A LONGITUDINAL STUDY OF ENERGY INTAKE AND ANTHROPOMETRY IN RURAL PREGNANT THAI WOMEN

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This form of research, involving field work, is only possible when several observers are involved in the study. In the present instance, the overall supervision was carried out by Dr. Kallaya Kijboonchoo, my field supervisor. I was responsible for training observers, recruiting volunteers for the study, planning a timetable, closely supervising and carrying out measurements of anthropometric variables, preparing monthly reports to the project Director, and conducting intermittent analyses of data.

Mrs. Wiyada Thasanasuwan

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SUMMARY

According to the previous study (Thongprasert et al.,1987), Thai pregnant women demonstrated a high intake with an increment of 56,900 kcal from 10 weeks until term, which apparently covered the energy cost of pregnancy. This finding was in contrast with other centres and so this present study was carried out in the same area and using the same method in order to find out the cause of the difference from other centres.

From March 1987 to April 1991, 121 women in Ubon, wishing to get pregnant, were followed up in order to collect data from pre-conception. 87 women became pregnant of which 63 pregnant women had data before becoming pregnant while other 24 were already pregnant as at the first interview. Data are presented on energy intake, weight gain, fat gain and the outcome of pregnancy. The mean birth weight and length of the babies were 2.98 kg and 0.48 m respectively which were similar to the finding from Thongprasert et al.(1987). Assessment of energy intake was done by using 5 consecutive days precise weighing method every 4 weeks. The average energy intake at pre-conception was 2,170 kcal/d (9.0 MJ/d) for the women who later become pregnant and 2,185 kcal/d (9.1 MJ/d) for the 27 women who did not become pregnant during the period of this study. These values are similar. There was a marked drop of energy intake to the value of 1,892 kcal/d (7.92 MJ/d) by the 8th week of gestation. This drop cancelled out the subsequent rise during the second and the third trimesters. Finally the

result showed a deficit of 840 kcal (3.6 MJ) throughout pregnancy or 3 kcal/d (12 kJ/d). This is completely different from the previous study (Thongprasert et al., 1987) as a result of difference in the base-line values.

The averages of body weight and body fat at pre-conception was 49.7 kg and 12.8 kg respectively and then during the 12th week of gestation these pregnant women lost body weight and body fat of about 1.4 kg and 1.2 kg respectively. The mean of weight gain during pregnancy was 7.8 kg and estimated fat gain by three methods was 0.08 kg both of which were also less than the findings from Thongprasert et al. (1987). However, there was a great variation in changes in fatmass, these ranging from gain in fatmass of 5.2 kg to loss in fatmass of 5.3 kg.

There is no doubt that these pregnant women could not meet the energy cost of pregnancy only by an increase in energy intake. The apparent reduction of weight and fat during the first trimester might be a source of supply energy to these pregnant women, and as a result, they could produce healthy babies even though no extra energy intake was apparent. This seems to be one form of adaptation of pregnant women who begin pregnancy with an adequate fat store.

CHAPTER 1

DOES A PREGNANT WOMAN NEED TO EAT MORE?

Maternal nutrition is known to be an important issue for public health both in developed and developing countries. Special care has to be paid to ensure the good health of mothers and proper development of babies. It is therefore obviously necessary to have a reasonably accurate knowledge of how much extra food is required during pregnancy.

1.1 THE THEORETICAL ASPECT

The energy cost of pregnancy was estimated by Hytten & Leitch (1971) and this has been widely accepted for many years. The extra energy needed during pregnancy is to cover the growth and development of the fetus, build up maternal tissue (for example, the uterus, breasts) , fat store, and to compensate for the increased metabolism due to increased activity of the cardiovascular, respiratory and urinary systems, and the addition of the fetal metabolism.

The BMR : The first important part of energy cost of pregnancy, which is increased is due to the increased oxygen requirements of the fetus and the extra maternal tissue. The total increment in BMR during the whole pregnancy can reach about 50% of the total cost of pregnancy, and is 36,000 kcal or 150MJ (Hytten & Leitch; 1971).

Maternal fat: The second important part of energy cost of pregnancy which may reach about 30,000 kcal (125MJ) can be calculated by looking at the components of the weight gain which is shown in **TABLE 1.1** (Hytten and Leitch, 1971). The weight unaccounted for (about 3.5 kg) which is got by subtracting all components of the weight gain from the total increase of body weight, was assumed to be maternal fat store. This fat store can be used as an energy bank which is normally utilized during the last trimester when the nutrition needs of the fetus are at their peak, and also during lactation.

The products of conception which consist of the fetus, placenta, amniotic fluid, blood and other increases in maternal tissue, is the last part of the energy cost of pregnancy. An analysis of these products of conception was found to consist of two major sources of energy: protein and fat, which are presented in **TABLE 1.2** (Hytten & Leitch, 1971). The total amount of protein is 925 g equivalent to about 5,186 kcal (22 MJ) and of fat in the products of conception is 480 g equivalent to about 4,560 kcal (19MJ). Therefore, adding the total amount of protein and fat in the products of conception gave a total of 9,746 kcal (41MJ).

Finally, the total energy cost of pregnancy is about 85,000 kcal(355 MJ) as summarised in **TABLE 1.3**.

TABLE 1.1 ANALYSIS OF WEIGHT GAIN

TISSUE & FLUIDS ACCOUNTED FOR AND TOTAL WEIGHT GAIN	INCREASE IN WEIGHT UPTO: (g) 10WK	20WK	30WK	40WK
FETUS	5	300	1,500	3,400
PLACENTA	20	170	430	650
AMNIOTIC FLUID	30	350	750	800
UTERUS	140	320	600	970
MEMMARY GLAND	45	180	360	405
BLOOD	100	600	1,300	1,250
EXTRACELLULAR & EXTRA VASCULAR FLUID				
1.NO OEDEMA OR LEG OEDEMA	0	30	80	1,680
2.GENERALIZED OEDEMA	0	500	1,520	4,897
TOTAL				
1.NO OEDEMA OR LEG OEDEMA	**340**	**1,950**	**5,020**	**9,155**
2.GENERALIZED OEDEMA	**340**	**2,420**	**6,460**	**12,372**
TOTAL WEIGHT GAIN				
1.NO OEDEMA OR LEG OEDEMA	**650**	**4,000**	**8,500**	**12,500**
2.GENERALIZED OEDEMA	**650**	**4,500**	**10,000**	**14,500**
WEIGHT NOT ACCOUNTED FOR				
1.NO OEDEMA OR LEG OEDEMA	**310**	**2,050**	**3,480**	**3,345**
2.GENERALIZED OEDEMA	**310**	**2,080**	**3,534**	**2,128**

FROM HYTTEN & LEITCH (1971)

TABLE 1.2 WEIGHT GAIN DURING PREGNANCY ANALYSED BY COMPONENTS OF WATER, PROTEIN AND FAT

COMPONENT OF	WEIGHT GAIN (g)	WATER (g)	PROTEIN (g)	FAT (g)
FETUS	3,400	2,414	440	440
PLACENTA	650	540	100	4
AMNIOTIC FLUID	800	792	3	-
UTERUS	970	800	166	3.9
MAMMARY GLAND	405	304	81	12.2
BLOOD	1,250	1,083	135	19.6
TOTAL	9,155		925	480
ENERGY EQUIVALENT (kcal)			5,186	4,560
(MJ)			22.0	19.0

FROM HYTTEN & LEITCH (1971)

TABLE 1.3 ENERGY COST OF PREGNANCY

	EQUIVALENT kcal/kJ PER DAY Weeks gestation								CUMULATIVE	
	0-10		10-20		20-30		30-40		TOTAL	
	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ	kcal	kJ MJ
PROTEIN	3.6	15	10.3	43	26.7	111	34.2	143	5,186	22
FAT	55.6	232	235.6	985	207.6	868	31.3	130	36,329	152
OXYGEN consumption	44.8	187	99.0	414	148.2	619	227.2	949	35,717	149
TOTAL NET energy	104.0	435	344.9	144	382.5	1598	292.7	1221	77,234	323
METABOLISABLE ENERGY	114	480	379	158	421	1761	322	1347	84,957	355
(total net plus 10%)										

FROM HYTTEN & LEITCH (1971)

1.2 RECOMMENDED ENERGY REQUIREMENT IN PREGNANCY

A woman can meet the energy cost of pregnancy by increasing her intake or reducing her energy expenditure or both. Hytten and Leitch (1971) estimated the total extra energy cost of pregnancy at about 85,000 kcal (355MJ). To supply this, the FAO/WHO recommended that the dietary allowance (RDA) in 1973 for well-nourished pregnant women in developed countries should be about an extra 285 kcal/d (1.2MJ/d) over the 280 days of pregnancy, or about 150 kcal/d (0.63MJ/d) in the first trimester and 350 kcal/d (1.46MJ/d) during the second and third trimesters. However, the FAO/WHO/UNU (1985) recently recommended that this amount of energy intake was for the pregnant women who can not reduce their work; if healthy women reduced their activity it is considered reasonable to reduce the average additional allowance to 200 kcal/d (0.84MJ/d). The FAO/WHO/UNU (1985) remarked that women of small stature tend to have small babies and would logically fall in the lower range of normal weight gains and as a result they would require less additional energy than the average. In Thailand the committee on recommended daily dietary allowances (1989) reported that Thai well-nourished woman of 50 kg body weight, required an extra energy intake of 300 kcal(1.25MJ) daily throughout pregnancy to produce a healthy infant birth weight of 3.0 kg or more and increase her body weight by about 10.0 kg.

1.3 ENERGY INTAKE IN FREE-LIVING POPULATIONS

There is a wide range of energy intake among different communities. Many studies of food intake have shown that pregnant women usually do not increase their consumption as much as the FAO/WHO/UNU (1985) recommendation. 54 well-nourished white American women were studied during 95 pregnancies by Beal(1971) who reported that the median energy intake of these women was 1,900 kcal/d (8.0MJ/d) and the highest intakes during pregnancy were reached in the second trimester with average increase of about 100 kcal/d (420kJ/d). Weight gain during pregnancy was 10.7 kg and the birth weight of full-term infants was 3.25kg. Whitehead et al.(1981) studied energy intake of 24 pregnant women recruited near the beginning of the first trimester in Cambridge. The mean daily energy intake of these women was 1,978±350 kcal (8.3±1.5MJ) and this did not vary throughout pregnancy. The weight gain and the birth weight were however similar to the figures derived from the theory of Hytten and Leitch (1971).

