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FACTORS AFFECTING WEIGHT GAIN DURING PREGNANCY AND THE GROWTH OF THE INFANT

by

S. J. WIMALAWANSA[1] AND T. W. WIKRAMANAYAKE[2]
(Faculty of Medicine, University of Peradeniya, Sri Lanka)

SUMMARY. Weight gain during pregnancy has been studied in both rural and urban populations in Sri Lanka. Rural women gained less than 6.5 kg between the beginning of the second trimester and partus. In a mixed urban-rural population the mean weight was less than 7.5 kg (range 3.0 to 11.0), the mean weight gain in 4-weekly intervals being 1.2, 0.9, 1.0, 0.9, 1.1 and 1.0 kg. with an average of about 254 g per week. There was a fall in weight gain with increase in parity. Weight gain increased significantly with increase in the per capita family income and the level of education of the mother. Although the same supplements were distributed to all mothers throughout pregnancy, those in the lower income group and of a lower nutritional status early in pregnancy gained less weight than those in the higher income group.

Body weight, lean body mass and total body fat fell markedly by the end of the third month postpartum. Among the multiparae all 3 parameters were below the corresponding levels at the end of the first trimester.

The average birth weight was 2.756 kg, about 30% of infants weighing less than 2.5kg. Birth weight correlated significantly with weight gain during pregnancy in women of lower social status and with lower per capita income. Infants born to women who were working outside their homes during the last trimester were heavier than the others, probably because the per capita income of the household and, therefore, the nutrition of the mother, was dependent on whether the mother worked or not.

INTRODUCTION

During the past 3 decades a great deal of interest has centered around the importance of birth weight in determining the survival of the infant and its physical and mental development.[3,17,20,33,34] The beneficial effect of adequate weight gain during pregnancy on the size at birth is well documented[1,2,3,26]

1. Present address : Endocrine Unit, Department of Chemical Pathology, Royal Postgraduate Medical School, London W 12, ONN, England.

2. Present address : Food and Nutrition Unit, University of Kelaniya, Sri Lanka.

In industrialized countries there is a minimal weight gain of 1 to 2 kg during the first trimester and, thereafter, a progressive increase in weight gain, averaging 0.35 to 0.4 kg per week.[14] The most favourable outcome is said to follow a weight gain of 9 to 11.5 kg during pregnancy[14]. Poor nutritional status of the mother is reflected in low birth weight of infant[30]. A small infant is presumed to have reduced nutritional reserves and to be at risk during the first few months of life[30]. In Sri Lanka nearly one-third of new borns weigh less than 2.5kg.[5]

A few studies in developing countries report that the average weight gain during pregnancy is less than the 10 to 15 kg gain observed in developed countries[12,13,26]. Only about 10% of women in Sri Lanka are said to gain more than 8 kg.[5]

This is a report of a longitudinal study on a mixed population of urban and rural women attending an ante-natal clinic at the General Hospital, Kandy, carried out in 1980. The influence of factors such as pregnancy weight gain and weaning practices on the growth of the infant were also studied.

The results of 3 preliminary studies on rural women, carried out between 1977 and 1979, which have been presented earlier[31], are also included.

THREE PRELIMINARY STUDIES

In Study 1, 94 mothers attending an ante-natal clinic at Kaltota, in the Ratnapura District, were investigated in 1977/78. Each mother was weighed at every visit to the clinic throughout her pregnancy, using the "personal" scales available at rural clinics.

The weights of the mothers, averaged for each 4 week period and grouped according to parity, are shown in Table 1.

TABLE 1. Mean body weight at four-weekly intervals, of women attending the ante-natal clinic at Kaltota grouped according to parity (Study 1)

Parity	n		Age yr.	Body weight in kg. 13—16 wk.	17—20 wk.	21—24 wk.	25—28 wk.	29—32 wk.	33—36 wk.	37—40 wk.	Average weight gain kg
P_1	27	$\bar{X}$	21.4	45.3	46.5	47.2	49.5	49.9	50.2	51.8	6.5
		S.D.	4.5	4.9	3.9	5.1	5.3	3.9	5.3	5.4	0.6
P_2+P_3	29	$\bar{X}$	24.4	46.1	48.0	48.8	50.2	51.4	51.8	52.4	6.3
		S.D.	3.0	4.1	4.6	3.8	4.0	5.0	4.7	5.1	0.6
$P \geqslant 4$	38	$\bar{X}$	32.9	47.8	48.9	50.3	51.7	52.5	52.9	53.8	6.0
		S.D.	3.7	4.0	4.3	5.1	3.9	4.0	3.7	4.5	0.7
All subjects	94			46.8	48.5	49.7	50.8	52.0	52.2	53.0	6.2

The average weight gain between the 4th and the 10th four-week periods, i.e. between 13-16 weeks and 37—40 weeks of gestation, is less than 7 kg. Primigravidae, although lighter than the others at the beginning of the 2nd trimester, gained more weight.

