n' - No. of subjects

GA - Gestational age in weeks.

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obliterated at post partum. A similar phenomenon has been observed with regard to vitamin E. In the low income group (LIG) parturient women and their infants from three different areas were studied but since their serum levels were not different from each other the pooled data (HIG + LIG) is analysed and presented. Table - 24 shows that the proportion of subjects having serum cholesterol level ∠225 mg/dl is high in mothers of small-for-date (SFD/SGA)* compared to mothers of full-term infants with expected weights. This has been confirmed in more extensive studies carried out subsequently in Baroda (Shah, 1986). A further analysis of the data showed that, about 73% of mothers of full term normal infants had cholesterol levels above 225 g/dl, whereas this figure was 25% in the case SGA. The values of χ^2 for this difference was statistically significant (Table - 24).

The higher proportion of low values for serum cholesterol in the mothers of premature and SGA* infants raises a question regarding the implication of this for fetal development. In fact the serum cholesterol levels of premature and small for dates were found to be significantly lower than that of full term normal infants, suggesting a correlation between maternal and infant cholesterol levels.

A correlation between serum cholesterol level of full-term infants, low birth weight babies and premature infants

*SGA – Small for Gestational Age.

TABLE - 24: Distribution of post-partum serum lipids (mg/dl) in mothers in relation to infant status

	Total 'n'	G.A.	Serum lipids (mg/dl) <225	Serum lipids (mg/dl) ≥ 225	χ^2
			Percentages with figures in parentheses.		
CHOLESTEROL					
(a) full term (i) AGA	43	39	28.0 (12)	72.1 (31)	
(ii) SGA/SFD	12	37	76.9 (9)	25.0 (3)	$P<0.001$
(b) Premature	23	33	78.3 (18)	21.7 (5)	

AGA - Appropriate for gestational age;
SGA/SFD. Small for gestational age.
GA - Gestational age in weeks.
n - no. of subjects.

has been reported by Sharma et al.,(1983) and Lane and McConathy (1983). On the other hand, Jugowaka and MieCznikowska (1975) and Ginsburg and Zitterstrom (1980) have reported a higher level of serum cholesterol and phospholipids in both low birth weight babies and prematures compared to full-term infants and normal birth weight babies. Similar conflicting observations have also been made with regard to triglycerides (Frossbrooke and Wharton, 1973; Elphick et al., 1978).

Since there was an indication of a possibility of correlation between birthweights, infant cholesterol levels and maternal cholesterol levels, the data on infant and maternal cholesterol levels were analysed in relation to birth weights (Table - 25). Variations in birth weight were associated with differences in infant and maternal serum cholesterol levels. The subsequent detailed studies carried out in Baroda on LIG and HIG indicate similar observations (Table-26) by Shah, (1986). Since the maternal and infant serum cholesterol levels differed in relation to birth weights, the data were examined for any association at certain cut of points of maternal cholesterol levels and birth weight of babies (Table - 27).

The cut-off points for serum cholesterol were chosen after a more detailed analysis of the frequency distribution

TABLE - 25: **Maternal** and infant serum cholesterol levels (mg/dl) in relation to birth weight

Birth weight (kg)	Serum cholesterol level (mg/dl)	
	Infant	Mother
	Mean ± S.E.; 'n' (above) and range (below) in parentheses.	
∠2.5	77 ± 2.2 (32) (49 - 95)	206 ± 0.9 (142 - 250)
2.5 - 3.0	99 ± 1.1*** (29) (60 - 140)	224 ± 7.2* (173 - 264)
3.0	107 ± 2.6*** ‡‡ (18) (62 - 140)	269 ± 2.2*** ‡‡ (171 - 340)

Values marked with asterisk are significantly different from ∠2.5 group.

* $P < 0.02$; *** $P < 0.001$.

‡‡ Values significantly different from preceding value in the same column. $P < 0.01$.

TABLE 26: Cord and Maternal serum cholesterol in relation to birth weight and gestational age in low (LIG) and High (HIG) income groups (BARODA)

Birth weight (kg)	No. of subjects				SERUM CHOLESTEROL							
					CORD				MATERNAL			
	FULL TERM		PREMATURE		FULL TERM		PREMATURE		FULL TERM		PREMATURE	
	LIG	HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG	HIG	LIG	HIG
					Mean ± SE and Mean birth weight in parantheses.							
Less than 2.5 kg	32	1	14	4	66 ± 2.3 (2.16±0.04)	91 (2.38)	58±2.8 (1.71±0.09)	67±4.5 (2.2±0.07)	176± 3.7	258	180± 5.3	194± 9.0
More than 2.5 kg	54	52	3	3	87±2.2 (2.86±0.05)	91±2.2 (3.07± 0.05)	57±3.2 (2.56±0.03)	63±2.3 (2.76±0.17)	218±* 4.7	223± 5.1	193± 5.9	196± 8.1

* Values significantly different from previous 't' value + P ∠0.001.

Reference: Shah (1985).

TABLE 27. Birth weight and serum cholesterol levels of infants in relation to maternal cholesterol levels

Maternal serum cholesterol (mg/dl)	Infants: Birth weight (kg)	n	Infants: Serum cholesterol (mg/dl)
Mean ± S.E.; 'n' (above) and range (below) in parentheses.			
$<$ 175	2.2 ± 0.22	(5)	87 ± 4.9
	(1.6 - 2.9)		(75 - 100)
175 - 225	2.2 ± 0.03	(36)	79 ± 2.4
	(0.7 - 3.5)		(49 - 100)
$>$ 225	2.8 ± 0.10***		100 ± 4.7
	(1.5 - 4.0)		(52 - 130)

*** P $<$ 0.001 significantly different from value for $<$ 175 group.

of maternal serum cholesterol as some of the (12%) pregnant women in the 30 - 40 weeks of gestation well still in the less than 175 mg/dl serum cholesterol levels. However more clear cut differences in birth weight were found for values above 225 mg/dl range, when compared with the studies at Baroda (Table 28). These differences could partly be accounted for by the high average values for maternal serum as compared to those reported at Baroda (Table - 28). However both studies suggest a correlation between maternal cholesterol levels, birth weight and infant cholesterol levels, and that these can be considered as risk indicators during pregnancy.

The correlation between maternal and infant cholesterol levels suggest that, infant lipid status is influenced by maternal status. However, other investigators have not observed a similar association (Kessel and Narayanan, 1966; Aleksander <u>et al</u>., 1975; Mehta and Mehta, 1984). This might be possible because of differences in the range of values obtained in the different studies.

Further studies on non-pregnant, pregnant and parturient women belonging to different income groups with associated variations in fat intakes are necessary. The need for such studies is brought out by the differences found between women (pregnant as well as parturient women) in low

TABLE 28: Cord serum cholesterol and birth weight in relation to maternal serum cholesterol in low (LIG) and high (HIG) income groups

Maternal serum cholesterol (mg/dl)	No. of subjects		Cord Serum Cholesterol (mg/dl)		Birth weight (kg)	
	LIG	HIG	LIG	HIG	LIG	HIG
			Mean ± SE and mean maternal serum cholesterol in parantheses			
Less than 175	19	3	65±3.2 (158±1.9)	96 ± 14.0 (162 ± 6.1)	2.24±0.06**	3.05 ± 0.01
175 - 225	45	28	84 + 2.3 (197 ± 2.1)	87 ± 2.1 (200 ± 2.6)	2.69 ± 0.08*+	3.00 ± 0.07
More than 225	22	22	90 ± 4.0 (252 ± 4.5)	96 ± 3.8 (256 ± 5.3)	2.74 ± 0.06**	3.15 ± 0.07

Values significantly different from HIG *P $\angle$0.01 and **P$\angle$0.001

Values significantly different from previous values +P $\angle$0.001.

Ref: Snaw (1986).

and high income groups in Kerala, in which case, although the mean values were not significantly different, a study of frequency distribution (Table -21)) showed clearly a higher proportion of low values of cholesterol in the low income group and high values in the high income group.

Serum vitamin E levels in pregnant and parturient women

As mentioned earlier the tocoperol and PUFA content of the diet in Kerala are low compared to other regions, a fact consistent with the use of coconut oil and coconut. Previous studies in this laboratory conducted at Kerala suggested that the serum vitamin E levels of these populations are low (Ramachandran and Ramakrishnan, 1968; Thomas, 1975).

In the light of the above observations of the relatively lower levels of serum vitamin E in the poor groups particularly in Kerala the question arises as to whether or not the women in the different periods of gestation achieve the expected rise during pregnancy. Hence the present investigation on serum vitamin E levels was carried out at different stages of pregnancy and post-partum. The data given in Table 27 shows a progressive increase in serum vitamin E levels at different stages of pregnancy. Social class differences are also maintained throughout the gestation period. This pattern was found to be consistent with data obtained on cross-sectional and longitudinal studies in this laboratory (Dave, 1980; Shah, 1987) and those reported elsewhere (Ferguson et al., 1955; Linder et al., 1967; Vobecky et al., 1973; 1974; Horwitt et al., 1975; NIN Annual Report, 1978; Haga and Kran, 1982). However studies by

TABLE 29 : Changes in serum vitamin E (mg/dl) at different stages of gestation and post-partum in high (HIG) and low (LIG) income groups

GROUPS	Non-pregnant	Gestation period (weeks)				Post-partum
		10	10-20	20-30	30-40	
			Mean ± S.E. with range below and 'n' above in parentheses.			
HIG	(12) 0.75±0.04 (0.52–1.20)	(12) 0.82±0.09 (0.36–1.45)	(19) 0.87±0.06 (0.36–1.35)	(14) 0.99±0.06 (0.76–1.45)	(27) 1.19±0.05 (0.82–1.35)	(22) 1.05±0.03 (0.76–1.30)
LIG	(12) 0.68±0.06 (0.41–0.98)	(13) 0.72±0.07 (0.33–1.03)	(18) 0.75±0.05 (0.36–1.13)	(21) 0.90±0.05 (0.38–1.15)	(24) 1.04±0.04 (0.76–1.60)	(14) 0.93±0.04 (0.76–1.2)

Ng and Chong (1975) suggest a fall in vitamin E levels during pregnancy.