Food intake in developing countries seems to be much lower than in developed countries. For example, Adair (1984) found that caloric intake of rural Taiwan pregnant women ranged from 1,167±307 kcal/d (4.9±1.3MJ/d) to 1,678±340 kcal/d (7.0±1.4MJ/d) but mean birth weight of the babies was reasonably acceptable. However, assessment of energy intake of this study was based on weighed food intake on one day per study period which might not be representative of day-to-day food intake as food intake of an individual has been reported to vary from day to day

(Beaton et al.,1979 & 1983; McGee et al.,1982; Todd et al.,1983). Whitehead (1983) and Beaton (1983) pointed out that in many non-industrialized countries the average energy intake of pregnant women is far below that recommended by International Standards but birth weights are only slightly reduced, therefore, suggesting that recommended calorie intakes may be set too high.

However, there are very few longitudinal studies which attempted to follow the mothers through most of pregnancy. Some of the studies made a cross sectional comparison of energy intake in non-pregnant women and pregnant women. To determine accurately the extra energy needed during pregnancy, Durnin (1982) designed a protocol for a study which attempted to obtain reasonably definitive longitudinal data on groups of women living in different communities from very early pregnancy (or before pregnancy if possible) through to lactation. The study was carried out in five countries; two from developed countries, Scotland and the Netherlands and three developing countries, The Gambia, Thailand and The Philippines. All centres used the same method (Durnin, 1987a) and the results are as follows:

88 Pregnant women in Scotland from the study of Durnin et al.(1987) gained an average weight of 11.7kg (from 10 weeks to 40 weeks gestation) and average birth weight of the babies was found to be 3.37kg. Both weight gain and birth weight in the study of Durnin et al.(1987) were similar to those from Hytten and Leitch (1971). The average estimated maternal fat gain (from 10 weeks) was 2.1 kg and

the calculated rise in BMR from the whole of pregnancy was 30,100 kcal (126MJ) both of these were less than those estimated from Hytten and Leitch (1971). Based on Hytten and Leitch (1971),total energy cost of pregnancy was calculated and found to be 67,130 kcal (281 MJ). It is surprising that the increment of energy intake was only 21,000 kcal (88MJ) with deficit of about 46,130 kcal (193MJ).

The study of Raaij et al.(1987) showed similar results to those from Scotland. The calculated average energy cost of pregnancy of 57 healthy women was 68,400 kcal (286MJ) which is about 11% lower than the theoretical estimate of requirements. The cumulative increase in energy intake over pregnancy however, was estimated as 5,500 kcal (22MJ) which caused an energy gap in pregnancy of about 225 kcal/d (940 kJ/d).

50 Gambian women of whom 29 women received supplementary food, were studied longitudinally in early pregnancy (the first interview was within 8-10 weeks of being pregnant). Lawrence et al.(1987) reported that dietary supplementation had measurable effects on the mother's physiology, resulting in increased energy expenditure on basal metabolism and improving maternal fat deposition. The calculated energy cost of pregnancy in the supplemented group was 27,400 kcal (114.7MJ) while that in the unsupplemented group was -11,700kcal (-49.0MJ) both of which were much lower than that estimated from Hytten and Leitch (1971). This was as a result of the difference in both of the BMR and maternal fat store. BMR increased in

the group with dietary supplementation while it decreased in the group without dietary supplementation during pregnancy. This pattern of change was also observed for maternal fat store. In the supplemented group the energy requirements for increase of the BMR and maternal fat store was 1,000 kcal (4.2MJ) and 22,000 kcal (9.2MJ) respectively, while the unsupplemented group on the other hand saved energy as a result of reduction in BMR of about 10,700 kcal (44.5MJ) and also the energy supply from reduction in maternal fat store of about 5,400 kcal (22.6MJ). The total effect of supplementation was therefore to increase energy requirements during pregnancy.

A longitudinal study in 40 rural Philippino women was carried out from 11-16 weeks of pregnancy until 3 months post-partum. Weight gain and estimated maternal fat store from 13 weeks of gestation and term was 8.4 kg and 1.3 kg respectively. There was no increase in energy intake and the mean energy intake throughout the final two trimesters of pregnancy was 1,750 kcal/d (7.3MJ/d). However, the outcome of pregnancy in these women was successful with mean birth weight of 2.885 kg.

1.4 ENERGY REQUIREMENTS IN RURAL PREGNANT THAI WOMEN (Thongprasert et al.,1987)

The study was carried out in Ubon which is located in the North-eastern part of Thailand. Altogether 44 women were interviewed from about 10 weeks gestation until term. All of them were poor farmers who were healthy and well-nourished. The maternal characteristics are shown in **TABLE 1.4**. They were of small stature compared to the two studies from developed countries (Scotland and the Netherlands) and the Gambian women, with an initial average weight of 47.6 kg and height of 1.52 m. The average birth weight of the babies was 2.98±0.53 kg which was similar to that from the study in the Philippines. Maternal weight gain which was calculated from the difference between weight at term and the initial weight at 10 weeks was 8.9±2.9 kg. Maternal fat gain was estimated by three different methods; 1.the changes of the skinfold thicknesses, 2. the factorial method and 3. the changes of maternal body weight. The average fat gain from these was found to be 1.2kg.

The change in BMR is presented in **FIG.1.1** where it is compared to the theoretical values. A slight increase in early pregnancy was observed and thereafter a marked increase resulted in a total increment from 10 weeks until term of 24,000 kcal (100MJ).

The energy cost of pregnancy which was calculated based on Hytten and Leitch (1971) was 47,200 kcal (197.5MJ). Assessment of energy intake was measured by using the precise weighing method for 5 consecutive days at 6 weeks' intervals. The average energy intake was 1932±358 kcal/d (8.0±1.5 MJ/d) at about 10 weeks and showed the marked increase during the second trimester with a total rise of 56,900 kcal (238MJ) until term (see **FIG.1.2**). Total energy expenditure of these women were also measured simultaneously with the food intake. The average energy expenditure at 10 weeks was 1,870±287kcal/d (7.8±1.2MJ/d) and the total calculated increment from 10 weeks until term

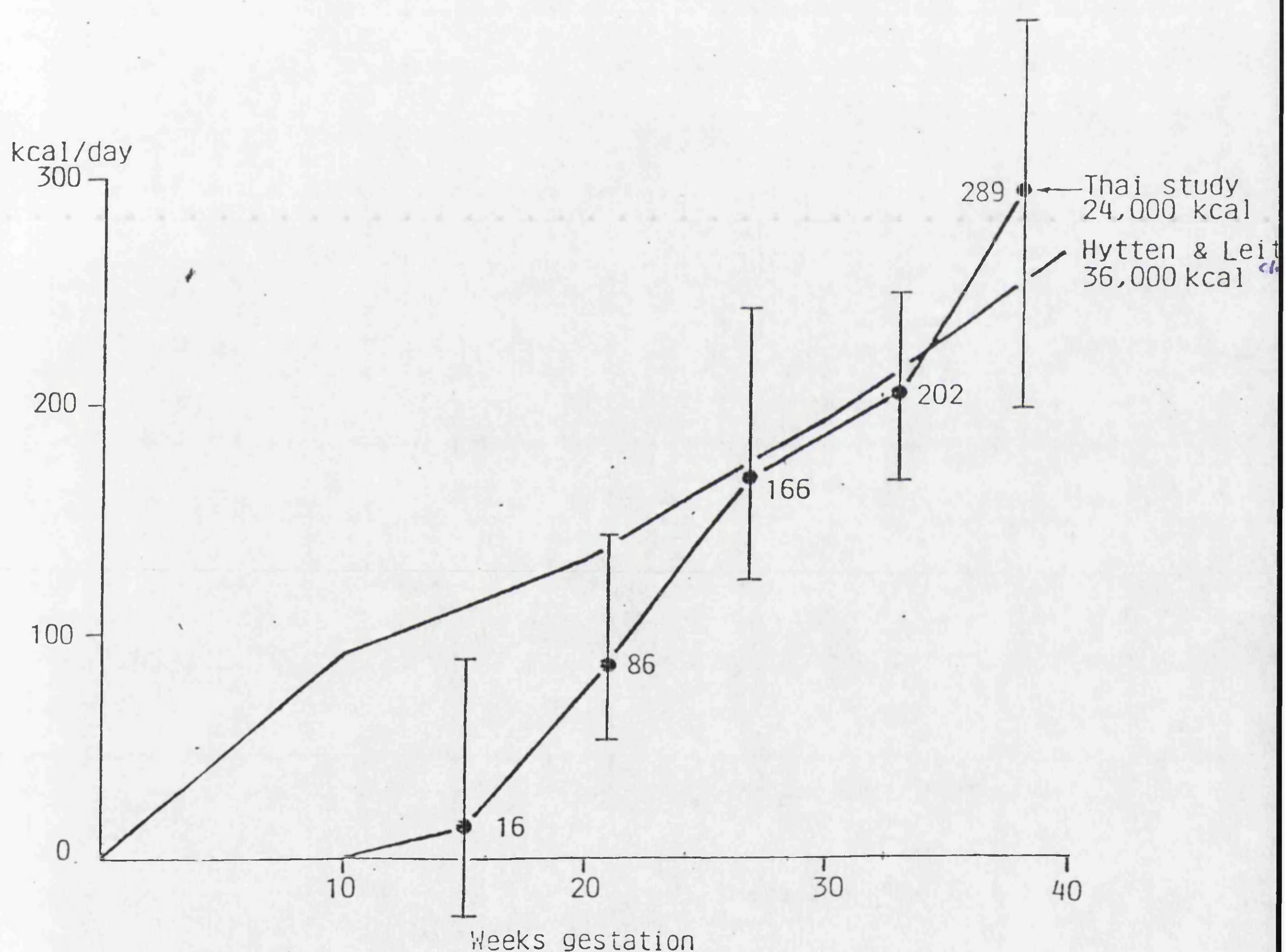
TABLE 1.4 GENERAL CHARACTERISTICS OF THE MOTHERS AND THE OUTCOME OF PREGNANCY[a]

	MEAN(SD)
N	44
AGE (Yr.)	23.1(1.4)
PARITY	1.7(0.7)
HEIGHT (m)	1.52(.05)
INITIAL WEIGHT (kg)	47.4(5.7)
WEIGHT GAIN (kg)[b]	8.9(2.9)
LENGTH OF GESTATION(wk)	38.9(1.6)
BIRTH WEIGHT(kg)	2.98(.35)
BIRTH LENGTH(m)	0.48(.02)
PLACENTAL WEIGHT (kg)	0.53(.09)
% LOW BIRTH WEIGHT	12
SEX (M/F)	18/25