In study 2, women attending health clinics conducted by the Department of Community Medicine, University of Peradeniya at Kadugannawa, Deltota and Hindagala, during 1978 were randomly selected, weighed on a beam balance (UNICEF-Avery) and their skin-fold thicknesses at four sites (biceps, triceps, sub-scapular and supra-iliac, on the left side of the body) measured, using Harpenden calipers. Three readings were taken at each site and the mean value used in estimating total body fat, using the conversion table of Durning and Womersley.[9]

The results of this cross-sectional study are shown in Table 2.

TABLE 2. Mean body weight, at four-weekly interavls, of women attending ante-natal clinics at Kadugnnawa, Deltota and Hindagala (Study 2)

Parity		Age	Mean body weight, in kg						
			13—16 wk.	17—20 wk.	12—24 wk.	25—28 wk.	29—32 wk.	33—36 wk.	37—40 wk.
P_1	$\bar{X}$	22.7	46.5	46.5	48.2	49.4	48.9	49.6	51.9
	S.D.	3.7	5.3	3.9	5.4	3.3	3.9	4.5	5.0
	n	—	17	19	19	23	20	16	11
$P_2 + P_3$	$\bar{X}$	26.4	45.1	45.8	46.8	47.6	50.2	49.8	50.7
	S.D.	2.9	4.7	6.0	5.5	3.7	5.0	4.7	5.9
	n	—	11	17	21	27	23	15	13
$P \geqslant 4$	$\bar{X}$	32.1	43.0	44.0	43.8	44.7	47.8	47.8	48.4
	S.D.	3.7	4.3	7.6	5.1	4.4	4.2	6.1	5.9
	n	—	8	15	18	20	13	12	14
All subjects			44.7	45.7	46.3	47.4	49.1	49.3	50.2

The changes in body fat are shown in Table 3.

TABLE 3. Changes in body fat during pregancy of the women in study 2

Parity	Average weight gain kg	Average change in body fat	
		%	total kg
P_1	5.4	2.37	1.23
P_{2+3}	5.6	−0.57	−0.24
$P \geqslant 4$	5.4	2.49	1.21

In study 3, women attending the same clinics as in study 2 were weighed at each monthly visit, up to the end of the pregnancy, using the same beam balance as in study 2.

The weight gained by the mothers in this longitudinal study are indicated in Table 4. The average weight gain is less than 7 kg, primigravidae gaining more weight than the others, between the 13—16 weeks and 37—40 weeks of pregnancy.

TABLE 4. Mean body weight, at four-weekly intervals, of women attending clinics at Kadugannawa, Deltota, and Hindagala, grouped according to parity (Study 3)

Parity	n		Age yr	Body weight in kg							Average weight kg
				13—16	17—20	21—24	25—28	29—32	33—36	37—40	
P_1	39	$\bar{X}$	20.9	42.4	44.2	45.5	46.0	47.3	48.1	48.8	6.4
		S.D.	3.7	3.9	3.5	5.0	4.6	5.0	3.9	5.2	0.8
P_{2+3}	61	$\bar{X}$	24.9	44.7	45.0	46.6	47.4	48.8	49.5	50.7	6.0
		S.D.	3.2	4.5	3.9	5.0	4.2	3.7	5.0	4.5	0.8
$P \geqslant 4$	55	$\bar{X}$	30.9	44.7	45.3	46.2	47.5	48.0	49.5	50.5	5.8
		S.D.	4.8	4.7	5.0	4.8	4.1	5.1	4.0	4.5	0.8
All subjects	155		—	44.1	45.3	46.2	47.2	48.1	49.2	50.2	6.1

These three studies were on rural women attending ante-natal clinics in their villages. In the present study, a mixed population of urban and rural women attending an ante-natal clinic at the General Hospital, Kandy, have been investigated.

MATERIALS AND METHODS

All mothers interviewed at the first visit to the ante-natal clinic conducted at the General Hospital, Kandy, by the Professor of Obstetrics and Gynaecology were included in the study (n=212). Of these, 43 were removed from the study due to lack of follow-up during pregnancy or post-partum, and another 38 because of multiple pregnancy or complications during pregnancy.

Their weights were measured at each visit and at 3 months post-partum using a UNICEF Avery beam balance. Heights were measured with a stadiometer (Holtain). Skin-fold measurements at 4 sites were taken at each visit, and total body fat calculated, using the tables of Durnin and Womersley.[9]

The mothers were divided into 3 socio-economic groups, group 1 with a monthly per capita income of more than Rs. 600, group 2 with a per capita income between Rs. 300 and 600, and group 3 with an income less than Rs. 300 (per capita income equals family income divided by the number in the family).