Further, when the subjects are distributed according to serum vitamin E levels (Table 30), the results show that initially most of the women had serum vitamin E levels ranging from 0.6 to 0.9 mg/dl and with progress of gestation (at 20 weeks) almost all crossed the 0.6 mg/dl levels. Thus, most of the subjects showed improvement in their vitamin E status with progress of pregnancy.

Similarly, though initially the percent of non-pregnant women having serum vitamin E value 1.2 mg/dl was negligible, by the end of gestation period, a good proportion of women attained this value. However those whose levels could not arise might be the ones who are at risk of prematurity and growth retardation.

Though the serum vitamin E level rises during gestation, a fall in postpartum levels is reported (Varangot <u>et al</u>., 1943; Attranossin, 1946). Low serum vitamin E levels have been reported in parturient women by Hassan <u>et al</u> (1982). However, in the present investigation the post-partum fall was not significant. This might be because of its relationship with the cholesterol levels which also did not show a significant fall in the present study. The post-partum fall of serum cholesterol is reported to be slow and is expected to take 4-6 months post-partum to reach non-pregnant levels

TABLE- 30 : Distribution of serum vitamin E levels at different stages of gestation and post-partum in high (HIG) and low (LIG) income groups.

		No. of subjects	Serum levels (mg/dl)			
			<0.6	0.6 - 0.9	0.90 - 1.2	>1.2
			Percent value with 'n' in parentheses.			
Non-Pregnant	HIG	12	8.3 (1)	41.7 (5)	50.0 (6)	-
	LIG	12	41.7 (5)	41.7 (5)	16.6 (2)	
Weeks of Gestation						
<10	HIG	12	25.0 (3)	25.0 (3)	41.7 (5)	3.3 (1)
	LIG	13	30.8 (4)	30.8 (4)	38.5 (5)	-
10-20	HIG	19	21.4 (3)	26.3 (5)	42.1 (8)	10.5 (2)
	LIG	18	22.2 (4)	50.0 (9)	27.8 (5)	-
20-30	HIG	14	-	28.6 (4)	57.1 (8)	14.3 (2)
	LIG	21	14.3 (3)	19.0 (4)	61.9 (13)	4.8 (1)

TABLE- 30 (Contd.)

		No.of subjects	Serum levels (mg/dl)			
			<0.6	0.6–0.9	0.90–1.2	>1.2
30–40	HIG	29	-	18.3 (3)	44.8 (13)	44.8 (13)
	LIG	24	-	20.8 (5)	54.2 (13)	25.0 (6)
Post-partum	HIG	22	-	13.6 (3)	72.7 (16)	13.6 (3)
	LIG	14	-	28.6 (4)	71.4 (10)	-

(Peters *et al.*, 1951; Oliver and Boyd, 1959; Hansen *et al.*, 1964; Morse, 1975; Katiyar, 1978). Hence serum vitamin E, which is correlated with cholesterol levels and lipoproteins concerned with transport of vitamin E, might also take time to go down to non-pregnant levels. These observations also suggest that the differences in serum vitamin E levels between the LIG and HIG may be due to differences in lipoproteins concerned with transport of vitamin E.

Other studies in this laboratory have shown that maternal deficiency of vitamin E increases the risk of prematurity and fetal growth retardation and that the deficiency of this vitamin is a risk factor involved for the successful outcome of pregnancy (Shah *et al.*, 1984).

Serum magnesium levels in pregnant and parturient women

In certain clinical conditions such as diseases of the small intestine, celiac disease, enteritis, childhood malnutrition, chronic renal disorders and disorders of parathyroid the role of magnesium is well documented (Wallach et al, 1962; Booth et al., 1963). Epidemiological studies have also suggested a link between magnesium status and cardiovascular disorders (Vitale et al., 1959; Hughes and Tonks, 1965; Nath et al., 1969; Abraham et al., 1978). However, it is generally assumed that an adequate supply of this mineral in human diets should not pose a serious problem as it is ubiquitously present in commonly consumed foods such as food grains and vegetables. However, in areas where rice is consumed and water is low in magnesium, the supply of magnesium may fall short of requirements. In some areas such as Burma prevalence of magnesium deficiency has been reported (Gopalan, 1973; Seelig, 1974). A similar situation is likely to occur in Kerala where the diets provide about 100 to 150 mg/day of magnesium as against recommended allowances of 300 - 400 mg/day (Seelig,1982). This may affect pregnant and lactating women even more as maternal magnesium requirements increase during pregnancy and lactation because of increased protein synthesis and other biochemical functions related to maternal and fetal growth as well as milk production (Lim et al., 1969; Cohlan et al., 1970; Widdowson et al, 1980; Feng Lai Wang et al., 1971; Hurley and Cosens 1971; Hurley, 1976; Seelig, 1981). Several deficient diets showed fetal resorption or teratogenic effects on full term off-spring (Hurley, 1976). It is also recognised that in such regions magnesium deficiency is found in association with protein-energy malnutrition (Caddell, 1969, 1975; Zieve, 1975).

In collateral studies in this laboratory, serum magnesium levels were found to differ in malnourished child-ren in Trivandrum and Madurai presumably because of greater magnesium content of the foods consumed such as pulses, vegetables, and tamarind by the poor in Madurai, than in Kerala. The water in Madurai is also hard.

The results of studies on magnesium status of pregnant women in Kerala are given in Table - 31. As income status did not show differences in serum magnesium levels both the Low and High income groups were clubed and the data is presen-ted in the table. It can be seen that, serum magnesium levels registered initially a small rise followed by a significant fall during 10-20 weeks of gestation and maintained thereafter. The values at term were significantly lower than non-pregnant values. The fall during pregnancy is believed to be due to the utilisation of magnesium for the synthesis of various pro-tein complexes in placental and other accessory tissues (Caddell, 1973; Heaton, 1980).

TABLE 31 : Changes in serum magnesium levels (mg/dl) with the progress of gestation (HIG; LIG combined)*

Non-pregnant	Period of gestation (weeks)				Post-partum values for mothers	
	<10	10-20	20-30	30-40	AGA	Premature
Serum magnesium (mg/dl); Mean ± S.E., 'n' (above) and range (below) in parentheses.						
1.89±0.05	2.06±0.07	1.78±0.05	1.90±0.05	1.77±0.04	1.78±0.04 **	1.47 ± 0.06 ***
(32)	(25)	(38)	(35)	(52)	(37)	(9)
(1.62-2.2)	(1.3-2.6)	(1.3-2.5)	(1.3-2.4)	(1.5-2.2)	(1.5-2.2)	(1.2-1.7)

AGA - Appropriate gestational age.

* Combined, since no differences were found between income groups.

*** $< p$ significant at 0.001 compared to Non-pregnant level

** $< p$ " 0.01 " " "

Post partum serum magnesium levels were found to compare with term values in mothers who delivered full-term healthy infants. On the other hand, the magnesium levels were significantly low in mothers who delivered premature infants raising the question whether magnesium deficiency is one of the predisposing factors for prematurity. In an elaborate study in this laboratory on fetal growth and maternal magnesium status by Shah (1986) showed that the total magnesium stores in all the tissues were related to fetal size indicating that the lower size of the fetus at birth may pose a risk for muscle development and other activities later.

In these studies no correlation was found between serum magnesium levels of the mothers and cord serum levels of the infants. Similarly the data showed no correlation between maternal serum levels of either full term or premature infants. The differential pattern shown between Kerala and Baroda may perhaps be accounted for by the fact that the diets in Baroda are not deficient in magnesium content contributing to about 200 -230 mg/day where as Kerala diet supplies only about 100 - 150 mg/day of magnesium. Thus magnesium inadequacy might be a contributory factor and may reflect the fetal needs for magnesium during this period (Widdowson et al., 1951; Widdowson and McCance, 1961; Seelig, 1980).

PART - II

Studies on adult man and women at different ages in relation to plane of nutrition

Increase in life expectancy has culminated in larger number of elderly people in all over the world and India is no exception to it. The elderly are hospitalized proportionally more often for longer periods and for more serious and chronic disorders than younger population groups at disproportionate cost (Steffe 1980, Tomajolo 1981). It is by now clear that the health status of individuals depends on the nutritional status of the population and this in turn depends on the dietary pattern of that region and there is complexity in assessing the nutritional status of the edlerly.