=43

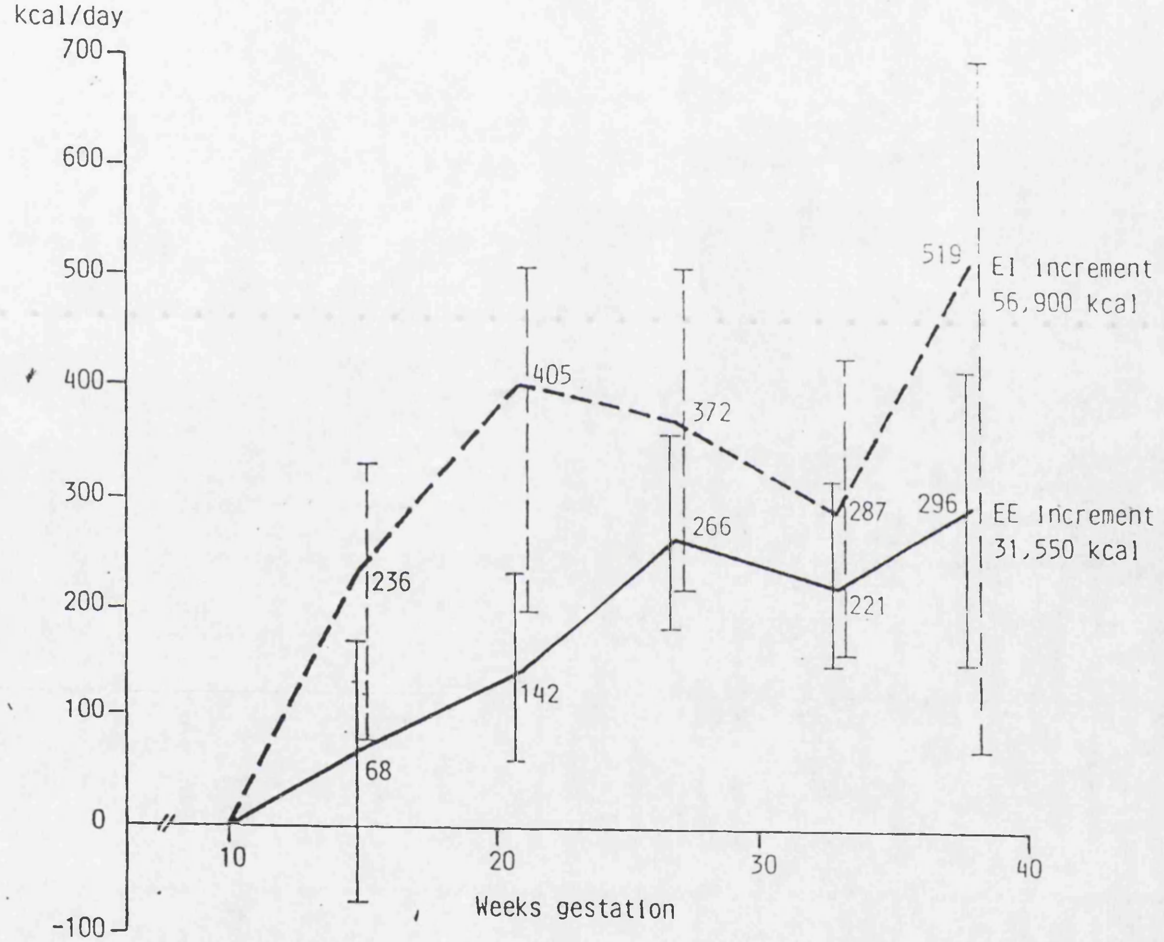
[a] the study from Thongprasert et al.(1987)
[b] calculated from the difference between 10 wk and 40 wk

FIG 1.1 COMPARISON OF BMR INCREMENT FROM 10 WEEKS UNTIL TERM IN THE THAI STUDY (MEDIAN AND CONFIDENCE LIMIT) AND FROM CONCEPTION (HYTTEN & LEITCH,1971)



* From Thongprasert et al.(1987)

FIG. 1.2 INCREMENT OF ENERGY INTAKE AND EXPENDITURE DURING PRENANCY (MEDIAN AND CONFIDENCE LIMIT)*



* From Thongprasert et al.(1987)

was found to be 31,600 kcal (132.2MJ). The result of the difference between the increment of energy intake and expenditure was similar to the energy needed for the energy deposition in maternal adipose tissue and the product of conception as shown in **TABLE 1.5**. The study from Thai is the only one in the five centres which met energy requirements of pregnancy by the estimated increase of energy intake. This was equivalent to an increment of about 225 kcal/d (940kJ/d) during pregnancy.

An integration of the longitudinal data from the 5-country study by Durnin (1987b) showed that the total energy costs of pregnancy which was standardized from body weight was 60,000 kcal (250MJ) for all groups except the Gambian women. Energy intake, however, increased throughout pregnancy in Scotland, the Netherlands, the Philippines and almost certainly also in the Gambian population by no more than 100 kcal/d (420kM/d).

It is important to note that the data of workload of Thai women does not seem to be different from that of the Philippines and all presented data appeared similar in all other centres apart from a marked increase in food intake in Thai women. The study from Thai women may be a complete absence of any form of adaptation to the energy needs of pregnancy. All the data however were based on base-line values at 10 weeks gestation and the results might be over- or under-estimated if their values at pre-conception were lower or higher than those values at 10 weeks of gestation. Therefore, a further study which observes from prepregnant stage until term was needed. The present study

TABLE 1.5 AVAILABLE ENERGY FOR TISSUE DEPOSITION DURING PREGNANCY

	kcal	MJ
- ENERGY BALANCE	**kcal**	**MJ**
Total net increase in energy intake	56,900	238
Total net increase in energy expenditure	31,600	132
RESERVED ENERGY	**25,300**	**106**

- ANALYSIS OF ENERGY DEPOSITION IN MATERNAL ADIPOSE TISSUE STORE AND THE PRODUCTS OF CONCEPTION

	kcal	MJ
Protein	5,385	22.5
Fat (fetus)	4,544	19.0
Fat (maternal),1.2kg	13,200	55.2
TOTAL	**23,129**	**96.7**

From Thongprasert et al. (1987)

was carried out in the same area and the same method as the previous study to investigate the cause of the high increment of energy intake in Thai pregnant women, by starting the study from the prepregnant stage.

CHAPTER 2

METHODOLOGY

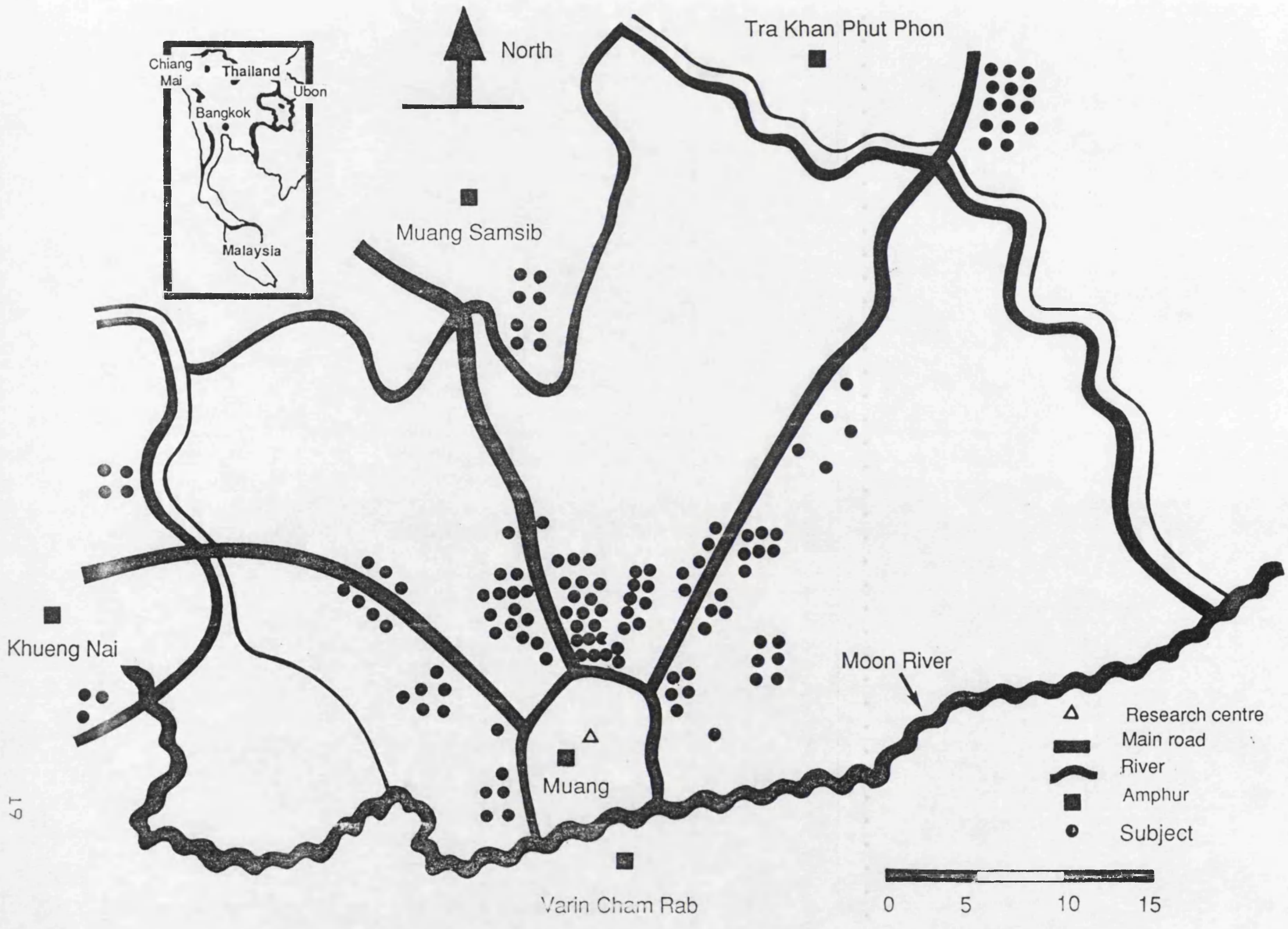
2.1 AREA STUDY

Ubon which is located in the north eastern part of Thailand, about 650 kilometres from Bangkok, was selected for the study. It is the second biggest city in Thailand covering an area of about 18,900 square kilometres. The population of Ubon province in 1989 was 1.8 million with the rate of growth 1.42 per cent per year; most of them being classified as rural. They earn their living by farming and the majority of land is planted with glutinous rice. After the harvest season they grow some vegetables such as chilli, long green beans, groundnuts, water-melon, etc. Livestock production is also common for example, pigs, chickens, ducks, etc. These are raised to help family income. Ubon is subdivided into 21 districts, 4 of which are big districts containing about one-fourth of the population of Ubon. These districts were selected for the study because they are near the research centre **(FIG. 2.1)**. About 100 villages were surveyed from these districts as follows:

- Mung sam sib	8 villages
- Trakan phut phon	21 villages
- Khueng nai	10 villages
- Muang	50 villages

Map of volunteer residents

Figure 2.1



2.2 SUBJECTS

About 1,000 women were initially screened by the researcher from the information supplied by midwives, village heads and village health volunteers who collected the names of married women aged between 18-30 years who were not using any form of contraception from 100 villages which were located within 30 kilometres from the research centre. 121 women were finally selected from this group of women using the following criteria:

- Healthy women aged between 18-30 years.
- Rural farmer with no plans to go out of the village during the study period.
- Not on any form of contraception.
- Willing to get pregnant.
- Having a small family (with members living with the family not more than 6-7 persons)
- Having not more than two children.
- Normal medical and reproductive histories with no previous abortions

The selected women who agreed to participate in the study were enroled in free medical care. At first, it was very difficult to increase the number of volunteers but as the project went on, many villagers started to realize the benefit of taking part of this study, particularly in terms of medical care service (which will be discussed in details later) so some of the women therefore expressed their willingness to become subjects. However, the success of recruiting the women also depended on the season. During the first half of the year, the villagers had finished harvesting and stayed in the villages, therefore it was easy to visit and recruit them. During the rainy season, however, it was very difficult to recruit subjects because many farmer families were busy with their rice plantation and some migrated to stay in their temporary huts out of the villages. During the three months of the Buddhist lent (from mid July to mid October), there was a lack of weddings. This made recruiting of newly married women difficult.