The nutritional status of the mothers at the first visit was assessed by estimating their haemoglobin levels (using the cyanmethaemoglobin method)[8], total serum proteins (biuret method), serum transferrin (by rocket electrophoresis)[19], serum vitamin B_{12} (by the method of Green *et al*)[11] and serum folate levels by a radio-assay reported earlier.[24]

The total weight gain during preganancy is taken to be the weight recorded prior to admission to the delivery room minus the weight at the first visit to the ante-natal clinic (towards the end of the first trimester).

Infants born to the mothers were weighed on a Homs platform balance accurate to 50 g. The interval between the birth of each child and the commencement of breast-feeding was noted.

The mothers and their infants were seen regularly at post-natal clinics and the time of commencement of weaning and the clinical history of the infant, as reported by the mothers, recorded.

RESULTS

Some of the characteristics of the 131 mothers are given in Table 5.

TABLE 5. Some characteristics of the 131 mothers studied at the General Hospital, Kandy

	Mean	S.D.	Minimum	Maximum
Age, yr	26.3	4.8	16.0	40.0
Height, cm	150.9	4.9	138.0	163.0
Age at menarche, yr	13.4	1.2	10.0	16.0
Age at marriage, yr	21.3	3.3	15.0	31.0
Average birth spacing, months	29.0	11.1	13.0	71.0
Number of living children	2.0	1.71	0	9
Weight gain during pregnancy, kg	7.49	1.35	3.7	11.0
Weight at 3 months post partum	46.6	5.3	33.0	66.0

The average gain in weight between the 8—12 week and the 37—40 week periods of gestation (7.49) kg) is higher than the values obtained in studies 1, 2 and 3. This could be due to the fact that patients attending clinics at the hospital are drawn mainly from the urban population ; 34% of the mothers in this study lived within 7 km of the hospital and only 29% lived more than 15 km from the city centre.

The results of measurements of body weight, total body fat and lean body mass (body weight minus body fat) have been arranged in 9 periods according to the time during which the measurements were made, viz, period 1, 8-12 weeks of gestation (POG), period 2, 13—16 weeks, period 3, 17—20 weeks, period 4, 21—24 weeks, period 5, 25—28 weeks peirod 6, 29—32 weeks, period 7, 33—36 weeks, period 8, 37—40 weeks and period 10, 3 months post partum. Since there were multiple measurements taken in each 4-week period, mean values were obtained for each mother. The mean of these have been plotted against the period (as indicated by period 1 to 10), in figs. 1—4. Each point in a graph may represent between 40 and 300 observations.

Fig. 1 shows that the body weight increased steadily from the 13—16 week POG to 37—40 weeks, the rate of increase for different parities being given by the following regression equations :

for para 1, weight (kg)=40.5+0.251 POG (weeks)

for paras 2 & 3, weight (kg)=39.9+0.281 POG (weeks) and

for paras $\geqslant 4$, weight (kg) =37.6+0.248 POG (weeks)

The increase in total body weight is paralleled by the increase in lean body mass (Fig. 2). The total body fat (Fig. 3) did not increase at the same rate as body weight, the regression equations for accumulation of body fat being.

for para 1, total body fat (kg) = 10.6+0.077 POG (weeks)

for paras 2—3, total body fat (kg) = 10.2+0.0891 POG (weeks) and

for paras $\geqslant 4$, body fat (kg) = 10.0+0.0739 POG (weeks)

There was a negative correlation (correlation coefficient, r= −0.110) between weight gained and the age of the mother which was not statistically significant. The weight gained increased only slightly with birth spacing (r=0.149).

The relationship between weight gained during pregnancy and the per capita income, given by the regression equation

Weight gained (kg) = 5.92 + 0.00678 × income (rupees), is highly significant (r=0.71, $p<0.001$).

There is a highly significant positive association ($p<0.001$) between weight gain and the level of education of the mother (Table 6). This association is seen when the mothers at each level of education are divided into two groups, those gaining less than 7.5 kg and those gaining 7.5 kg or more. That this is probably influenced by the mother's socio-economic status is shown by the data in Table 7. Women of higher socio-economic status had achieved a higher level of education.