As mentioned earlier, the dietary patterns in Kerala are such as to lead us to expect some differences in nutritional status between Keralites and people in other regions (e.g. serum lipids and magnesium) and between vegetarians and non-vegetarians. The various groups studied in Kerala may differ not only with regard to growth and adult stature, but also with regard to somatic and biochemical profiles and the pattern of changes in these with advancing age. The investigations were carried out primarily to study serum lipid changes with age. The details of subjects investigated with their occupation are given in Table - 32.

<u>Somatic measurements of adult men and women at different ages in relation to plane of nutrition:</u>

The changes reported in body composition with age in adults include a progressive increase in body fat, decrease in lean body mass and alternations in skeletal weight (Frobes and Reina, 1970; Brichman, 1976). It has long been known that certain organs of the elderly such as liver, pancreas and endocrine glands are smaller due to atropy (Roessle and Roulet, 1932; Calloway *et al.*, 1965). In addition, the nature and magnitude of age specific changes may vary with the plane of nutrition, health-status as well as over all life style not to mention genetic and psychosocial factors.

In the case of low-income group, fat gain and weight increase do not seem to be perceptible perhaps because energy expenditure is high whereas food supply is restricted (Bourliere and Parot, 1962; Rajalakshmi and Chandrasekharen, 1966).

TABLE 32: Occupation of subjects studied.

High Income Group				Low Income Group			
Men	'n' =130	Women	'n' =110	Men	'n' =45	Women	'n' =72
Administrative staff	13	Administrative staff	5	Cooks	3	Coolies	14
Businessmen	30	Balasevikas	10	Coolies	12	Cashewnut desheller	20
Clerks	10	Doctors	6	Electricians	6	Helpers	14
Doctors	10	House wives	20	Lab.attendants	10	House wives	8
Lawyers	2	Librarians	3	Watchmen	8	Lab.Assistants	5
Librarians	2	Mother superiors	6	Ward Boys	6	Sweepers	6
Pujaris	10	Nurses	15			Ward attendants	5
Pharmacists	15	Pharmacists	6				
Retired workers	25	Retired women	6				
Teachers	4	Students	20				
Technicians	9	Stenographers and Clerks	8				
		Technicians	5				

The present investigation was primarily aimed at studies on serum lipid changes with age. Though comparison of somatic measurements at different ages would need large number of samples, an attempt was made to collect data on the available subjects to get some preliminary picture.

The data on weights and heights are presented in Tables 33 & 34. In HIG (Table 33), men showed an increase in weight up to middle age. In the case of women, there was an increase even in the 6th decade (Table 34). This pattern of increase was not observed in the LIG.

Similar observations have been made in previous studies in this laboratory (Rajalakshmi and Chandrasekharan, 1966) and by others elsewhere (Hooten and Dupertis, 1951; Stoudt et al, 1965; Parot, 1966; Underwood et al., 1972). In considering the "desirable" body weights for adults males should decrease to weight 12 kg less at age 65-70 than age 25 years and females 5 kg less (Forbes AndReina, 1970).

Buchi (1950) reported a decrease of 2.9 cm in men from 47 to past 70 years and Rossman (1977) reported a decrease of 2.9 cm in men, 4.9 in women during the average life of an individual.

TABLE - 33: Body weights (kg) and heights (cm) of adult men at different ages and income groups (MEN)

	Age group (yrs) 20 - 29	30 - 49	50-69	All ages combined
	Mean ± S.E.; 'n' (above) and range (below) in parentheses			
MEN:				
HIG				
Weight (kg)	50.8±1.2 (34) (39.0-69.5)	62.3±1.3*** (57) (41.0-80.0)	58.2 ± 1.4*** (39) (46.5 - 81.0)	58.0 ± 0.9 (130) (39.0 - 81.0)
Height (cm)	167.7±1.1 (34) (152.5-180.0)	166.0±0.9 (57) (153.0-182.0)	164.5 ± 1.0 (39) (153.0-180.0)	166.4 ± 0.6 (130) (152.5-182.0)
LIG				
Weight (kg)	47.4±1.4 (11) (42.0-58.0)	48.5±1.6 (17) (41.0-61.0)	48.3 ± 1.0 (17) (43.0 - 61.5)	48.1 ± 0.8 (45) (41.0 - 61.5)
Height (cm)	163.0±1.2 (11) (158.0-170.0)	161.0±1.7 (17) (147.0-170.0)	160.0 ± 1.0 (17) (151.0 - 169.0)	161.0 ± 0.8 (45) (147.0 - 170.0)

TABLE - 34: Body weights (kg) and heights (cms) of adult women at different ages and income groups (WOMEN)

	Age groups (Years) 20-29	30-49	50-69	All cases combined
	MEAN ± S.E 'n' above & range below.			
Women:				
HIG				
Weight (kg)	46.6 ± 1.9 (28) (33.0 - 71.0)	52.9 ± 1.1*** (47) (36.5 - 68.0)	55.7 ± 2.0*** (35) (38.5 - 73.0)	51.8 ± 0.9 (110) (33.0 - 73.0)
Height (cm)	154.0 ± 1.3 (28) (143.0 - 165.0)	152.0 ± 0.7 (47) (147.0 - 165.0)	152.0 ± 0.7 (35) (146.0 - 157.0)	152.6 ± 0.6 (110) (143.0 - 165.0)
LIG				
Weight (kg)	41.5.5 ± 1.1 (24) (32.0 - 53.0)	44.8 ± 1.6** (29) (33.5 - 64.0)	45.0 ± 1.3** (19) (34.5 - 55.0)	43.7 ± 0.8 (72) (32.0 - 64.0)
Height (cm)	150.0 ± 1.1 (24) (142.0 - 159.0)	149.0 ± 1.2 (39) (137.5 - 166.0)	149.9 ± 1.1 (19) (139.0 - 158.0)	149.6 ± 0.8 (72) (138.0 - 166.0)

** Significantly different from 20-29 years age group $P < 0.01$.

*** Significantly different from 20-29 years age group $P < 0.001$.

In the present study, Tables 33 & 34 show a height decrease of 3 cm in both HIG and LIG men with a decrease of 2 cm only in HIG women. The reported trend was observed in men where as in women this trend was not seen. This might be because of wide intragroup variations or due to a low body mass unlike the western heavy women who carry themselves with a flexion at the knees and hips (Howells, 1970). In an ICMR ~~(1961)~~ study by Rao et al (1961) a decrease of only 1.3 cm in men and 0.7 cm in women between 30 to < 50 years is reported. However, a larger sample is required for better understanding of the age decrement in height.

As may be expected, the weight/height ratio (kg/cm) is consistently higher in both men and women in the high income group as shown in Table 35. When men are compared with women, at different ages, initially the ratio is less in women and increases thereafter . This might be due to a greater increase in weight before middle age in men but which continued to increase in women beyond the age of 50 years. When the same is calculated as per cent of LIG in both men and women there is a steady increase upto fifty years, and beyond in women as HIG women put on fat after reproductive period.

TABLE 35: Ratio of weight (kg)/height (cm) in adult men and women at different ages.

	Age groups (years)		
	20 - 29	30 - 49	50 - 70
MEN:			
HIG	0.30	0.38	0.35
LIG	0.29	0.30	0.30
HIG values as per cent of LIG values	103	127	117
WOMEN:			
HIG	0.29	0.36	0.38
LIG	0.26	0.31	0.38
HIG values as per cent of LIG values	104	116	127
Values for women as % values for men	97	99	105

HIG - High Income Group; LIG - Low Income Group.

A weight-to-height ratio of 0.44 was reported for Canadian and American population (US Department Vital and Health Statistics, 1960-62; Pett and Ogilvie, 1956; US Department Health Examination Survey, 1965, 1970). Similar studies on the Indian population living around Hyderabad showed a ratio of 0.32 (NIN Annual Report, 1965) and studies on Pakistani men in the general population and the privileged college population showed a ratio of 0.34 and 0.36, respectively. The results of the present investigation are in agreement with the Asian studies reported.

In the high income group, all the body measurements presented in Table 36 show an appreciable increase with age which is consistent with increase in body weight. The increases were of similar magnitude in men and women in the high income group, except for abdominal circumference which is appreciably higher in women than in men at the older age group. Women seem to accumulate more fat and men more lean body mass at old age (Milev and Demireva, 1966; Bourliere, 1970; Frobes and Reina, 1970).

In men belonging to LIG, chest circumference, abdomen circumference and mid-arm circumference seem to be less than in HIG group. In women belonging to LIG, the chest circumference and mid arm circumference do not seem

TABLE 36 Somatic measurements (cm) of adult men and women

			Age group (Years)			All ages combined
			20 - 29	30 - 49	50 - 69	
			Mean ± S.E., 'n' (above) and range (below) in parenthese			
CHEST CIRCUMFERENCE	MEN	HIG	80.4 ± 0.96 (34) (69.0) - 92.0)	90.4 ± 0.80***@ (57) (81.0 - 102.0)	89.0 ± 1.09***@ (39) (75.5 - 105.0)	87.3 ± 0.67 (130) (69.0 - 105.0)
		LIG	81.1 ± 1.41 (11) (75.0 - 88.0)	83.7 ± 1.21***b (17) (77.0 - 94.5)	82.2 ± 1.39 (17) (72.5 - 94.0)	82.5 ± 0.7 (45) (72.5 - 94.5)
	WOMEN	HIG	81.8 ± 1.3 (28) (69.0 - 93.5)	91.7 ± 1.3***@ (47) (73.0 - 120.0)	95.1 ± 1.75 (35) (83.5 - 113.0)	89.9 ± 0.9 (110) (69.0 - 113.0)
		LIG	80.1 ± 0.95 (24) (72.0 - 92.0)	84.5 ± 1.4***@b (29) (72.0 - 100.5)	82.3 ± 1.2***b (19) (72.5 - 90.5)	82.4 ± 0.7 (72) (72.0 - 100.5)

TABLE 36 (Contd..)