2.3 DURATION

The project was first started in June 1987 and the whole month was spent surveying and training observers then by the end of this month the schedule was set up to follow up each volunteer from pre-pregnant stage until parturition. Surveying was continuously carried out until December 1989 and all volunteers were expected to become pregnant before the end of July 1990 and it was aimed to finish data collection of pregnancy period by the end of April 1991.

2.4 OBSERVERS

10 Observers were selected from about 50 female dietitians who studied for 2 years in division of nutrition after high school level. All of these observers were from the local area with good communication and good relationship with the villagers. They also had good knowledge of the rural culture, villager food habits and

process of cooking local food as well. These helped the observers to communicate, be friendly, be highly efficient in food record and have reduced interaction of long-term inconvenient interview. Before working in the field they were trained by the supervision of the principal investigator in the research centre on how to use all the weighing scales and how to record data accurately. One observer was able to observe 3-4 volunteers in a month and would interview the same subject throughout the study in order to avoid personal error and the volunteers also preferred the same observer. All the observers started work at about 6:00 a.m. each morning. They were taken to the subjects houses and recorded all the dietary intake of the subjects from breakfast until their final meal which was about 6-7 p.m. The observers were then brought back to the research centre.

2.5 FOOD INTAKE RECORD AND THE METHOD

2.5.1 The method

The precise weighing method, one of the most accurate and widely used in field studies was used for assessment of food intake in this study. Food consumption was recorded by observers for 5 consecutive days each period of interview. During pre-pregnant stage, one volunteer would be interviewed each month for 3 consecutive months. The pregnant stage starts when they had a positive urine test of pregnancy. All women who became pregnant continued to be followed up every 4 weeks until full term and each time after they were interviewed, the next period would be set up and the observers would tell the pregnant women when the next visit would be. Sometimes it was not convenient to visit some of the pregnant women for some special reasons such as during some special celebrations or when the pregnant women had to go somewhere which might change their normal life especially their food consumption and so the schedule for the interview had to be re-arranged. Each volunteer was approximately interviewed on about 12 occasions; 3 times during pre-pregnancy and 9 times during pregnancy (see **TABLE 2.1**). The well-trained observers had to follow the volunteers like a shadow to record and weigh all food items eaten by the volunteers. Due to the fact that Thai food components in cooked food are not constant, it makes it difficult to estimate an accurate calories energy intake. Therefore, food intake of every volunteer was weighed from raw material stage until after cooking and also the amount of food consumed. The weighing procedure was as follows;

- Before cooking: All the ingredients for any particular meal were weighed separately at the raw stage and in the form of ready to cook for example, vegetables should have any inedible parts removed before weighing and then cooked. Sometimes the inedible parts could not be removed before being cooked, such as, shell, fish bone. Then the observers had to collect these inedible parts from the left over of the whole family to be subtracted from the original raw weight and cooked weight. For example, in steamed fish

TABLE 2.1 DATA COLLECTION AND FREQUENCY

	PREPREGNANT	PREGNANT	AFTER DELIVERY
1 INTAKE	/ / / 3 times monthly	/ / / / / / / / / every 4 weeks until term	
2 ANTHROPOMETRY			
-MOTHER			
4 Skinfold thickness	/ / /		/
Weight record	|------------ every week	--------------------	|
Height	/ /		
-BABY			
3 Skinfold thickness			/
3 Circumferences			/
Weight			/
Height			/
Placental weight			/

(**TABLE 2.2**), raw weight and cooked weight of cat fish was 280g and 320g respectively both of which included fish bone. The observers had to appeal to every member in the family to collect the total of fish-bone after meal for subtracting from 280g and 320g to make the estimated raw food components more accurate. The weight of other ingredients added during cooking such as, vegetable oil, fish sauce, sugar, etc, should be known before addition too.

- After cooking: The total amount of cooked food was weighed again. If some cooked foods were not homogenous, for example, chicken soup, hot curry with pork, these main ingredients should be weighed separately. The cooked weight of all main ingredients would be used to estimate those in raw stage. For example, some soup of which the main ingredients were chicken and vegetables, it was important to know the weight of chicken and vegetables. In other situations where some cooked food had been well mixed , such as, fried rice , papaya salad, these could be weighed in total with no need to be separated from the mixed items. The weight of total well mixed food could be used to compute for raw weight of all components.

- The women's portion: Homogenous dish,the portions to be taken by the subjects were weighed before being taken and then again after being eaten. The weight difference between before and after eating was assumed to be the amount of subjects consumption.

TABLE 2.2 AN EXAMPLE OF A DAILY FOOD COMSUMPTION OF A WOMAN

ITEM OF FOOD INGREDIENT	TOTAL COOKED PORTION		PORTION FOR THE SUBJECT		
	Raw wt (g)	cooked wt (g)	initial wt (g)	left overs (g)	amount consumed (g)
BREAKFAST					
-Glutinous rice	1500	2310	250	0	250
-Fried egg		56	56	10	46
chicken egg	50-1				
fish sauce	3				
onion	10				
-Chicken & lettuce soup		1580	252		
chieken	572-130	602-130	55-12	12	43
letuce	235	323	135	5	130
sugar	5				
fermented fish	17		62		47
salt	2				
water					
LUNCH					
-Glutinous rice			218	0	218
-Papaya salad		238	158	0	158
raw papaya	192				
garlic	2				
tomato	18				
chilli, dried	8				
lime juice	19-12				
fermented fish	10				
DINNER					
-Glutinous rice			320	4	316
-Steamed vegetable					
sponge gourd	180	190	82	10	72
cauliflower	250	280	108	5	103
-Steamed fish		320-50	138-22	22	116
cat fish	280-50				
salt	2				
-Chilli sauce		35	35	20	15
chilli, dried	10				
fermented fish	20				
garlic	5				

: Dish not well mixed, the observers had to be much more careful than for homogenous dish because the concentration taken by the volunteers might not be the same as the original cooked portion. For example, hot curry with chicken and vegetables, the volunteers might take only vegetables and stock and so these would be over-estimated for calories energy intake if the observers weighed only the total portion taken by the volunteers to predict the raw materials of food consumption by computing from the weight of total original cooked portion. Therefore, the main components of the women's portion should be weighed separately and again for leftover as well.

: Some food items which the volunteers bought from outside or were given from their neighbours, should be carefully recorded. The observers had to record all ingredients that they saw and noted what were the major ingredients. These could help to estimate raw ingredients by computing from local ingredients lists which were collected from the previous observation, but if the composition of the food had no information, then the observers had to ask about the ingredients from the food sellers. These details would be given to the dietitian to estimate the raw components.

All the women's consumption should be recorded by the system as shown in **TABLE 2.2** which gives an example of how to record food intake. Every observer would send the completed food record to the lab the day after data

collection because if the supervisor found that there were some comment or any incomplete food items the observers could remember and answer back correctly. These weights of cooked food taken by the volunteers then were manually computed back to raw components. Thereafter These raw components were estimated for calories energy intake by using Food composition tables which were Thai food composition table (Div. Nutr.1978 &1981) and Food composition table for use in East Asia (Wu Leung, Buirum & Change,1972). The processing of estimated calories intake and nutrition components by using 16 bit computer program " Verb.
Nutritionist 3 " from the United State of America with data source based on Thai food composition and the South east Asia food table.

2.5.2 The weighing scale

- Sochnle digital spring balance

This equipment can read to the nearest 1 g and have the capacity to 1 kg. Mostly this scale was used for weighing women's food intake portion and some small food items. On the day before the interview this scale was calibrated by standard weights.

- Spring balance scale

This scale has a moving pointer and can read to the nearest 10 g and up to a maximum of 3 kg. This calibrated scale was used for weighing some items which weighed more than 1 kg such as total cooked portion, raw and steamed glutinous rice.

2.6 Anthropometry

Maternal anthropometry was normally measured on the 6th day after complete data food intake record by the technical staff.

2.6.1 Height

The subject was asked to stand on a horizontal with their heels together and the anthropometry was used for the height which was done only in the first two periods during pre-pregnancy.

2.6.2 Weight

By using digital bath room scale which can read to the nearest 0.5 kg and the maximum is 150 kg. This bath room scale was standardized by standard weight every time it was used. The woman was asked to empty her bladder and wear the same dress before weighing. Every volunteer was trained on how to use and to read the scales during the first interview and thereafter, they would weigh themselves every week in the morning. Their weekly weight record would be checked to see that they could read their weight correctly at every period interview.

2.6.3 Skinfold thickness

Four different sites of skinfold thickness were measured on the right side of the body by using Harpenden caliper (Holtain Ltd, Brybrarian, Crymych, Prembrokeshire). The calipers were calibrated to give a constant pressure of 10 g/mm^2. The skinfold was picked up firmly between thumb and fore finger and pulled away slightly from the underlying tissue. Then the pressure of the caliper jaws was applied about 1 cm below the line mark to the skinfold at the moment, these two fingers were removed and the skinfold thickness was read within 2 seconds after the pointer stopped. Each site of skinfold thickness was measured 3 times and recorded to the nearest 0.2 m.m.

These four sites of skinfold were

- biceps: The skinfold was picked up over the mid point of the belly of the biceps muscle with the arm relaxed at the side.