TABLE 6. The distribution of mothers by their weight gain during pregnancy and their level of education. Mean weight gain is given within brackets

Educational level	Weight gain during pregnancy <7.50 kg	⩾ 7.50 kg	All subjects
None	44 (5.95	0	4 (5.95)
Grades 1—5	16 (5.98)	8 (8.41)	24 (6.79)
Grade 6 to GCE "O" level	30 (6.32)	28 (8.36)	58 (7.30)
Up to and including GCE "A" level	9 (6.98)	33 (8.57)	42 (8.23)
Higher education	0	3 (8.27)	3 (8.27)
All subjects	59 (6.30)	72 (8.46)	131 (7.48)

khi-square =27.380 D.F.=4 p <0.001

TABLE 7. The relationship between the socio-economic status of the family and the level of education of the mother

Socio-economic status	Level of education of the mother					All Subjects
	nil	gr. 1—5	gr. 6 to "O" level	Up to 'A' level	Higher Education	
Group 1	0	6	24	27	2	59
Group 2	0	5	19	15	1	40
Group 3	4	13	15	0	0	32
All subjects	4	24	58	42	3	131

khi—square = 39.395 D.F. 8 p <0.001

Although the father's educational level did not show a similar relationship with weight gain, the father's occupation was an important factor determining weight gain (Table 8).

TABLE. 8.—The distribution of the mothers by their weight gain during pregnancy and the occupation of their husbands. The mean weight gain of each group is indicated within brackets

Husband's occupation	Weight gain during pregnancy		All subjects
	< 7.50 kg.	⩾ 7.50 kg.	
Professional	11 (6.59)	29 (8.49)	40 (7.98)
Skilled worker	27 (6.48)	37 (8.40)	64 (7.60)
Un-skilled worker	21 (5.91)	6 (8.55)	27 (6.50)

khi—square = 16.872 D.F. 2 p <0.001

Table 9 summarises some of the haematological and biochemical characteristics of the 131 mothers at 8—12 weeks of gestation.

TABLE 9. Some haematological and biochemical characteristics of the 131 mothers during early pregnancy (10 to 14 weeks)

	Mean	S.D.	Minimum	Maximum
Haemoglobin, g dl^{-1}	11.2	1.3	7.8	14.0
Packed cell vlolume, %	39.1	2.5	30.0	44.0
MCHC, %	29.8	3.0	24.0	38.0
Total serum proteins, g l^{-1}	60.7	3.7	53.0	70.0
Serum albumin, g l^{-1}	30.8	3.5	23.0	39.0
Serum transferrin, g l^{-1}	2.8	0.6	1.8	4.4
Serum folate, μg l^{-1}	5.38	1.2	2.8	8.6
Serum vitamin B_{12}, ng l^{-1}	340.0	125.0	90.0	710.0

Table 10 shows that there is a close association between the per capita income of the women and their Hb levels. The difference in Hb levels between the highest income level and the lowest is highly significant ($p<0.001$). About 85% of the women in income level 1, 62% of those in income level 2 and only 16% of those in level 3 had Hb levels equal to or greater than 11 g dl^{-1}. The Hb level was 11.3 ± 1.27 g dl^{-1} in para 1 and 11.55 ± 1.14 g dl^{-1} in paras 2 and 3 decreasing slightly for paras ≥ 4, but the effect of parity was not significant ($0.05>p>0.02$).

TABLE 10. The distribution of the mothers by their haemoglobin concentration and their socio-economic level. The average haemoglobin concentration of each group is given within brackets

Haemoglobin level dl^{-1}	Socio-economic status			All subjects
	Group 1	Group 2	Group 3	
≤9.9	2 (9.85)	7 (9.16)	16 (9.21)	25 (9.25)
10.0–10.9	7 (10.44)	8 (10.75)	11 (10.49)	26 (10.59)
≥11	50 (12.16)	25 (12.05)	5 (11.32)	80 (12.07)
All subjects	59 (11.16)	40 (11.29)	32 (9.98)	131 (11.23)

khi=square 45.243 D.F. 4 $p<0.001$

There was a positive correlation between the weight gained during pregnancy and the nutritional status of the mother during the first trimemster, as judged by the Hb concentration ($r=0.62$), total serum protein ($r=0.50$), serum albumin ($r=0.65$), serum transferrin ($r=0.499$), serum folate ($r=0.54$) and serum vitamin B_{12} ($r=0.64$).

Some characteristics of the babies born to the 131 mothers are indicated in Table 11.

TABLE 11. Some characteristics of 131 infants born to mothers studied at the General Hospital, Kandy.

	n	Mean	S.D.	Minimum	Maximum
Birth weight, kg	131	2.757	0.385	1.950	3.700
Head circumference, cm	131	33.65	0.34	32.10	34.4
Crown rump length, cm	131	32.66	0.38	32.0	33.7
Placental weight, g	131	470	70.0	350	650
Gestational age, weeks	131	39.86	0.69	38	41
Weight at 3/12 yr, kg	116	4.29	0.53	3.1	5.4
at 6/12 yr, kg	86	5.69	0.73	4.2	7.5
at 1 yr, kg	123	7.95	1.09	5.9	10.8

The relationship between birth-weight and the weight gained by the mother during pregnancy (Table 12) is highly significant. More than 28% of women gaining less than 7.5 kg had low-birth-weight babies, whereas only 1 out of 84 women who gained 7.5kg or more delivered a baby weighing less than 2.5 kg. However, when mothers of different socio-economic status are considered separately, birth weight correlated significantly with weight gain only at the lower socio-economic levels (groups 2 and 3). At socio-economic status 1, the relationship is not significant ($0.5>p>0.1$). The relationship between birth-weight and weight gain during pregnancy was significant ($p<0.001$) at all parities, the correlation coefficient being 0.85 for P_1, 0.69 for P_2 plus P_3 and 0.68 for $P \geqslant 4$.