			Age group (years)			All ages combined
			20-29	30-49	50-69	
ABDOMEN CIRCUMFERENCE	MEN	HIG	74.2 ± 0.94 (34) (66.0 - 82.0)	87.5 ± 1.37***@ (57) (72.0 - 102.0)	84.4 ± 1.6***@ (39) (67.6 - 101.5)	83.5 ± 1.0 (130) (66.0 - 102.0)
		LIG	71.0 ± 1.5 (11) (64.0 - 82.0)	76.6 ± 1.5***@b (17) (66.5 - 91.0)	78.7 ± 1.2***@b (17) (71.0 - 84.0)	75.96 ± 1.0 (45) (64.0 - 91.0)
	WOMEN	HIG	77.4 ± 1.8 (19) (64.0 - 90.0)	86.8 ± 1.4***@ (47) (86.0 - 115.0)	93.0 ± 2.0***@ (35) (78.5 - 112.0)	84.6 ± 1.1 (110) (64.0 - 115.0)
		LIG	70.3 ± 1.6 (24) (59.5 - 81.0)	75.3 ± 1.5*@ (29)***b (63.0 - 92.0)	75.7 ± 1.28**@ (19) ***b (66.5 - 84.0)	74.2 ± 0.9 (72) (59.5 - 84.0)

TABLE 36 (contd..)

			Age group (years)			All ages combined
			20 - 29	30 - 49	50 - 69	
MID-ARM CIRCUMFERENCE	MEN	HIG	24.7 ± 0.41 (34) (21.0 - 29.0)	29.1 ± 0.38***@ (57) (23.5 - 36.5)	27.5 ± 0.35***@ (39) (23.0 - 32.0)	27.5 ± 0.3 (130) (21.0 - 36.5)
		LIG	24.5 ± 0.9 (11) (20.5 - 30.0)	26.0 ± 0.7***b (17) (22.0 - 33.0)	24.1 ± 0.2***b (14) (23.0 - 28.0)	24.9 ± 0.4 (45) (20.5 - 33.0)
	WOMEN	HIG	25.0 ± 0.6 (28) (19.0 - 31.0)	27.9 ± 0.4***@ (47) (21.0 - 35.5)	28.9 ± 0.8***@ (35) (24.0 - 34.5)	27.3 ± 0.4 (110) (19.0 - 35.5)
		LIG	23.8 ± 0.5 (24) (19.5 - 27.0)	24.9 ± 0.6***b (29) (19.5 - 30.0)	25.1 ± 0.7***b (19) (20.0 - 29.5)	24.6 ± 0.3 (72) (19.5 - 30.0)

@ Values significantly different from respective reference age group. (20 - 29)

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

b, Values significantly different from HIG group.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

to differ from that of the same class. An analysis (Table 37) of mid arm circumference with reference to its relation to body weight change at different ages shows a steady increase in mid-arm circumference with increase in body weight in both men and women. As indicated earlier women show higher values than men in the same weight range. However, within the same sex and weight range, generally mid-arm circumference seems to show similar measurements. This shows that mid-arm circumference and weight are well-related, as might be expected, as both reflect the degree of adiposity. The coefficient of correlation calculated showed a significant relationship (r = 0.75 and 0.76) between mid-arm circumference and weight in both men and women. These observations are in agreement with the results obtained earlier by others (Milev and Demireva, 1966; Sukkar, 1976).

To conclude, weights and somatic measurements seem to increase to varying degrees with age. The differences in this regard between men and women are consistent with reported observations in literature and those between the two income groups with differences in dietary patterns and life styles. The men and women in the low income groups show little perceptible changes with age.

TABLE 37: Mid-arm circumference (cm) in relation to body weight.

Age group	BODY WEIGHT (KG) 40	40-44	45-59	50-54	55-59	60-64	65-70	Total subjects
	Mean ± S.E., 'n' in parentheses							
MEN:								
20 - 29	--	22.8±0.8 (8)	24.3±0.6 (17)	25.2±0.4 (9)	27.0±0.7 (9)	27.5±0.5 (2)		45
30 - 49	--	24.3±0.6 (6)	26.1±0.9 (12)	26.8±0.8 (7)	27.3±0.6 (13)	28.9±0.5 (12)	31.0±0.7 (34)	74
50	--	23.5± (1)	24.0±0.4 (16)	26.3±0.6 (12)	27.2±0.4 (10)	27.4±0.7 (6)	29.4±0.8 (9)	56
WOMEN:								
20 - 29	22.1±0.4 (15)	23.6±0.6 (14)	25.6±0.6 (14)	28.0±0.0 (4)	28.8±0.8 (3)	--	31.1± (2)	52
30 - 49	22.2±0.4 (12)	23.8±0.6 (13)	25.6±0.4 (12)	28.1±0.4 (13)	29.4±0.6 (14)	30.0±1.0 (10)	30.5±2.8 (2)	76
50	23.3±1.2 (5)	25.1±1.4 (14)	25.3±0.8 (9)	27.7±0.5 (9)	30.4±1.1 (7)	30.1±0.9 (5)	32.1±1.2 (5)	54
ALL AGES:								'r'
Men	--	24.1±0.9 (15)	24.7±0.4 (45)	25.8±0.4 (28)	27.2±0.3 (32)	28.3±0.4 (22)	30.5±0.4 (33)	0.75
Women	22.1±0.3 (32)	24.3±0.4 (41)	25.6±0.3 (35)	28.0±0.3 (26)	29.4±0.5 (24)	30.3±0.1 (15)	31.3±0.9 (9)	0.76

'r' - Coefficient of correlation P ∠0.001.

Blood glucose levels in adult men and women at different ages

Fasting blood glucose level is one of the parameters which tends to increase with age in an appreciable proportion of adults who become more prone to diabetes mellitus after middle age. This is more likely to happen among the affluent and urbanised people. (Gupta et al, 1978; Verma et al, 1986).

The data on blood glucose levels in different age groups are presented in Table 38. Blood glucose levels refer to fasting state in all cases. As expected, blood glucose levels are found to show a tendency to increase with age with a progressive proportion of values being in the above 90 mg/dl level (Table - 39). At all ages, the values tend to be greater in the HIG than in the LIG. However, the pattern of change with age appears to be similar in the two income groups and in men and women although differences are found in absolute values.

TABLE 38: Blood glucose levels (mg/dl) in adult men and women at different ages

		AGE GROUP (YEARS)			All ages combined
		20 - 29	30 - 49	$\geq$ 50	
		Mean ± S.E.; 'n' (above) and range (below) in parentheses			
MEN:	HIG	68 ± 1.3 (23) (57 - 82)	78 ± 1.4+++ (36) (60 - 96)	87 ± 1.5*** (24) (68 -101)	78 ± 1.2 (83) (57 - 101)
	LIG	67 ± 2.7 (11) (60 - 87)	75 ± 2.6+ (17) (60 - 95)	83 ± 1.5** (17) (72 - 96)	76 ± 1.6 (45) (60 - 96)
WOMEN:	HIG	72 ± 1.9 (17) (58 - 90)	77 ± 2.0 (32) (56 - 110)	86 ± 1.8*** (17) (71 - 98)	78 ± 1.3 (66) (56 - 110)
	LIG	69 ± 1.4 (24) (60 - 80)	76 ± 1.8 (29) (62 - 101)	77 ± 2.0*** (19) (67 - 93)	74 ± 0.9 (69) (60 - 101)

HIG - High Income group
LIG - Low Income group
'n' - number of subjects

$p <$ + Significant at 0.05 from the preceeding value.
$p <$ +++ Significant at 0.001 from the preceeding value.

$p <$ ** Significant at 0.01 from the 20 - 29 age group.

$p <$ *** " at 0.001 " " 20 - 29 " "

TABLE 39: Frequency distribution of fasting blood glucose levels in different age group

	Blood glucose (mg/dl)	Age group (Years) 20 - 29	30 - 49	50 - 70	Total Subjects
		Per cent distribution of subjects*			
MEN :					
	∠70	59 (8+11)	19 (4 + 6)	2 (0 + 1)	30 (12+18)
	70-90	41 (3+11)	71 (9 +28)	73 (14+16)	81 (26+55)
	90	-	10 (2 + 3)	24 (3+ 7)	34 (5+10)
	TOTAL	(33)	(52)	(41)	
WOMEN:					
	∠ 70	51 (13+7)	16 (3 + 6)	3 (4+ 0)	30 (17+ 3)
	70 - 90	46 (9+9)	74 (23+20)	71 (15+12)	88 (47+41)
	90	3 (1+0)	10 (3+3)	24 (2+ 7)	16 (6+10)
	TOTAL	(39)	(58)	(37)	

* LIG + HIG subjects in parentheses.