- triceps: The calipers jaws were applied at the back of the relaxed arm, on a vertical line of the mid point between the acromial process and the olecranon process and directly in line with these two processes.

- subscapula: The position of this skinfold was under the angle of the scapula, below the top of the inferior angle of the scapula and this skinfold was picked up immediately at an angle of about 45 to vertical, and with the finger touching the bone.

- subpraillia c: The skinfold was taken at vertical position above the anterior superior iliac spine in the mid-axillary line.

These skinfold thicknesses would be used to assess the amount of body fat which can be derived from the summation of four skinfolds and body weight using specific equations (Durnin & Womersley,1974 ; Siri,1956).

2.7 HOW TO GET BASE-LINE VALUES AT PRE-CONCEPTION STAGE AND CONTINUE DURING EARLY PREGNANCY

All women who were selected from survey lists were likely to become pregnant, i.e. no birth control, had stopped breast feeding , had just married. Before the first interview women were asked their last menstrual period (LMP) and the level of hormone HCG was tested in their urine by using pregnancy test before interview to make sure that they were not pregnant. After finishing 3 base-line periods, each subject was given a form to record body weight weekly and also asked to record their menstrual period. All non-pregnant volunteers were regularly visited by the nurse monthly to ask for their last menstrual period. The check up was performed every month for each and every individual along with the suggestion of the ovulation self assessment and sperm count in some cases. The nurse would check and report if any of the women had missed their period and their urine samples collected to be tested. As soon as any positive test of pregnancy was found, the volunteers would continue follow up throughout pregnancy.

2.8 MEDICAL SERVICE

All the women who intended to participate in this study were offered free medical care throughout the study. This helped to increase the number of vulunteers. Medical schedules were performed to visit pregnant volunteers monthly up to the seventh month of gestation and then every two weeks during the eighth month of gestation and thereafter weekly until delivery. Medical service could be at Ante natal clinic in the provincial hospital or the nurse would go to visit at their house.

2.8.1 Antenatal Clinic

After the first period of interview during pregnancy, all pregnant women were taken to ante-natal clinic to register their pregnancies. Here, their medical-history was taken and a physical examination such as, blood pressure, urine examination was done. Any woman who had an irregular menstruation cycle or who was unsure of their LMP had their gestation week estimated by physicians.

2.8.2 Home visit

The pregnant women, after registering their pregnancies at the provincial hospital were visited and had their clinical examination at home. The nurse would record all their illnesses and report if there were any illness during the interview which might affect the data collection. If so that data was excluded from the analysis. If there were any unbelievable data for example, too many changes in daily food intake of some women, these details would be given to the nurse who would also ask the reason from the women during home visit.

2.9 DATA ANALYSIS

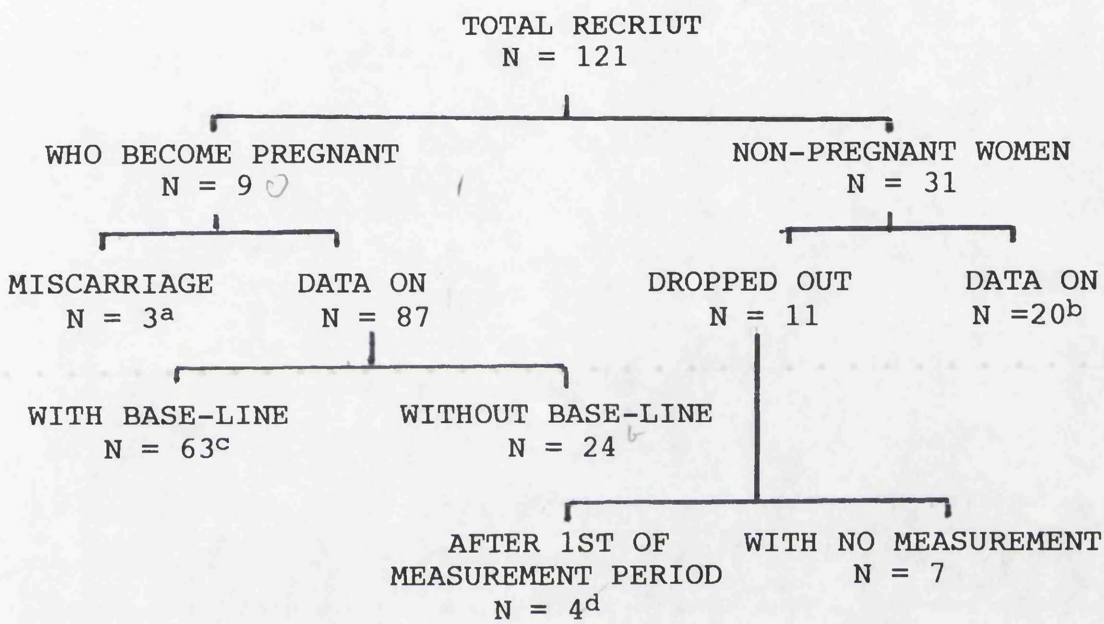
All raw data of maternal food intake and anthropometry were put in the 16 bit computer and grouped by weeks of the gestation which were carried out by the Lotus program. Base-line values in this study are the values at 0 week or those before becoming pregnant of all pregnant women. Mean base-line values were averaged from individual mean values and were compared to periodic values throughout pregnancy by using Student 't' tests. Statistical analysis were also processed by this Lotus program.

CHAPTER 3

GENERAL CHARACTERISTICS

From June 1987 until December 1989, about 100 villages in 4 districts were surveyed and 121 healthy volunteers aged between 18-30 years were recruited from about 50 villages. All were farmers and had low socioeconomic status. Thirty-one of these women did not have data collection either because they had not become pregnant after more than two years or they dropped out of the study for various reasons. These can be subdivided in to two groups; firstly, seven women changed their mind during only the first-day interview about participating in the study because of the inconvenience to them of data collection and/or they were ashamed to let others know what food items they consumed so these women had no data collection at all. Secondly, four women dropped out of the study after completing the first period of pre-pregnancy because they had to follow their husbands who had found jobs in other provinces, or some women decided to continue using birth control. Finally, the total of pregnant women by the end of July 1990 was ninety, but three of these women miscarried after the first trimester. Therefore, the total number of all subjects who were completely followed up throughout pregnancy in this study was 87 mothers, as shown in **FIG. 3.1**.

FIG. 3.1 BREAK DOWN OF DISTRIBUTION OF SUBJECTS



non pregnant women discussed in effect of seasonal variation
a + b + c + d = 90

For this study, it was decided to recruit a group of women who were not yet pregnant so as to obtain base-line information. By carefully recruiting women who were likely to become pregnant, data before the women became pregnant was gathered from 63 women. There is no base-line information for the other 24 pregnant women because they were pregnant at the time of the first interview, although their urine pregnancy tests were negative and their initial gestation weeks were between one and five weeks of gestation. The base-line results of this study are therefore based on the measurement of 63 pregnant women; 67 per cent,of whom became pregnant three months after the base-line stage, 16 per cent between 3-6 months after data began to be collected and 17 per cent more than 6 months after the base-line stage.

TABLE 3.1 shows the general characteristics of this study compared to the study from Thongprasert et al. (1987). The women in the two studies had similar life styles, except that some women involved in this study who lived near the town of Ubon work in town during the non-agricultural season. The women recruited for the studies who became pregnant had similar characteristics in terms of age and height. Initial body weight of these women in this study was 49.7 kg which is about 2 kg greater than in the study by Thongprasert et al.,1987 ($p<0.05$) but if these are compared with the same gestation week, both of these studies are the same. Both studies looked at the difference in the weight gain of the women. In this study

TABLE 3.1 GENERAL CHARACTERISTICS OF THE MOTHERS

	PRESENT STUDY MEAN(SD)	PREVIOUS STUDY[a] MEAN(SD)
N	87	44
AGE (yr.)	22.6(2.9)	23.1(1.4)
PARITY	0.8(0.8)[b]	1.7(0.7)
HEIGHT (m.)	1.52(.04)	1.52(.05)
WEIGHT (kg.)		
AT BASE LINE (0 week)	49.7(6.0)[c]	-
AT 10 WEEK	48.3(5.9)	47.4(5.7)
WEIGHT GAIN :		
40- 0 WEEK	7.8(3.5)	-
40-10 WEEK	8.7(3.3)	8.9(2.9)
LENGTH OF GESTATION(wk.)	39.4(1.3)	38.9(1.6)

[a] the study from Thongprasert et al.(1987)

[b] significance difference from Thongprasert et al.(1987) $p<0.001$

[c] significance difference from Thongprasert et al.(1987) $p<0.05$

the weight gain was 0.9 kg less than that of Thongprasert et al. (1987) but if these two studies are compared according to the gestation week, the results are similar. The only difference between these two studies is the parity of the pregnant women. In the study from Thongprasert et al.(1987) most of the pregnant women were primiparae (they had given birth once already) whereas, this study included some nulliparae women (those who had never given birth). During the first year, the survey was focused only on newly-married women without children who would be more likely to become pregnant, but it was difficult to increase the number of recruits. It was found that most of these women married at an average age of only 15-17 years old after they had finished their education to a limited level. As such, they were quite young and thus might still be growing themselves, a factor which might possibly interfere with the data interpretation. Therefore, women who had one or two children were included in this study as well thus giving a result of an average parity 0.80.

The outcome of the pregnancies is presented in **TABLE 3.2.** Eighty-seven infants, of which 37 were female and 50 were male, were delivered in a provincial hospital at an average of 38 weeks gestation; one of these was still-born and ten were of low birth weight.