TABLE 12. Distribution of infants by their birth weight and the weight gained by the mother during pregnancy. The mean birth weight is given within brackets

Birth weight kg	Weight gained by mother	
	< 7.50 kg.	⩾ 7.50 kg
< 2.500	38 (2.150)	1 (2.250)
⩾ 2.500	9 (2.517)	83 (2.954)
All infants	47 (2.416)	84 (2.946)

khi—square = 22.12 D.F. 1 p, < 0.001

Although the mean birth-weight of males was about 100g greater than that of girls, the difference was not statistically significant. The greater the weight gain during pregnancy, the larger was the placenta ($r=0.74$, $p<0.001$) and the larger the placenta, the higher was the birth-weight ($r=0.82$, $p<0.001$).

Birth-weight correlated significantly ($p<0.001$) with the per capita income of the family (Table 13). All mothers of higher socio-economic status (group 1) gave birth to babies weighing 2.5 kg. or more. More than 87% babies born to women in group 3 and 27.5% born to women in group 2 economic status were of low birth-weight.

TABLE 13. Distribution of infants by their birth weight and the socio-economic status of their mothers. The mean birth weight is given within brackets

Birth weight kg	Socio-economic status		
	1	2	3
< 2.500	0	11 (2.431)	28 (2.268)
⩾ 2.500	59 (3.030)	47 (2.815)	10 (2.588)
All infants	59 (3.030)	40 (2.710)	32 (2.307)

khi-square 76.116 D.F. 2 p<0.001

Birth-weight increased only slightly with parity. Birth-weight was not influenced significantly by either the age of the mother or spacing between births.

Some of the mothers continued working outside their homes throughout pregnancy whereas others did not go out for work or stopped working early in pregnancy. Table 14 shows the relationship of birth-weight to the mother's occupation (whether working or not) in the third trimester. About 35% of women not working had low-birth-weight babies whereas less than 13% working had babies weighing less than 2.5 kg. The mean weight of children born to working mothers was slightly greater, although the difference is not statistically significant. A similar relationship was noted between the weight gained during pregnancy and the mother's occupation during the third trimester. As indicated in Table 15, the mother's socio-economic status (given by the per capita family income) is significantly related to her working throughout pregnancy.

TABLE 14. The distribution of infants by their birth weight and the occupation of their mothers in the last trimester (whether working outside their homes or not)

Birth weight kg	Mothers' Occupation		All infants
	None	Working	
< 2.500	35 (2.312)	4 (2.325)	39 (2.314)
⩾ 2.500	63 (2.920)	29 (2.991)	92 (2.942)
All infants	98 (2.708)	33 (2.910)	131 (2.755)
Khi—square = 6.572	D.F. 1	0.002 > p > 0.001	

TABLE 15. The relationship between the socio-economic status of the family and the mother's occupation during the last trimester

Socio-economic status	Occupation of mother		All subjects
	none	working	
Group 1	36	23	59
Group 2	34	6	40
Group 3	28	4	32
All subjects	98	33	131
khi—square = 10.895	D.F. 2	0.01 > p > 0.001	

Birth-weight correlated significantly with the nutritional status of the mother early in pregnancy as indicated by the haematological and biochemical parameters studied. The difference between mean birth weight of infants born to vegetarian mothers were, however, not significantly different from the birth weight of other children in the study.

Table 16 indicates the time interval between the birth of the child and commencement of breast-feeding. Almost 50% of mothers breast-fed their babies within 2 hours of partus and all were nursing the infant by 12 hours.

TABLE 16. Time of commencement of breast feeding

Time	n	cumulative %
immediately after birth	21	16.7
within 2 hr.	39	48.4
2—7 hr.	49	86.5
7—12 hr.	14	97.6
> 12 hr.	3	100.0

The time at which weaning commenced is shown in Table 17. Half the infants were being fed with semi-solid foods by the 6th month. The clinical history of each infant was noted during the first year of life and the incidence of malnutrition, bronchitis and diarrhoea, as diagnosed by the physician who treated the child, recorded. The relationship between the duration of breast-feeding and the morbidity of the infant is shown in Table 18. Breast-feeding appears to protect the infant from the protein-energy malnutrition and diarrhoeal disease during the first 12 months of life.