LIG - Low Income group
HIG - High Income group.

A higher prevalence of higher values is observed in the 4th and 5th decades. The percentage distribution seem to be almost similar in men and women. The greater prevalence of high values in the older age groups is consistent with expectations.

According to the literature available, considerable controversy prevails regarding changes in blood glucose with age. Studies by Silverstone (1957), Unger (1957) and Hayner et al.,(1965); Gupta et al, (1978); Verma et al (1978) suggest a rise in blood glucose level whereas others found no clear-cut difference with age or sex. Statistical analysis using the χ^2 (Tables 40)& 41) indicates a significant difference for blood glucose levels with age and sex but not with social class. This might be due to the high consumption of sugar in black coffee by LIG (Kattam coffee with sugar) and the type of dietary carbohydrate (rice + Tapioca) in large amounts. These results are in agreement with Campbell (1963) and Reiser et al (1981) who reported positive correlation with the amount of sugar and type of carbohydrate consumed.

With the progress of age, the lean body mass decreases and fat content increases (Frobes and Reina, 1970) especially in the affluent, leading to obesity. Hence it was of interest to see whether blood glucose is related to

TABLE 40: Chi-square analysis of blood glucose levels for different groups

	Groups compared	'p' value for χ^2
1.	HIG Vs LIG	NS
2.	Men Vs Women	0.05
3.	Age groups ($<$30, 30-49, 50)	0.001

NS - Not significant.

HIG - High income group.

LIG - Low income group.

body mass. Since weight over height is a better index of obesity, the relationship between blood glucose levels and weight/height index was examined and the results of the analysis are presented in Table - 41.

Blood glucose levels did not vary with weight per unit height in the young men and women, but in the older age groups, especially after middle age, an association was found between the two increasing values for blood glucose levels.

The increase in blood glucose levels with age are attributed to long term dietary patterns which culminate in manifestation of hyperglycemia. Nutritional and public health data (U.S. Dept., HEW, 1970) show that the death rate from diabetes increased progressively with age. Brunner et al, (1964) found an incidence of 0.05% diabetes mellitus in the Yomanite Jews who arrived newly in Israel compared with 0.55% in those who were living in Israel for more than 10 years. The ten-fold difference was interpreted by the authors to be due to change in dietary habits and life styles as they cannot be attributed to racial differences. Similar results were reported by Cohen (1961) in Israel; Campbell (1963) and Jackson (1978) in S. Africa; Standing Committee report on Aboriginal Health (1978) in Australia, Prior et al (1978) in Newzeeland; West (1978)

TABLE- 41 : 'p' values for χ^2 between blood glucose levels and weight/height index in different groups.

Groups	Blood glucose (mg/dl)	Weight/height index (kg/cm)			'p' value for χ^2
		< 0.3	0.3 to 0.4	> 0.4	
	No. of subjects with percentages shown in parentheses				
MEN :					
	< 70	15	13	1	
(LIG, HIG)	70 - 90	19	47	16	0.01*
	> 90	1	8	5	
WOMEN:	< 70	22	10	0	
(LIG, HIG)	70 - 90	34	47	5	0.01*
	> 90	3	6	3	
HIG :	< 70	12	17	1	
(Men, Women)	70 - 90	13	63	21	0.001*
	> 90	2	9	8	
LIG :	< 70	25	6	0	
(Men, Women)	70 - 90	40	31	0	0.1*
	> 90	2	5	0	

HIG - High income group
LIG - Low income group

in Prima Indians in U.S.A.

In conclusion, fasting blood glucose levels were found to increase with age in all the groups studied. However, this is not an inevitable concomitant of aging as is shown by the observation that the age-specific changes are small, being more clear-cut only in men and women prone to obesity as judged by weight to height ratios.

Serum lipid profiles in men and women at different ages

The involvement of dietary fat in the manifestation of degenerative diseases such as atherosclerosis and other heart diseases is well established. However, as mentioned earlier, some controversies still prevail regarding the role of dietary fat and the extent of its involvement in the causation of hyperlipidemia (Murry et al., 1978; Werner et al., 1978).

The unique features of the dietary pattern in Kerala as distinct from other regions have already been pointed out. They include the consumption of foods such as tapioca, coconut and coconut oil, and fish in more generous amounts than in the other three regions of peninsular India. Also the overall adequacy of the diet with regard to food energy, protein and magnesium among the poor is also in jeopardy. On the other hand, families in the upper class consume generous amounts of coconut and coconut oil which are rich in saturated fats. Studies were therefore carried out to compare the lipid profiles of men and women from both poor and upper class families, and changes in these profiles with age. Differences between vegetarians and nonvegetarians were investigated in the upper class.

It can be seen from the data given in Table - 42 that with advancing age the serum cholesterol rises in all the groups irrespective of the type of diet consumed and differences in the socio-economic status.

A greater rise was observed in HIG men consuming nonvegetarian food compared to all other groups. Both men and women consuming a nonvegetarian diet had serum cholesterol levels higher than vegetarians in the same socio-economic group although the differences fell short of significance, presumably because of small sample size associated with large variation, but the trend was consistent both in terms of means and ranges. Among the HIG vegetarian men and in LIG, peak values were reached in the thirties and maintained thereafter with no further perceptible rise or decline whereas in women, the peak values reached much later i.e. after fifties. The values for HIG in both sexes were higher than LIG, especially at later ages and these differences are clearly borneout when expressed on percentage basis (Table - 43).

TABLE 42 Serum cholesterol levels (mg/dl) in adult men and women at different ages

		Age group (Years) 20 - 29	30 - 49	50 - 70	All ages combined
		Mean ± S.E.; 'n' (above) and range (below) in parentheses			
HIG:					
Men	NV	183 ± 5.5 (24) (146 - 225)	239 ± 4.5 (39) (186 - 300)	225 ± 5.5 (22) (186 - 270)	222 ± 4.4 (85) (146 - 300)
	V	177 ± 6.0 (10) (130 - 205)	211 ± 4.8 (18) (160 - 246)	214 ± 3.8 (17) (188 - 231)	204 ± 3.8 (45) (130 - 246)
Women	NV	178 ± 4.6 (21) (140 - 220)	218 ± 3.4 (32) (180 - 265)	241 ± 6.3 (18) (208 - 310)	212 ± 6.8 (71) (140 - 310)
	V	175 ± 13.4 (7) (134 - 230)	211 ± 4.8 (15) (176 - 234)	225 ± 3.9 (17) (155 - 250)	206 ± 4.1 (39) (134 - 250)
LIG: (All NV)					
Men		172 ± 4.5 (11) (150 - 194)	198 ± 7.0 (17) (155 - 240)	194 ± 6.0 (17) (168 - 250)	191 ± 5.2 (45) (150 - 250)
Women		169 ± 3.5 (24) (160 - 201)	189 ± 4.6 (29) (150 - 240)	197 ± 4.4 (19) (160 - 243)	188 ± 4.8 (72) (150 - 243)

NV - Nonvegetarian; V - Vegetarian; HIG - High income group; LIG - Low income group.

TABLE-43: Values for serum cholesterol for different groups as per cent of those for the group specified.

Groups		20-29	30-49	50
		Values as per cent of those for 20-29 years		
HIG:				
Men	N.V	100	130	122
	V	100	119	120
Women	N.V.	100	122	135
	V	100	120	128
LIG:				
Men		100	115	112
Women		100	119	115
		Values for vegetarians as per cent of those for non-vegetarians		
HIG:				
Men		96	88	95
Women		98	96	93
		Values for women as per cent of those for men		
HIG:	N.V.	97	91	107
	V	98	100	105
LIG:				
	N.V.	98	95	101
		Values for LIG as per cent of those for HIG		
MEN:				
	N.V	93	82	86
WOMEN:	N.V.	96	89	87

V - Vegetarians; NV - Nonvegetarian.
HIG - High income group; LIG - Low income group.

The results are in agreement with the earlier reports of an age-related increase in serum cholesterol levels both in animals and humans (Keys *et al.*, 1950; Kornerup, 1950; Feldman *et al.*, 1963; Lopez, 1967; Zweer *et al*, 1968; Nicolas *et al.*, 1976; Werner and Sarren, 1978; Kritchevsky, 1979; Carlile *et al*, 1986). However, in these studies peak values were attained beyond the fifth or sixth decade whereas in the present study men attained the peak values earlier i.e. in the fourth decade itself. This could be because of a combination of factors such as consumption of coconut oil rich in saturated fats and deficient in tocopherols as well as marginal deficiency of magnesium which will be discussed in the subsequent section. It has long been known that the vegetarians tend to have lower serum cholesterol levels as their diets have higher amounts of fiber, cellulose/pectin/ lignins and plant proteins which are hypo-cholesterelemic (Trowell, 1972; Eastwood and Kay 1979; Burkitt *et al.*, 1974) and unsaturated fats, and lower amount of saturated fats (Siato *et al.*, 1965; West and Hayes, 1968).

It has been shown by animal experiments that plasma cholesterol was higher when animals were fed with casein than when they were fed diets containing plant proteins (Carroll and Hemilton, 1975; Terpstra *et al.*, 1983; Park *et al*, 1987). Further it is also observed by some investigators that this increase is due to the increased levels of VLDL and LDL cholesterol (Terpstra et al., 1982; 1983; Park et al., 1987).