TABLE 3.2 OUTCOME OF THE PREGNANCY

	PRESENT STUDY MEAN(SD)	PREVIOUS STUDY* MEAN(SD)
NO. OF BABIES	87	44
WEIGHT(Kg.)	2.98(.39)	2.98(.35)
LENGTH(m.)	0.48(.03)	0.48(.02)
PLACENTAL WEIGHT (Kg.)	0.55(.10)	0.53(.09)
% LOW BIRTH WEIGHT	9	12
SEX (M/F)	50/37	18/25

* the study from Thongprasert et al.(1987)

CHAPTER 4

FOOD INTAKE

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Total calorie intake

A total of 87 women were studied throughout pregnancy. Out of this 63 women had data collected at variable periods of between one and 24 months before becoming pregnant. The mean of energy intake before pregnancy of these 63 women calculated from individual mean values was 2,170±429 kcal/d (9.08±1.79 MJ/d) and was used as the base-line of this study. **TABLE4.1** shows the mean daily energy intake before and after pregnancy. The recordings were done on different gestation weeks and gestation week 0 (first column) represents an average recording during non-pregnancy. The results presented on this TABLE shows that the mean energy intake during pregnancy decreased from a base-line value of 2,170±429 kcal/d (9.08±1.79 MJ/d) to 1,892±358 kcal/d (7.92±1.50 MJ/d) in the first trimester. There was an increase of energy intake during the second trimester to a mean value of 2,276±341 kcal/d (9.52±1.43 MJ/d). The second trimester value is similar to the base-line value (at 0 week). There was a further increase in the third trimester to a value of 2,319±403 kcal/d (9.70±1.69 MJ/d) just before delivery. However, no statistically significant change in

TABLE 4.1 MEAN DAILY INTAKE OF PREGNANT WOMEN

GESTATION WEEK	N	ENERGY INTAKE kcal/d MEAN	SD	MJ/d MEAN	SD
0	63	2,170	429	9.0	1.7
1 - 4	32	2,122	500	8.8	2.0
5 - 8	71	1,892	358[a]	7.9	1.5[a]
9 - 12	82	1,967	354[b]	8.2	1.4[b]
13 - 16	84	2,120	365	8.8	1.5
17 - 20	83	2,252	356	9.4	1.4
21 - 24	87	2,276	341	9.5	1.4
25 - 28	87	2,282	410	9.5	1.7
29 - 32	86	2,226	377	9.3	1.5
33 - 36	87	2,196	335	9.6	1.4
37 and above	64	2,319	403	9.7	1.6

[a] significance difference from 0wk $p<.001$
[b] significance difference from 0wk $p<.005$

energy intake is observed except between the 5th and 12th weeks of gestation.

Although this is a longitudinal study in which every pregnant woman had to be interviewed at 4 weekly intervals the total number of subjects at each period was not the same, especially for the first two periods and the last period (**FIG.4.1**) This is because most of the women had urine pregnancy test positive only after the 4th week so it was not possible to collect data at the exact time of becoming pregnant. Some of the women were suspected to be pregnant as at the time of initial data collection. Secondly, some of the pregnant women gave birth before the 40th week of gestation. So the base-line data was not recorded for 24 pregnant women because of the reasons mentioned above.

4.1.2 Changes of energy intake during pregnancy

The changes of energy intake during pregnancy were estimated by calculating the deviation from the base-line value as shown in **FIG. 4.2**. The initial decrease of energy intake in the first trimester of 142 kcal/d (595kJ/d) was calculated from the area under the curve. The energy intake during the third trimester was higher by 105 kcal/d (440kJ/d) than the pre-pregnant base line value. The total change of energy throughout pregnancy was a deficit of 854 kcal (3.6MJ) or about 3 kcal (12kJ) per day.

FIG.4.1 TOTAL SUBJECTS IN EACH PERIOD OF INTERVIEW

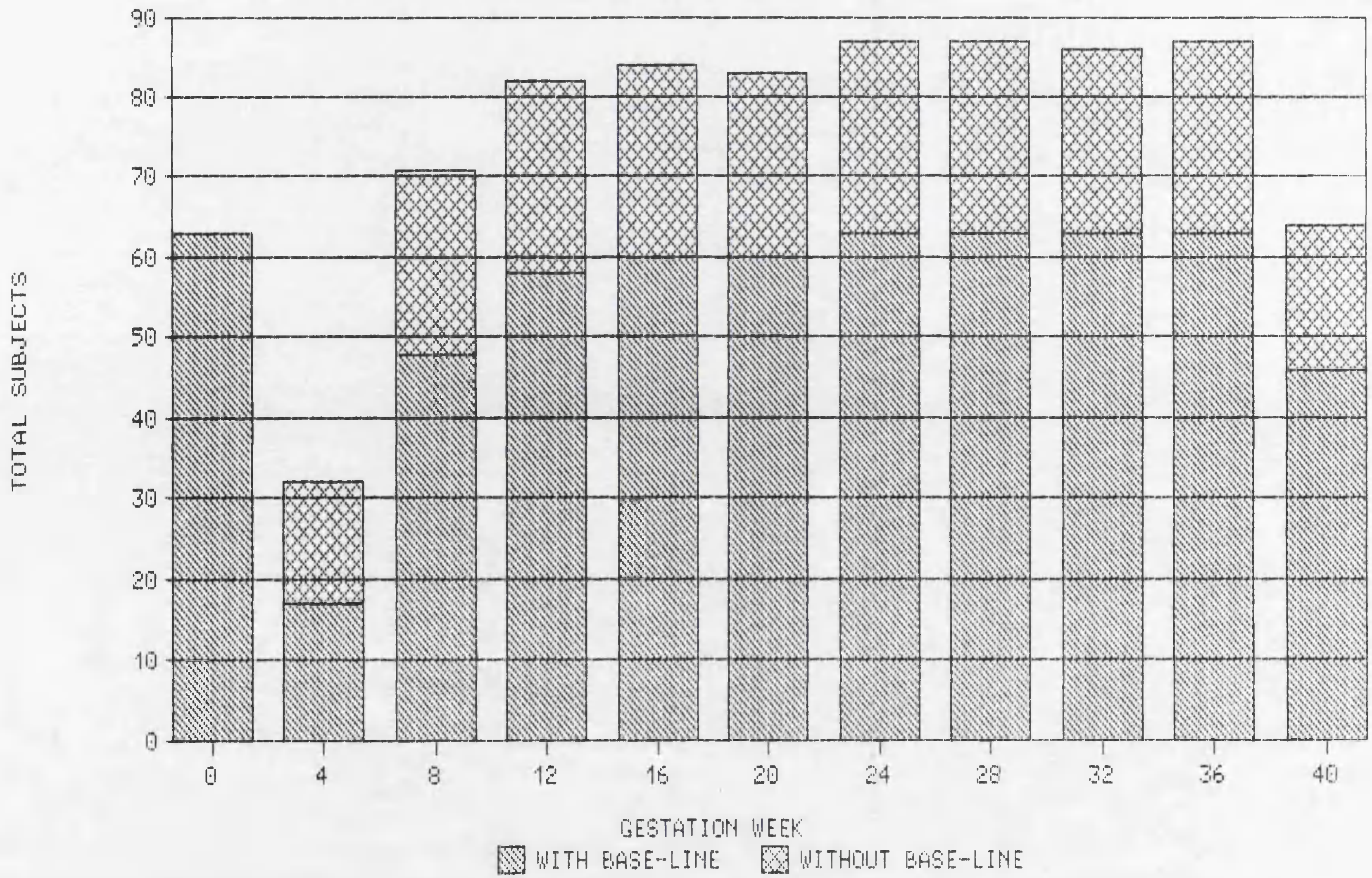
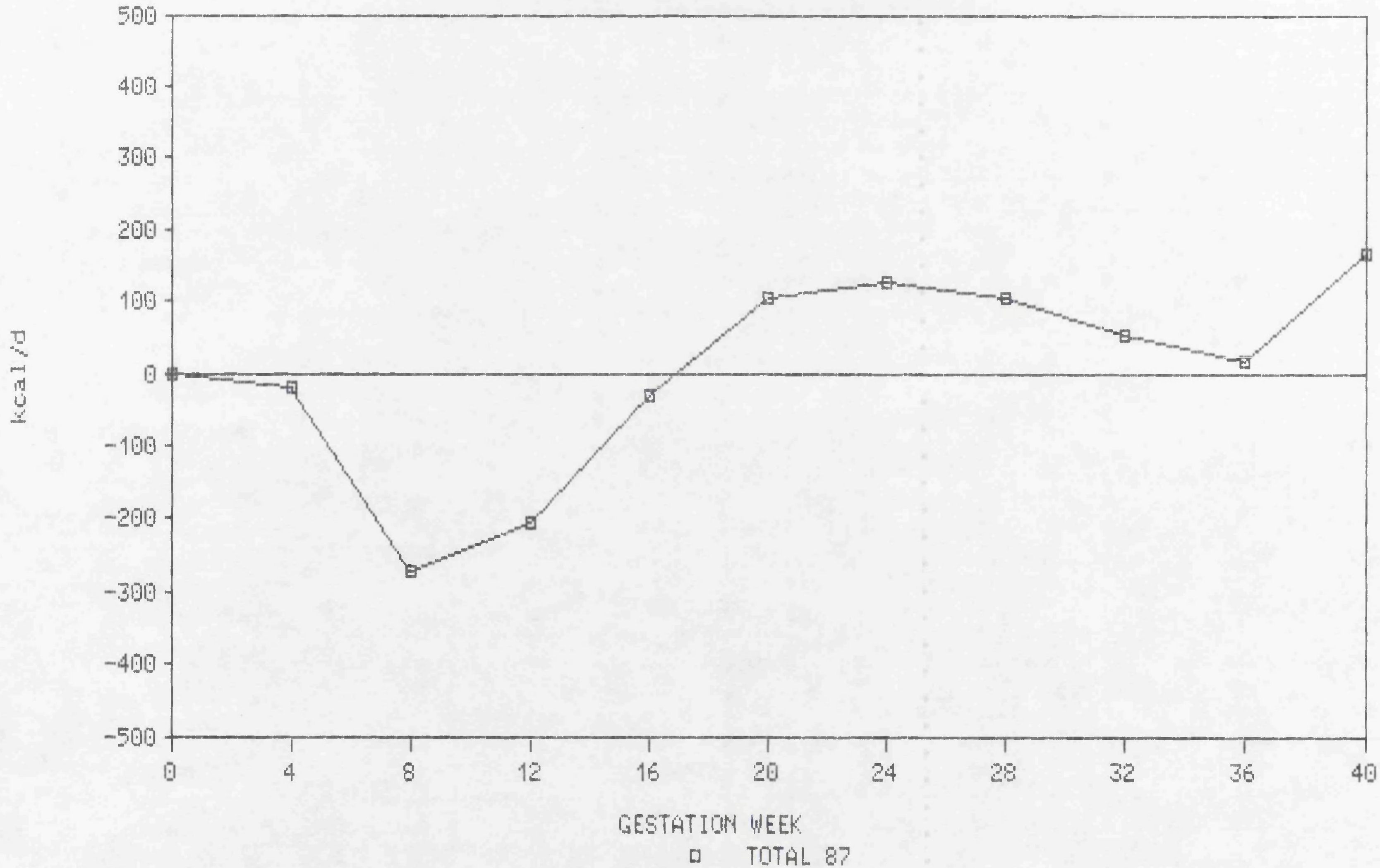


FIG. 4.2 CHANGES OF DAILY ENERGY INTAKE
DURING PREGNANCY (MEAN)



This finding is in contrast to the extra energy intake level recommended by the FAO/WHO/UNU Report (1985) of 285 kcal/day (1.2MJ/d) over the nine-month pregnancy period. This recommendation also states that even if the pregnant women are able to reduce their levels of physical activity, they still require an average extra energy intake of about 200 Kcal (840kJ) daily.