TABLE 17. The time at which infants were first fed cereals or other semi-solid food

Month	Number of infants	cumulative %
0—3	6	5.0
4—6	61	55.3
7—9	49	95.9
10—12	5	100.0

TABLE 18. The relationship between the duration of breast-feeding and morbidity during infancy

	Duration of breast feeding			All subjects
	⩽ 4 m	5—8 m.	⩾ 9 m.	
Clinical PEM				
absent	17	36	50	103
present	13	10	5	28
	khi-square 13.549		D.F. 2	0.01> p> 0.001
Bronchitis				
absent	13	28	35	76
present	17	18	20	55
	khi-square 3.522		D.F. 2	0.5> p> 0.1
Diarrhoea				
absent	4	25	41	70
present	26	21	14	61
	khi-square 29.255		D.F. 2	p<0.001

The infant's weight at 1 year was related significantly ($r=0.80$, $p < 0.001$) to birth weight but not to the duration of breast-feeding.

DISCUSSION

Performance of mother

The longitudinal studies 1 and 3 (Tables 1 and 4) indicate that the weight gained by most rural Sri Lankan women between the beginning of the second trimester and partus is less than 6.5 kg, there being a slight fall in weight gain with increase in parity. The cross-sectional study (Tables 2 and 3) gave even lower values for weight gain and indicated only a marginal increase in body fat during the same period. The longitudinal study at the General Hospital, Kandy, on a mixed population, both urban and rural, showed a mean weight gain between the 12th week and term of less than 7.5 kg (range 3.0 to 11.0) with a fall in weight gain with increase in parity, the mean weight gains at four -weekly intervals being 1.2, 0.9, 1.0, 0.99, 1.1 and 1.0 kg, the average being 254 g per week. These values are lower than those reported in a more recent study at Kotte[10] where the weight gained between 16-14 weeks and 36—40 weeks of gestation was more than 8 kg (range 0.5 to 14.1 kg). The rate of increase in body weight in the present study as well as that in Kotte is well below values quoted by Hytten and Leitch[14]. Thomson and Billewicz[29] reported a gain of 11.4 kg between the 13th week and term. The total weight gain is however larger than figures obtained by Clements[5] in his study in Sri Lanka in 1962, probably due to improved ante-natal care during the intervening years. The increase in body weight is at the lower limit of the range of 250-350 g per week reported by Kawakami *et al.*[16] for Japanese.

Weight gain is increased significantly by an increase in the family per capita income (Tables 7 and 8), and in the level of education of the mother. The importance of socio-economic factors on weight gain is also indicated of by studies in Kotte[10], India[26], Nigeria[13] and Guatemala[4].

Women of poor nutritional status early in pregnancy, as judged by biochemical and haematological parameters between the 10 and 14 weeks of gestation, gained less weight than those of a higher status, although the same supplements were given to all. The amount of supplement given to those in the lower income group appears to be insufficient to enable than to catch up with the less deprived. Therefore, when only a limited supply of supplement (such as triposha) is available, its distribution should be determined by some index of nutritional status of the mother (e.g. Hb concentration).

The increase in lean body mass was parallel to the increase in total body weight. Body fat increased less uniformly. This may be due to the skin-fold measurement being a measure of fat accumulation as well water retention in the skin. As much as 8 l of water may be retained in tissues during pregnancy without obvious oedema[15]. Whether the equations of Durnin and Womersley,[9] obtained from studies on non-pregnant British women, are applicable to Sri Lankan, pregnant women, may be questioned.

Figs. 1, 2 and 3 shows the fall in body weight, lean body mass and body fat during the 3 months post partum. The effect on multiparae is very marked. In the group $P \geqslant 4$, all 3 parameters are below the values in the first trimester, indicating that 3 months of breast-feeding is a severe drain on body reserves. When food intake during lactation is inadequate, the advisability of breast-feeding without supplementary feeding may be questioned.