Normally plasma cholesterol increases with age (Kritchevsky, 1979; Carlile et al., 1986) and this is shown to be due to the decrease in the fractional rate (FR) of estrification and the higher net rate (NR) of estrification of plasma cholesterol in mature rats. This was again interpreted to be due to higher body weight and increased plasma volume since the NR of estrification was found to be lowered when weight was kept constant. Also similar decrease in FR of estrification was observed with casein (animal) protein (Forsythe et al., 1980; Carlile et al, 1986).

The ratio of fecal excretion of neutral sterols was significantly higher in immature rats than in mature rats and in animals fed plant protein at both ages than in those fed casein. Thus age, quality, protein and body weight/body mass play a role in the plasma/serum levels of cholesterol and triglycerides.

Further, proteins in animal foods are rich in methionine which promote cholesterol formation (Orr and Watt, 1957; Oslon et al., 1970; Carroll et al, 1980).

Even the proteins in legumes such as bengalgram are found to have a similar effect (Grande et al., 1965; Klaugh et al., 1966; Jenkin et al, 1975; Carrol and Hamilton, 1975; Carroll et al., 1978) whereas the complex starches in food grains are found to have a hypocholesterolemic effect (Kuo et al., 1967; Starke, 1950; Helch et al., 1955). Higher serum cholesterol levels in the nonvegetarians in the present study can therefore be due to increased intakes of total energy, saturated fats from animal origin and total animal protein in the diet.

The data on serum phospholipids are given in Table 44. As in the case of cholesterol, an increasing trend with age is found for this parameter also. In the case of HIG, the peak value was found in fourth decade for men and after fifty for women as in the case of cholesterol. Again a trend of lower values for vegetarians when compared to nonvegetarians was observed. Differences with regard to sex and socio-economic status are similar on percentage basis as well.

Under normal conditions of health, serum phospholipids and cholesterol maintain a constant relationship, i.e. P/C remaining constant (Peters and Man, 1943; Ahrens et al., 1949). This is also found to be the case in the present studies (Table - 45).

TABLE- 44 : Serum phospholipid levels (mg/dl) in adult men and women at different ages.

		Age group (years)			All ages combined
		20-29	30-49	50-70	
		Mean ± S.E.; 'n' (above) and range (below) in parentheses.			
HIG :					
Men	N.V	187 ± 5.8 (24) (162 - 266)	250 ± 5.5 (39) (190 - 340)	230 ± 5.9 (22) (178 - 259)	230 ± 4.3 (85) (162 - 340)
	V	194 ± 8.6 (10) (169 - 240)	222 ± 5.9 (18) (180 - 258)	224 ± 3.5 (17) (198 - 259)	217 ± 3.2 (45) (169 - 259)
Women	N.V.	198 ± 5.0 (21) (150 - 231)	227 ± 4.0 (32) (126 - 260)	252 ± 6.7 (18) (206 - 233)	230 ± 2.9 (71) (126 - 333)
	V	190 ± 11.6 (7) (160 - 240)	219 ± 4.4 (15) (191 - 245)	232 ± 4.3 (17) (200 - 260)	219 ± 3.2 (39) (160 - 260)

TABLE- 44 (Contd.)

	20-29	30-49	50-70	All ages combined
LIG (All N.V) :				
Men	177 ± 4.4 (11) (145 - 194)	209 ± 7.5 (17) (160 - 280)	216 ± 7.1 (17) (162 - 260)	206 ± 3.8 (45) (145 - 280)
Women	179 ± 4.5 (23) (145 - 220)	200 ± 4.7 (30) (151 - 250)	205 ± 5.7 (19) (174 - 248)	197 ± 2.8 (72) (145 - 250)

N.V - Nonvegetarians
V - Vegetarians
HIG - High income group
LIG - Low income group

TABLE- 45 : Ratio of phospholipid to cholesterol (P/C) at different ages.

Groups			Age group (years)			All ages combined
			20–29	30–49	≥ 50	
			P/C Ratio			
HIG :						
	Men	N.V.	1.02	1.06	1.03	1.04
		V	1.1	1.05	1.05	1.06
	Women	N.V.	1.08	1.04	1.05	1.08
		V	1.09	1.04	1.04	1.06
LIG : (All N.V.)						
	Men		1.03	1.06	1.1	1.08
	Women		1.06	1.06	1.04	1.05

N.V - Nonvegetarians
V - Vegetarians
HIG - High income group
LIG - Low income group

Serum triglycerides (Table - 46) also showed an increase with age. In this connection, serum triglycerides are found to be influenced by the intake of foods rich in saturated fats, total food energy and sugar (Kinsell et al., 1952; Beveridge et al., 1963; Anlar et al., 1964; Hodger et al., 1965; 1967; Baron and Stein, 1968; Schultz and Grande, 1968; West and Haves, 1968; Chevalier et al., 1972). In Kerala, beef consumption is also common now and this might also contribute to elevation of LDL and VLDL in serum (William et al., 1984).

Since the lipid fractions increase with age, the data were analysed for the percent contribution of different lipids by considering total lipids as the sum of the three components (Cholesterol + Phospholipids + Triglycerides) (Table - 47). It is of interest to note that the proportions of various components do not change appreciably with age. These results are in agreement with earlier findings (Kornerup, 1950; Smith, 1965).

Further analysis of the data using x^2 for significance (Table 48) shows that the pattern of differences in relation to age, sex, and social class and between vegetarians and non-vegetarians are more clear. These results indicate that the rise in serum lipids and

TABLE- 46 : Serum triglyceride levels (mg/dl) in adult men and women at different ages.

		Age group (years)			All ages combined
		20-29	30-49	50-70	
HIG :					
Men	N.V	122 ± 3.6 (24) (81 - 145)	151 ± 3.7 (39) (104 - 190)	154 ± 3.2 (29) (120 - 185)	147 ± 2.0 (85) (81 - 190)
	V	114 ± 5.6 (10)	129 ± 5.4 (18)	137 ± 7.5 (16)	129 ± 3.2 (44)
Women					
	N.V.	111 ± 5.2 (21) (56 - 150)	128 ± 3.2 (31) (96 - 167)	144 ± 5.8 (19) (112 - 190)	131 ± 2.5 (71) (53 - 71)
	V	111 ± 7.2 (7) (84 - 140)	110 ± 4.5 (15) (80 - 150)	129 ± 4.3 (17) (102 - 152)	118 ± 2.9 (39) (80 - 152)

TABLE-46 (Contd.)

	20-29	30-49	50-70	All ages combined
LIG : (All N.V)				
Men	104 ± 6.7 (11) (75 - 140)	120 ± 4.5 (17) (84 - 152)	124 ± 3.6 (17) (93 - 142)	118 ± 2.7 (45) (75 - 152)
Women	107 ± 3.6 (22) (69 - 132)	111 ± 3.9 (29) (82 - 148)	121 ± 3.6 (19) (95 - 158)	114 ± 2.2 (70) (69 - 158)

N.V - Non-vegetarian
V - Vegetarian
HIG - High income group
LIG - Low income group

TABLE- 47 : Percentage contribution of different serum lipids to the total lipid in adult men and women at different ages.

Age group	MEN					WOMEN				
	N	Total lipid (mg/dl)	Cholesterol	Phospho lipid	Triglycerides	N	Total lipid (mg/dl)	Cholesterol	Phospholipid	Triglycerides
			% contribution					% contribution		
HIG :										
20-29	24	494	37	38	25	28	480	37	40	23
30-39	21	624	38	37	25	23	505	34	43	24
40-49	18	671	37	37	26	24	578	38	40	22
50-59	12	663	36	38	26	18	618	38	40	22
> 60	13	596	37	38	25	18	615	38	39	23
LIG :										
20-29	11	453	38	39	23	22	455	37	39	24
30-39	10	523	37	39	24	17	497	38	40	22
40-49	7	536	38	40	22	12	504	38	39	23
50-59	9	522	37	39	24	11	535	38	39	23
> 60	8	546	35	42	22	8	505	37	39	23

N - No. of subjects.
HIG - High income group
LIG - Low income group

TABLE- 48 : Significance of differences in χ^2 between different groups.

	Groups compared	Cholesterol	Triglyceride	Phospholipid
		'p' values for χ^2		
1.	LIG Vs HIG	< 0.001	0.001	< 0.001
2.	Men Vs Women	< 0.05	< 0.001	NS
3.	V Vs NV	< 0.05	< 0.001	NS
4.	Age groups	< 0.001	< 0.001	< 0.001

NS - Not significant
HIG - High income group
LIG - Low income group
N.V - Non-vegetarians
V - Vegetarians

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associated risk of degenerative diseases could be prevented or postponed by regulation of diet.

As reported earlier, since the major cooking oil used is coconut oil in Kerala, the data were analysed according to frequency of coconut oil intake. The subjects who could give correct information regarding the quantitative consumption of oil were taken into consideration for analysis. The oil consumption was rated as rare, occasional, frequent and regular and the results are presented in Table - 49 along with the significance of differences between means.

This observation is consistent with reports published earlier that the saturated fats in coconut oil and animal foods increase serum cholesterol levels (Katiyar et al, 1967; West and Hayes, 1968; Williams et al, 1984). Isocalorie substitution of coconut oil for carbohydrate is reported to result in increased serum cholesterol level (McGandy et al, 1966).