The results of the present study are, therefore, unexpected. Part of the discussion will attempt to explain why this group of women appear to have no extra energy intake but are still able to increase their body weight and produce healthy babies of about 3 kg of birth weight.

4.2. THE FACTORS INFLUENCING ESTIMATES OF CHANGES OF ENERGY INTAKE

The results of the total increment of energy intake from this study are completely different from those of Thongprasert et al.(1987) who found that the total increment of energy intake in Thai pregnant women throughout pregnancy was about 56,900 kcal (238 MJ). The interpretation of this difference in the observations of the present study and those of Thongprasert may be influenced by two factors as follows:

4.2.1 High base-line value

The average energy intake at pre-conception in this study was 2,170 kcal/d (9.08 MJ/d) which was used as the base-line value. The value is similar to the values of the 27 non-pregnant women who did not have data collected during pregnancy (20 women did not become pregnant and 7 women dropped out of the study) and 22 non-pregnant women who did not become pregnant during the study of Thongprasert et al.,1987(see below). **TABLE 4.2** presents the general characteristics of these women which are similar to the 87 pregnant women in this study (from **TABLE 3.1**) in terms of age, height, body weight and fatmass. From **TABLE 4.2**, it can be seen that the mean value of 27 non-pregnant women, who did not have data collected during pregnancy, was found to be 2,185±311 kcal/d (9.14±1.3 MJ/d) while unpublished data of 22 non-pregnant women from Thongprasert et al.(1987) put this value at 2,299±454 kcal/d (9.6±1.9 MJ/d). According to FAO/WHO/UNU (1985), daily energy requirement is calculated as a factor of the BMR. The estimated BMR of non-pregnant women of average body weight of about 49 kg and between the ages of 20 and 29 by FAO/WHO/UNU (1985) was 1,215 kcal/d (5.1 MJ/d). The average energy intake of non-pregnant women in this study is therefore classified as BMR, which is higher than the equivalent for a non-pregnant woman working in a heavy occupation (FAO/WHO/UNU,1985). If these women do not work consistently hard throughout the whole year, for reasons to

TABLE 4.2 GENERAL CHARACTERISTICS OF PRE-PREGNANT WOMEN

	PRESENT STUDY MEAN(SD)	PREVIOUS STUDY* MEAN(SD)
N	27	22
AGE (yr.)	23.1(3.2)	26.4(2.6)
HEIGHT (m.)	1.53(.03)	1.52(.04)
WEIGHT (kg.)	49.7(7.1)	49.0(4.7)
FATMASS (kg)	12.6(4.1)	12.4(3.2)
BMI (kg/m^2)	21.2(2.9)	21.3(2.2)
ENERGY INTAKE		
kcal/d	2,185(311)	2,299(454)
MJ/d	9.1(1.3)	9.6(1.9)

* Unpublished data from Thongprasert (1987)

be discussed later on seasonal variation, their daily energy intake during non-pregnancy appear to be high exceptionally for these populations.

4.2.2 Low energy intake during the first trimester

The average energy intake at 8-12 weeks of pregnancy in this study was found to be much lower than the pre-pregnant value. As a result this caused a decrease of 142 kcal/d (595 kJ/d) during the first trimester as compared to the base-line and even though during the third trimester their energy intakes were increased this had little effect on the overall energy intake during pregnancy. From the studies of Durnin et al.(1987) and Raaij et al.(1987) it was found that energy intake during the first trimester was not different from that from pre-pregnant stage and so the estimated cumulative increase in energy intake over pregnancy was found to be 21,000 kcal (88 MJ) from the study of Durnin et al.(1987) and 5,200 kcal(21.8 MJ) from that of Raaij et al.(1987). If the average energy intake in this study during the first trimester was not much different from the base-line value as in the study of Durnin et al. (1987) and Raaij et al.(1987), it is possible then to estimate the increment of energy intake only in the third trimester. Energy intake during the third trimester was 105 kcal/d (440kJ/d) higher than the pre-conception base-line value and so it was multiplied with 112 days (the last 16 weeks of gestation) which would give about 11,760 kcal (49.2MJ). However, this value is also far less than that from Thongprasert et al.(1987).

It is important to note that Thongprasert et al.(1987) used the average energy intake of about 1,932 ±358 kcal/d (8.1±1.5 MJ/d) at 10 weeks of gestation as the base-line values while this study used pre-conceptional values as the base-line. From **FIGURE 4.2**, the trough which is apparent from the plot of energy intake during gestation seems to explain that the study from Thongprasert et al.(1987) started from the lowest energy intake during pregnancy and the average of energy intake during 5-8 weeks of gestation in this study was similar to the average energy intake at 10 weeks of gestation from Thongprasert et al.(1987). In addition, the study from Thongprasert et al.(1987) probably over estimated the total increment of energy intake during pregnancy because of missing the reduction in energy intake in early pregnancy.

4.2.3 Effect of seasonal variation on expenditure

Thailand has three different seasons referred to as the hot season, the rainy season and the cool season. The weather is more changeable in the northern and north-eastern parts of Thailand in which area Ubon is situated, while in the central and southern parts of the country the weather is more constant. All volunteers of this study are farmers and their ways of life depend on the weather.

- Hot season: The hot season, which is very hot and generally dry starts at the end of February and ends around mid May. The highest temperature in the year which is about 32-36 °C in Ubon (**FIG.4.3**) is recorded in April, when Thai farmers have usually just finished harvesting their main crops and some start to grow other secondary crops like chillies, groundnuts, etc. They do not work as hard on the secondary as the main crops except some farmers who migrate to work as labourers in the city.

- Rainy season: The rainy season starts at the end of May. The total rainfall for the year varies depending on the monsoons. **FIG.4.4** shows total average monthly rainfall in Ubon during 1987-1990. During the middle of June, when the rain comes, rice seedlings are prepared for planting in some enriched humus blocks. Then transplantation of the seedlings which grow up enough, are made into the paddy fields from the end of July to September when there is a peak in the rainfall. Thai farmers have to start their work very early in the mornings till late in the afternoons and they have to finish rice plantation before the rain ends. This period can be called the hard working period.

- Cool season: The cool season starts in October after the rain stops and then the temperature drops to the average lowest temperature of about 15-18 °C in December (**FIG.4.3**). Most of farmers rest during initial part of the cool season as the rice is not ripe enough for harvesting.

FIG.4.3 MONTHLY CHANGES OF TEMPERATURE IN UBON

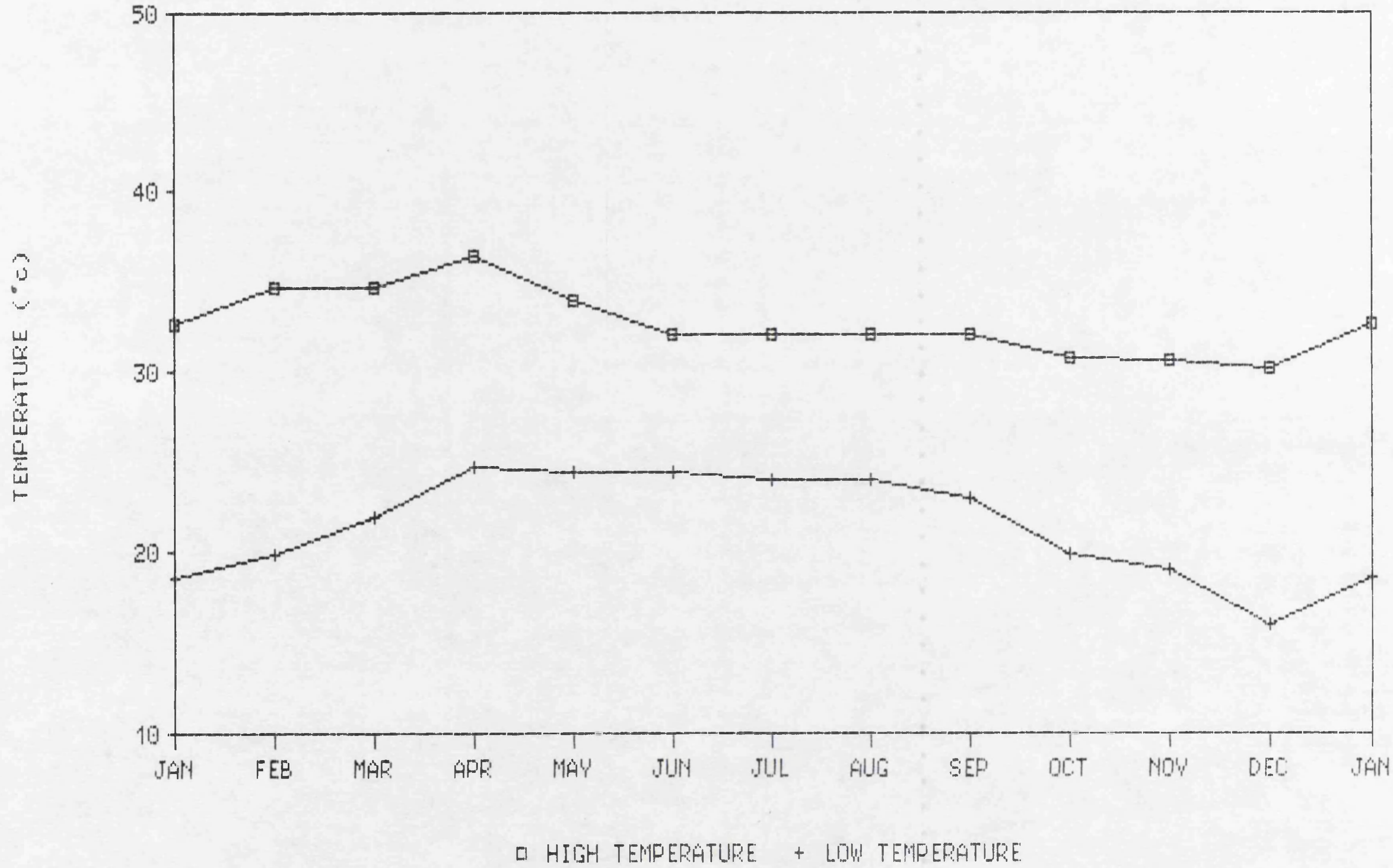
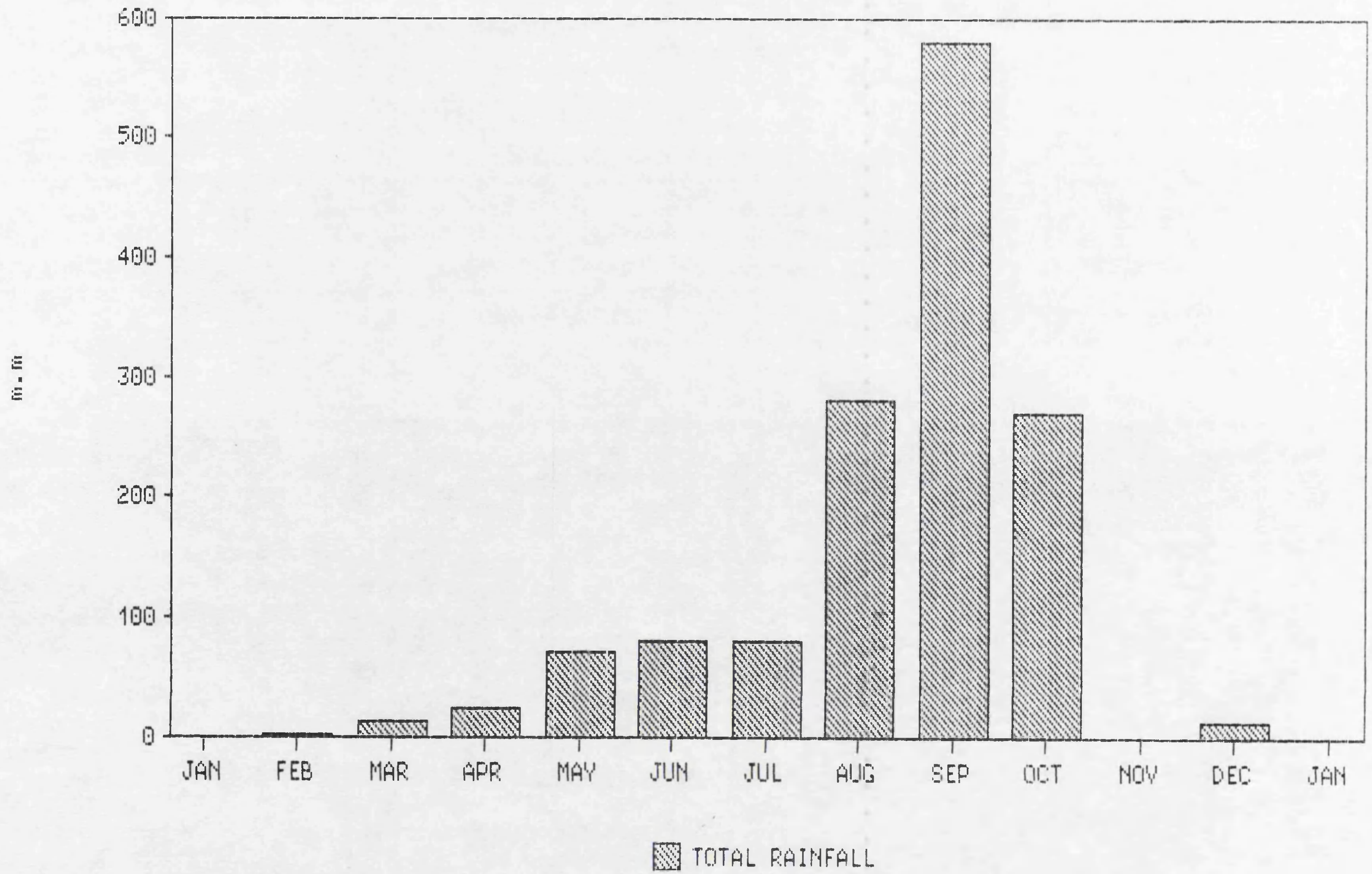