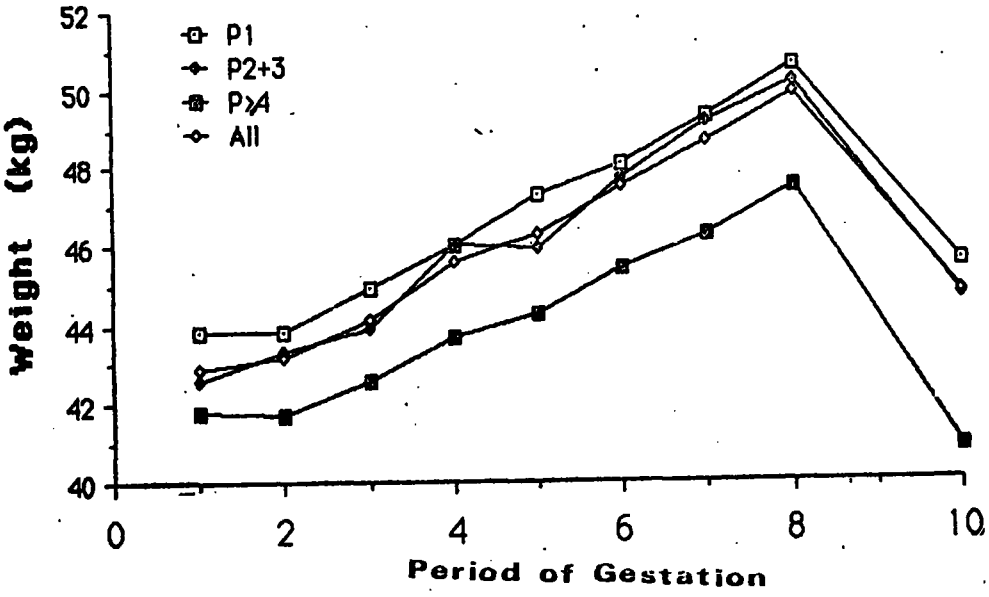

Fig. 1. Change in total body weight with period of gestation ;

period 1, 8—12 weeks ; period 2, 13—16 weeks,

period 3, 17—20 weeks ; period 4, 21—24 weeks,

period 5, 25—28 weeks ; period 6, 29—32 weeks

period 7, 33—36 weeks ; period 8, 37—40 weeks

period 10, 3 months post partum

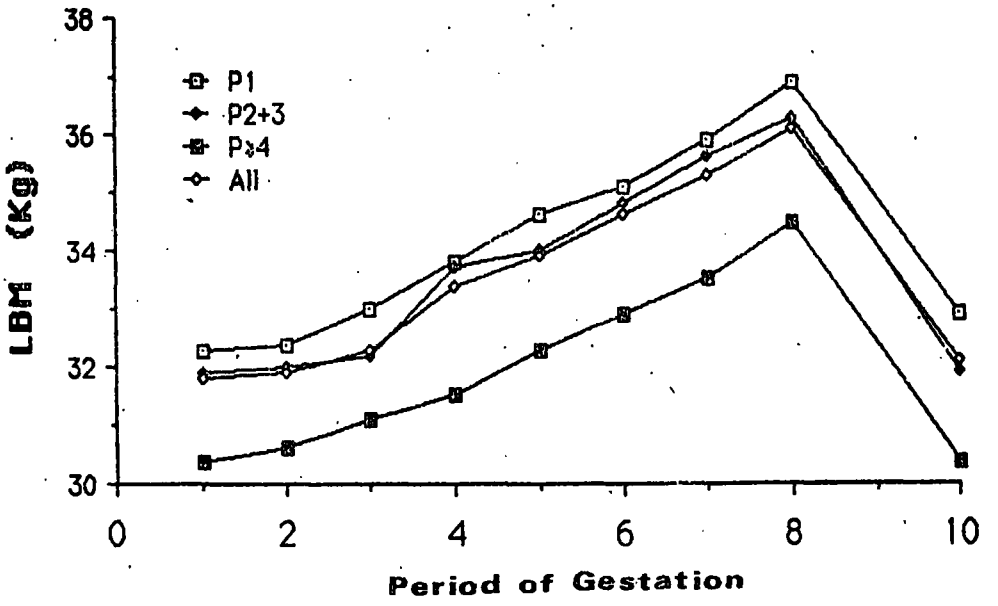

Fig. 2 Change in lean body mass (LBM) with period of gestation.
periods 1, 2 etc., as in Fig. 1.