These results show that with increased intake of coconut oil all the three components of serum lipids increase. However, it is to be noted that differences in coconut oil consumption are also associated with dietary

TABLE - 49: Serum lipid levels (mg/dl) in relation to frequency of coconut oil intake

Use of coconut oil	% subjects	% (approx. amount per day g.)	Serum level (mg/dl) Cholesterol	Phospholipid	Triglyceride	Total lipid
			Mean ± S.E.; and range in parentheses			
1. Rare	17	0 to 2	168 ± 3.2 (133 - 200)	172 ± 3.6 (140 - 219)	105 ± 3.9 (69 - 160)	448 ± 7.6 (372 - 535)
2. Occasional	16	2 to 8	191 ± 4.2 (150 - 236)	191 ± 3.8 (155 - 236)	123 ± 4.1 (83 - 170)	503 ± 9.7 (408 - 630)
3. Frequent	42	8 to 16	203 ± 3.6 (130 - 299)	212 ± 3.3 (146 - 277)	133 ± 3.7 (85 - 250)	547 ± 8.5 (410 - 960)
4. Regular	24	30	236 ± 4.9 (177 - 340)	231 ± 5.8 (160 - 340)	151 ± 5.6 (96 - 250)	618 ± 10.2 (430 - 960)

'p' values for 't' test of significance of differences between means.

Groups			Cholesterol	Phospholipid	Triglyceride	Total lipid
1. VS. 2		-	0.001	0.001	0.01	0.001
2. VS. 3		-	0.05	0.001	NS	0.01
3. VS. 4		-	0.001	0.01	0.01	0.001

NS - Not significant.

variations in other respects such as intake of total food energy, sugar, type of animal foods consumed etc. Data on consumption of beef, egg and fish are given in Tables - 50 -51 . It appears that even occasional consumption of beef may increase serum cholesterol level.

The data were further analysed to see the relation between triglycerides and body weight. It is interesting to note that, in spite of greater and more prolonged increase in body weights and fat deposition, the proportion of subjects with hyper triglyceridemia in HIG group is less in women than in men throughout. Also only 6% or less fell above the critical cut-off levels for cholesterol and phospholipids at younger age group (20 - 29) whereas with triglycerides a higher percent of subjects (about 40%) fall above the critical cut-off level (Tables 52) and this increased with age in men. This suggests that triglyceride level may be as important as serum cholesterol levels and it needs the attention of researchers in lipid research. In general, the present data are consistent with the observations of Carlson and Bothiger (1972), Goldstein et al.,(1973), Pelkonen et al., (1977) and Carlson (1978), Berry et al (1986).

Animal protein correlate positively with concentrations of total cholesterol, triglycerides VLDL cholesterol, TABLE-50 : Pattern of fish, egg and flesh food consumption in high income group in Kerala.

	Regular	Frequent	Occasional	Rarely
	% of families investigated			
Fish alone	23 (40–80)	11 (20–309)	—	—
Egg along with fish	—	2 (179)	6 (69)	—
Beef (with occasional consumption of fish and egg)	21 (60–80)	17 (27–30)	16 (∠ 109)	3 (3–59)

The approximate amount taken (g/day) is given in parentheses.

TABLE -51: Serum cholesterol levels (mg/dl) with the frequency of consumption of non-vegetarian foods in HIG

	Regular	Frequent	Occassional	Rarely
Serum cholesterol (mg/dl); Mean ± S.E.; 'n' in parentheses				
Fish alone	196 ± 3.6 (28)	190 ± 4.5 (14)	NS	NS
Egg with fish	NS	220 ± 9.5 (2)	203 ± 7.4 (7)	NS
Deaf with occasional use of fish and eggs	256 ± 5.0 (26)	244 ± 4.6* (27)	222 ± 4.5* (20)	220 ± 1.4* (4)

* Significant compared to fish group $P < 0.001$.

NS - No subjects.

TABLE- 52 : Percentage of subjects with high value for different lipids in various age groups.

Age (year)	Cholesterol > 225 mg/dl				Phospholipids > 225 mg/dl				Triglyceride > 125 mg/dl			
	Men		Women		Men		Women		Men		Women	
	%	(n)*	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
20-29	2	(43)	2	(50)	6	(45)	6	(51)	43	(46)	30	(51)
30-49	41	(73)	19	(74)	58	(74)	39	(77)	66	(74)	40	(75)
> 50	39	(57)	44	(54)	47	(58)	60	(55)	79	(57)	42	(55)

* 'n' - number of subjects

smaller LDL mass and VLDL mass, while plant proteins appear to be inversely related to triglycerides smaller LDL mass and both the cholesterol content and total mass of VLDL particles (Kahn <u>et al</u>, 1969; Gordon, 1970; Kato <u>et al</u>., 1973; Shekelle <u>et al</u>., 1981; Gordon <u>et al</u>., 1982; Williams <u>et al</u>., 1986).

The increased levels of plasma cholesterol found in animals fed casein diets than when they are fed plant protein diets might be due to the increased levels of VLDL and LDL cholesterol levels (Terpstra <u>et al</u>., 1982; 1983; Park <u>et al</u>, 1987). However, in the studies on populations consuming fish and fish oils it is observed show lowered cholesterol levels i.e. the LDL and VLDL are lower and HDL is higher. This sort of lipid profile is associated with a decreased risk of cardiac diseases. The mechanism of this has been attributed to the apparent beneficial effects of the n-3 poly unsaturated fatty acids present in the fish/fish oils (Sinclair, 1984; Herold & Kinsella, 1986; Nutr. Rev., 1986). This is attributed again to the altered ratio of prostacyclin and thromboxame formation leading to the increased bleeding time of the individuals (Herold and Kinsella, 1986). It is also interpreted that, because the poly unsaturated fatty acids are preferentially converted to ketone bodies in the liver rather than being incorporated into the triglyceride for export into plasma lipoproteins (Beynen and Katan, 1985) and the triglyceride levels are low with PUFA diet.

It has been observed by some workers that the increased levels of serum cholesterol and triglyceride might be due to age, body mass index (BMI) or obesity) (McDonald, 1964, 1966; Berry et al., 1986) and associated fat accumulation. Therefore, the data was analysed in relation to body weights (Tables 53 & 54). A clear-cut increase in body weight and with both cholesterol and triglyceride in both low and high income groups was found. Therefore a number of risk factors are involved in elevating serum lipids, leading to hyperlipidemia.

In conclusion, the major serum lipid components, namely, cholesterol, phospholipids and triglycerides increase with age both in men and women. These increases, in general, are greater in men than in women and greater in the high income group subjects than in the low income group subjects. Further, the increase is more in non-vegetarians than in vegetarians in the high income group. The increase in values for non-vegetarians in low income group is less than that for non-vegetarians

TABLE- 53 : Serum cholesterol level (mg/dl) in relation to body weight (kg) in different groups.

Group	Body weight (kg)				
	30-39	40-49	50-59	60-69	70
	Serum cholesterol (mg/dl); Mean ± S.E. with 'n' in parentheses.				
MEN :					
HIG	—	189 ± 4.58 (26)	209 ± 4.29 (51)	226 ± 3.39 (37)	249 ± 7.19 (14)
LIG	—	181 ± 3.40 (33)	193 ± 9.0 (11)	191 ± 0.00 (2)	-
WOMEN :					
HIG	179 ± 12.21 (7)	198 ± 5.40 (35)	221 ± 4.09 (35)	—	226 ± 4.42 (19 + 2)
LIG	178 ± 3.70 (22)	182 ± 4.10 (38)	—	209 ± 8.10 (8 + 5)	

HIG - High income group; LIG - Low income group

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TABLE- 54 : Serum triglyceride level (mg/dl) in relation to body weight (kg) in different groups.

Groups	Body weight (kg)				
	30-39	40-49	50-59	60-69	70
Serum triglyceride (Mean ± S.E. with 'n' in parentheses)					
MEN :					
HIG	—	124 ± 5.73 (23)	131 ± 4.45 (43)	146 ± 3.67 (34)	167 ± 6.1 (11)
LIG	—	115 ± 3.72 (32)	122 ± 4.76 (8)	125 ± 2.59 (2)	—
WOMEN :					
HIG	105 ± 10.29 (8)	119 ± 3.25 (33)	127 ± 5.2 (35)	138 ± 4.78 (19 + 2)*	—
LIG	103 ± 4.53 (22)	112 ± 2.56 (35)	131 ± 5.54 (10)	121 ± 5.84 (3)	—

HIG - High income group; LIG - Low income group.

in the high income group perhaps due to the difference in the amount and the type of animal food and other foods taken.

It appears that the amount of coconut oil and beef used may affect the serum cholesterol and triglycerides. These values seem to have some correlation with body weight in high income group. Further studies are needed with larger samples to understand the interrelation of body weight, sex, types and amounts of fat and protein taken on the serum lipids especially cholesterol and triglycerides. These studies may help to atleast plan control of serum lipids which may be one of the contributory factors for coronary disease.

Serum magnesium levels in adult men and women at different ages

As mentioned earlier one of the critical differences between Kerala diet and the diets of other regions is its marginal adequacy with regard to magnesium. Added to this is the softness of the water in Kerala. Studies described previously on pregnant women (Part - I of the present thesis) and severely malnourished children have shown the magnesium status to be poorer in Kerala than in the interior of Tamil Nadu. This raises questions about the adequacy of magnesium status of the general population especially in aging adults. This question assumes importance as deficiency of magnesium has been implicated in the etiology of cardiovascular disorders which are more prevalent among the aged (Brown et al., 1958; Hughes and Tonks, 1965; Hyatt et al., 1966; Kedarnath et al., 1969).

It seemed worthwhile to investigate the normal magnesium status of the adult population and changes, if any, with age. Serum magnesium levels were used as an index of magnesium status. Data on serum magnesium levels in adult men and women at different ages are shown in Table - 55 . The mean values are in the normal

TABLE- 55 : Serum magnesium level (mg/dl) in adult men and women at different ages.

	Age group (years)			All ages combined
	20-29	30-49	50-70	
	Mean ± S.E.; 'n' (above) and range (below) in parentheses			
MEN :				
HIG	1.9 ± 0.03 (29) (1.6 - 2.2)	2.0 ± 0.02 (52) (1.7 - 2.4)	2.0 ± 0.03 (38) (1.6 - 2.4)	2.0 ± 0.02 (119) (1.6 - 2.4)
LIG	2.0 ± 0.06 (10) (1.7 - 2.2)	2.0 ± 0.09 (17) (1.6 - 2.4)	2.0 ± 0.04 (17) (1.6 - 2.3)	2.0 ± 0.02 (44) (1.6 - 2.4)
WOMEN :				
HIG	1.9 ± 0.04 (26) (1.6 - 2.2)	2.0 ± 0.03 (46) (1.6 - 2.4)	1.9 ± 0.03 (35) (1.6 - 2.3)	1.9 ± 0.02 (107) (1.6 - 2.4)
LIG	1.7 ± 0.04 (22) (1.5 - 2.1)	1.9 ± 0.04 (25) (1.5 - 2.2)	1.9 ± 0.04 (18) (1.5 - 2.3)	1.8 ± 0.03 (65) (1.5 - 2.3)

HIG - High income group; LIG - Low income group.

range but the variation is wide with an appreciable proportion of values showing less than 1.8 mg/dl (Table - 56). It is also relevant to note that a lower mean value is found in women of the reproductive age group (20 - 29 Years) the same being significantly less than that for LIG men and for the same age and sex in the HIG. Apart from this difference the mean values did not show age, sex or social class differences. Earlier workers have reported similar observations (Wallach et al, 1962; Kedarnath et al., 1969; Lim et al., 1969; Seelig et al., 1974; Abraham et al., 1978). Regarding the range for serum magnesium levels for normal populations different authors have reported different values. Champarwal and Pohowaller (1966) reported 1.8 to 2.5 mg/dl for normal children. Bershon and Oelofse (1957) have reported a range of 1.8 to 3.0 mg/dl. Kedarnath et al., (1969) reported 2.3 to 3.2 mg/dl for Indians. All these ranges are higher than that observed in the present study.

As magnesium deficiency has been implicated in the etiology of cardiovascular diseases which is also associated with high cholesterol, data were analysed in relation to serum cholesterol (Table 57 & 58). For corresponding levels of serum magnesium, Serum cholesterol

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TABLE-56 Frequency distribution of serum magnesium levels (mg/dl) in adults in Trivandrum (Kerala).

	Serum magnesium levels (mg/dl)	Frequency		Accumulative frequency	
	Percentage in parentheses				
1.	1.5	6	(1.8)	6	(0.3)
2.	1.6	22	(6.6)	28	(1.3)
3.	1.7	30	(9.0)	58	(2.6)
4.	1.8	56	(16.7)	114	(5.2)
5.	1.9	61	(18.2)	175	(7.9)
6.	2.0	56	(16.7)	231	(10.4)
7.	2.1	54	(16.1)	285	(12.9)
8.	2.2	34	(10.2)	319	(14.4)
9.	2.3	8	(2.4)	327	(14.8)
10.	2.4	6	(1.8)	333	(15.1)
11.	2.5	2	(0.6)	335	(15.2)
Total		335			

levels are less in men than in women. This is consistent with sex differences with regard to cholesterol and their absence with regard to magnesium. It is indeed interesting to note that serum cholesterol levels corresponding to serum magnesium $\geq$ 2.1 mg/dl tend to be lower (Table-57) This trend seems to be more pronounced in women than in men in LIG.

The inverse relation found between serum magnesium and cholesterol levels (Table 58) is consistent with the reported association of decreased serum magnesium levels in stress conditions and cardiovascular diseases, believed to be mediated by changes in levels of catecholamines and corticosteroids (Bershon and Oelofse, 1957; Hughes and Tonks, 1965; Raab et al., 1969; 1972; Szelenyi, 1971, 1973).

Further when the analysis of variance and covarience statistic was applied to see the influence of magnesium over serum cholesterol in the presence of age and income it can be seen from the tables (59 & 60), that income and age do play a significant role. However, in the younger age group and the low income group the serum cholesterol levels are per se low. Thus the lower levels of magnesium might not effect serum cholesterol in that age much, but with

TABLE- 57 : Mean serum cholesterol levels (mg/dl) in relation to serum magnesium (mg/dl) levels. (> 50 years age)

Groups		Serum magnesium (mg/dl)						Total no. of subjects
		< 2.1			> 2.1			
		Serum cholesterol (mg/dl)						
		Mean± SE	'n'	%	Mean±SE	'n'	%	
MEN :								
	HIG	234±4.2	(30)	81	207±5.07	(7)	19	37
	LIG	195±6.8	(15)	83	187±10.03	(3)	17	18
WOMEN :								
	HIG	237±4.5	(29)	85	225±8.19	(5)	15	34
	LIG	199±7.4	(14)	78	177±10.36	(4)	22	18

'n' - no. of subjects.

HIG - High income group; LIG - Low income group.

Table 58: Mean serum cholesterol level (mg/dl) in relation to serum magnesium (mg/dl) level in different groups above 50 years of age

Groups		Serum magnesium level (mg/dl): <1.8			1.8 - 2.1			≥ 2.1			Total 'n'	'r'
		Serum cholesterol (mg/dl)										
		Mean+SE	%	n	Mean+SE	%	n	Mean+SE	%	n		
MEN:	HIG	231±5.3	11	(4)	223±4.7	70	(26)	207±5.1	19	(7)	37	-0.42**
	LIG	250±	6	(1)	191±5.8	78	(14)	187±10.0	17	(3)	18	-0.46
WOMEN:	HIG	231±6.2	26	(9)	236±5.8	50	(20)	225±8.2	15	(5)	34	-0.23
	LIG	207±19.1	17	(3)	197±7.8	61	(11)	177±10.4	22	(4)	18	-0.32
BOTH GROUPS	HIG	231± 4.5	18	(13)	230±5.2	65	(46)	215±5.0	17	(12)	71	-0.22*
	LIG	218±14.3	11	(4)	195±4.7	69	(25)	181±7.1	19	(7)	36	-0.36*

'r' = correlation for coefficient. * $P < 0.05$. ** $P < 0.01$

HIG - High income group; LIG - Low income groups.

Table 59: Analysis of variance and covariance to find the effect of age and income status on serum cholesterol in the presence of Mg. (Males)

A. Analysis of variance table

Source of variation	D.F.	S.S.	MSS	F
Income	1	21179.5	21179.5	25.34**
Age	2	38784.5	19392.25	23.20**
Interaction	2	5456.5	2728.25	3.26*
Error	121	101126	835.75	

B. Table of Covarience

Income	1	18598.69	18598.69	21.09516**
Age	2	39584.65	19792.32	22.44902**
Interaction	2	5600.235	2800.117	3.175972*
Error	120	100198.6	681.6567	

* P ∠ 0.5   ** F ∠ .01

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Table 60: Analysis of variance and covariance to find the effect of age and income status on serum cholesterol in the presence of Mg. (Females)

A. Analysis of variance table

Source of variation	D.F.	S.S.	MSS	F
Income	1	23892	23892	46.0**
Age	2	43801.5	21900.75	42.2**
Interaction	2	6339.0	3169.5	6.1**
Error	151	78365	518.97	

B. Table of variance

Income	1	24790.9	24790.24	45.42038**
Age	2	44616.82	22308.41	40.8732**
Interaction	2	5536.414	2768.207	5.071877*
Error	152	77424.49	545.7955	

* P ∠ 0.5 **P ∠.01.

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increasing age the deficient magnesium status might aggravate the lipid levels. This is thus more perceptible in the middle aged men who showed high serum cholesterol levels with low serum magnesium levels; thus indicating that the middle aged requirement for magnesium might be high. This might be more so in areas where there is a dietary magnesium deficiency. However further studies on middle aged population might give better idea on the role of magnesium in this age group.

In conclusion, although the diets in Kerala are marginally deficient in magnesium, a deficiency of this mineral in adult men and women was not evident on the basis of mean values for serum levels of magnesium. However the high consumption of saturated fats and the low levels of magnesium poses problem of cardiovascular diseases in the adults and suggests a reduction in saturated fats. Also a marginal deficiency in poor women of reproductive age is suspected.