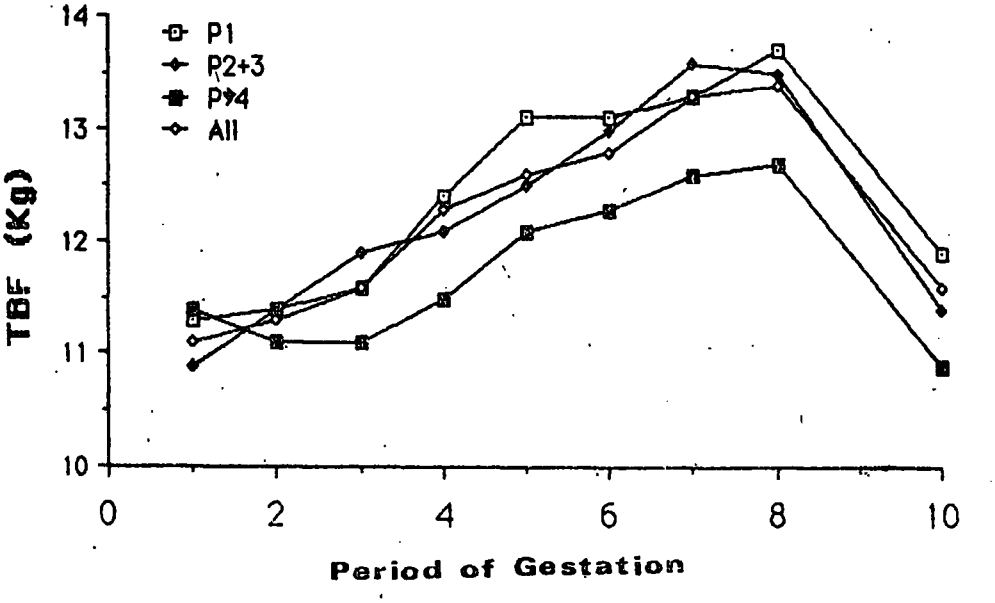

Fig. 3. Change in total body fat (TBF) with period of gestation.
periods 1, 2, etc., as in Fig. 1.

The fall in lean body mass post partum is due to loss of water as well as the expulsion of products of conception. Only in the primiparae is the lean mass slightly higher 3 months post partum than the value early in pregnancy. Even in this group total body fat has fallen to values near pre-pregnant levels, indicating that in the population studied, the chances of a woman gaining an excess weight during pregnancy are very remote. Fat stored during pregnancy can be "shed" by continued breast-feeding for 6 months or longer.

Performance of infant

The average birth-weight in study 4 (Table 11) is 2.756kg, about 30% of infants weighing less than 2.5 kg (Table 13). A retrospective study at the General Hospital, Kandy, of 766 infants born to mothers of high socio-economic status and of 1522 infants of low socio-economic status indicated a birth-weight of 3.030±0.446 kg, and 2.72±0.718 kg for boys and 2.992±0.531 and 2.65±0.661 kg. for girls, respectively[32]. For both sexes, the average birth weight has been reported to be 2.739±0.418 kg (n=53)[34] and 2.703±0.415 kg (n=294)[7], where the mother was of a low socio-economic status.

Birth weight correlates significantly with weight gained by the mother during the last 28 weeks of pregnancy (Table 12) and with the per capita income of the household (Table 13). However, the correlation between birth weight and weight gain during pregnancy was not marked at the upper socio-economic level. As the pre-pregnant nutritional status approaches optimum levels, the efficiency of conversion of ingested energy during pregnancy into birth weight, decreases[27]. The relationship between energy intake and birth weight is curvilinear[12]. The lower the nutritional status of the mother, the greater the influence of impaired nutrition on birth weight[25]. Supplements given to adequately nourished mothers will increase their body fat, not the weight of the infant.

Table 14 shows a very slight increase in weight of babies born to mothers who worked throught pregnancy as against those who did not. Neaye *et al*[22,28] found that birth weight is lower when mothers, whose energy intake is less than 70% of WHO recommendations, continue to work outside their homes after the 28th week of gestation. This may be due to an energy deficiency[28] and/or oxygen debt[23], and maternal exercise has been used as a screening test for utero-placental insufficiency[25]. Naeye[21] has shown that, in experimental animals, uterine blood flow decreases during maternal exercise. That the energy deficit has to be very acute to influence birth weight in the human is shown by data from Kaneba, in the Gambia[2]. During favourable months of the year the average energy intakes of pregnant and lactating women in Kaneba were 6.7 and 7.33 MJ per day. The gestational and lactational performance of the women were satisfactory in spite of continued physical activity, the weight gain being 1.5 kg per month, mean birth weight 2.95 kg, only 15% of infants being below 2.5kg. and breast milk output reaching a maximum of 850 ml at 2 to 3 months. However, in the wet season, when the maternal energy consumption fell to between 5.65 and 6.07 MJ per day, there was depletion of body fat during pregnancy, the weight gain was less than 0.5 kg per month and the mean birth weight fell to 2.75 kg, 35% being less than 2.5kg.

In the present study the family income level depended on whether the mother worked or not (Table 15). Had she stopped working, the lowered family income might have affected weight gain and birth weight adversely (Table 13). Therefore, if mothers are advised to start their maternity leave early in the last trimester, they should be given leave with full pay.

About half the infants in the study were breast-fed within 2 hours of partus (Table 16), which is much earlier than the time interval reported in other studies. More than 5% of the infants were weaned by the 4th month. That early weaning from breast to bottle results in a greater morbidity is shown in Table 18. The influence of early bottle feeding is greatest on the incidence of diarrhoeal diseases. Similar results have been reported even in industrialised countries[18].

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