FIG.4.4 MONTHLY RAINFALL IN UBON



When it becomes ripe, harvesting will take place in December then farmers have to work very hard again. However most harvesting is completed by mid January then the weather becomes warmer and the hot season recycles again.

4.2.4 Effect of seasonal variation on energy intake

The work load varies throughout the year so the season may influence the energy intake of Thai farmers because of differing energy expenditures. Estimated Energy requirements (based on the FAO/WHO/UNU document; 1985), depends on the BMR and energy expenditure

Energy requirements per day = BMR x factor

This factor varies with the type of work, e.g. 1.56 for light work, 1.64 for moderate work and 1.82 for heavy work. The season may influence the energy intake of Thai farmers because during the main crop plantation from May to September and the harvest season (in December), they probably work harder than during the hot season (from February to April), with consequent increase in energy intake. The work load during May to September and in December may be classified as hard work and during February to April may be classified as light work. January may be classified as moderate work since almost all Thai farmers finish rice harvesting in the middle of the month. From October to November most Thai farmer have just finished rice plating and in this period they may gather food such as mushrooms and vegetables for sale or consumption. They probably work slightly harder during these months than during the hot season (February to April) and so this period may be classified as moderate work. **TABLE 4.3** shows the estimated energy requirements of these non-pregnant women, computed by using the factor from FAO/WHO/UNU (1985), i.e. 1.82 was used for 6 months: May, June, July, August, September and December, 1.64 for 3 months: October, November and January and 1.56 for 3 months: February, March and April. The average daily energy requirement for the 12 months was found to be 1,916 kcal (8.0 MJ) which is lower than the average daily intake of these non-pregnant women.

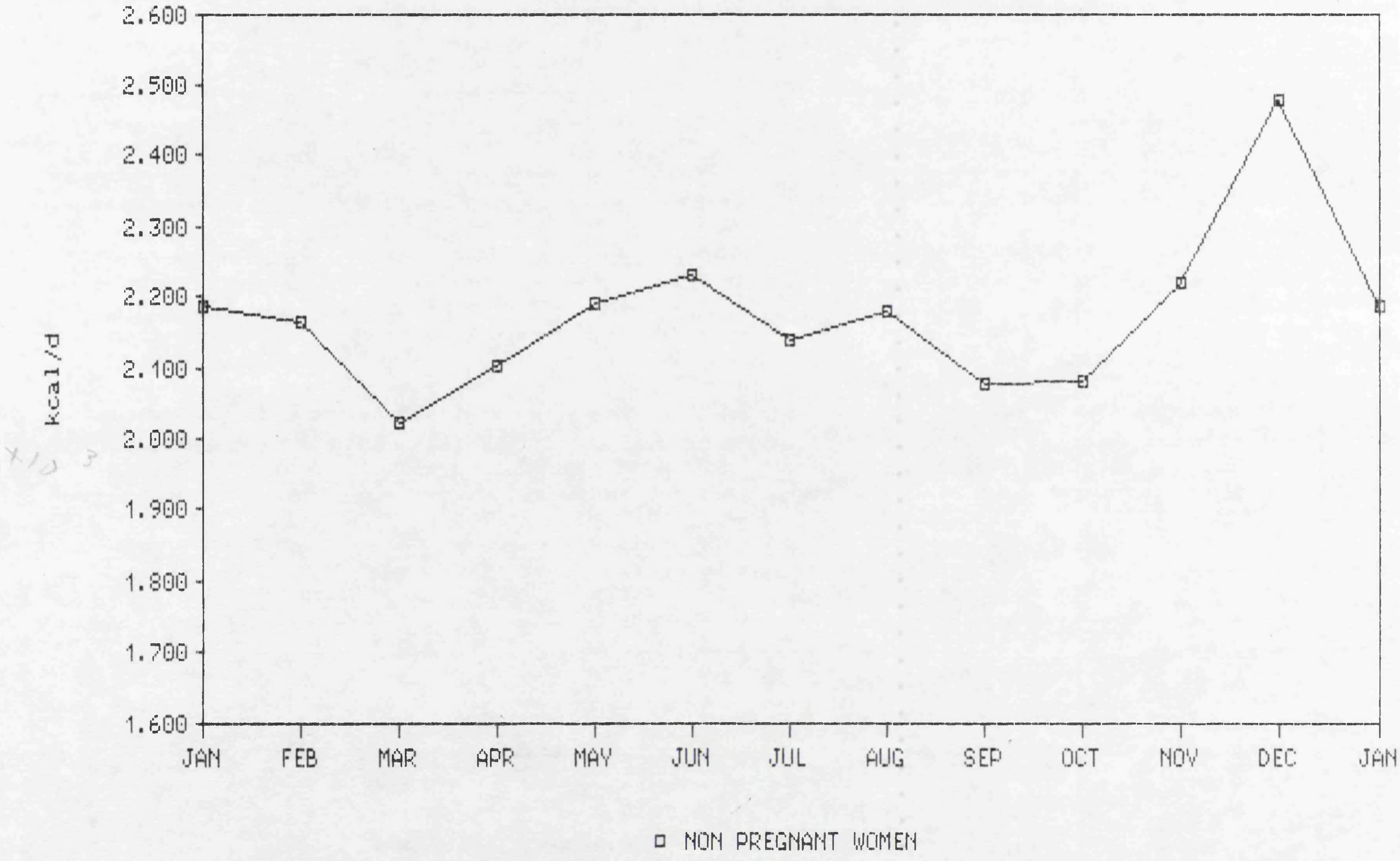
It was decided to group all the data intake of the 90 non-pregnant (see **FIG. 3.1**)women by month of the year to see whether or not there was any effect of the seasonal variation in energy expenditure on the energy intake of rural farmers. If there were seasonal variations in the group their energy intake should be reduced during February till April and increased during May to September and in December. **FIG.4.5** shows that the mean energy intake changed at different times of the year. There was a tendency to a higher energy intake only in December when Thai farmers have to work hard in harvesting. This may be associated with the availability of food during this period. In addition, the farmers may get extra income from the sale of their crops with an increase in their purchasing power and so can buy extra food for consumption.

TABLE 4.3 ESTIMATED ENERGY REQUIREMENTS OF NON PREGNANT WOMEN*

MONTH	TYPE OF WORK	BMR FACTOR	ENERGY REQUIRMENTS* kcal/d	MJ/d
JANUARY	MODERATE WORK	1.64	1,990	8.3
FEBRUARY	LIGHT WORK	1.56	1,890	7.9
MARCH	LIGHT WORK	1.56	1,890	7.9
APRIL	LIGHT WORK	1.56	1,890	7.9
MAY	HEAVY WORK	1.82	2,208	9.2
JUNE	HEAVY WORK	1.82	2,208	9.2
JULY	HEAVY WORK	1.82	2,208	9.2
AUGUST	HEAVY WORK	1.82	2,208	9.2
SEPTEMBER	HEAVY WORK	1.82	2,208	9.2
OCTOBER	MODERATE WORK	1.64	1,990	8.3
NOVEMBER	MODERATE WORK	1.64	1,990	8.3
DECEMBER	HEAVY WORK	1.82	2,208	9.2
MEAN			1,916	8.0

* Estimated from the equation of FAO/WHO/UNU (1985)

FIG.4.5 EFFECT OF SEASONAL VARIATION ON ENERGY INTAKE

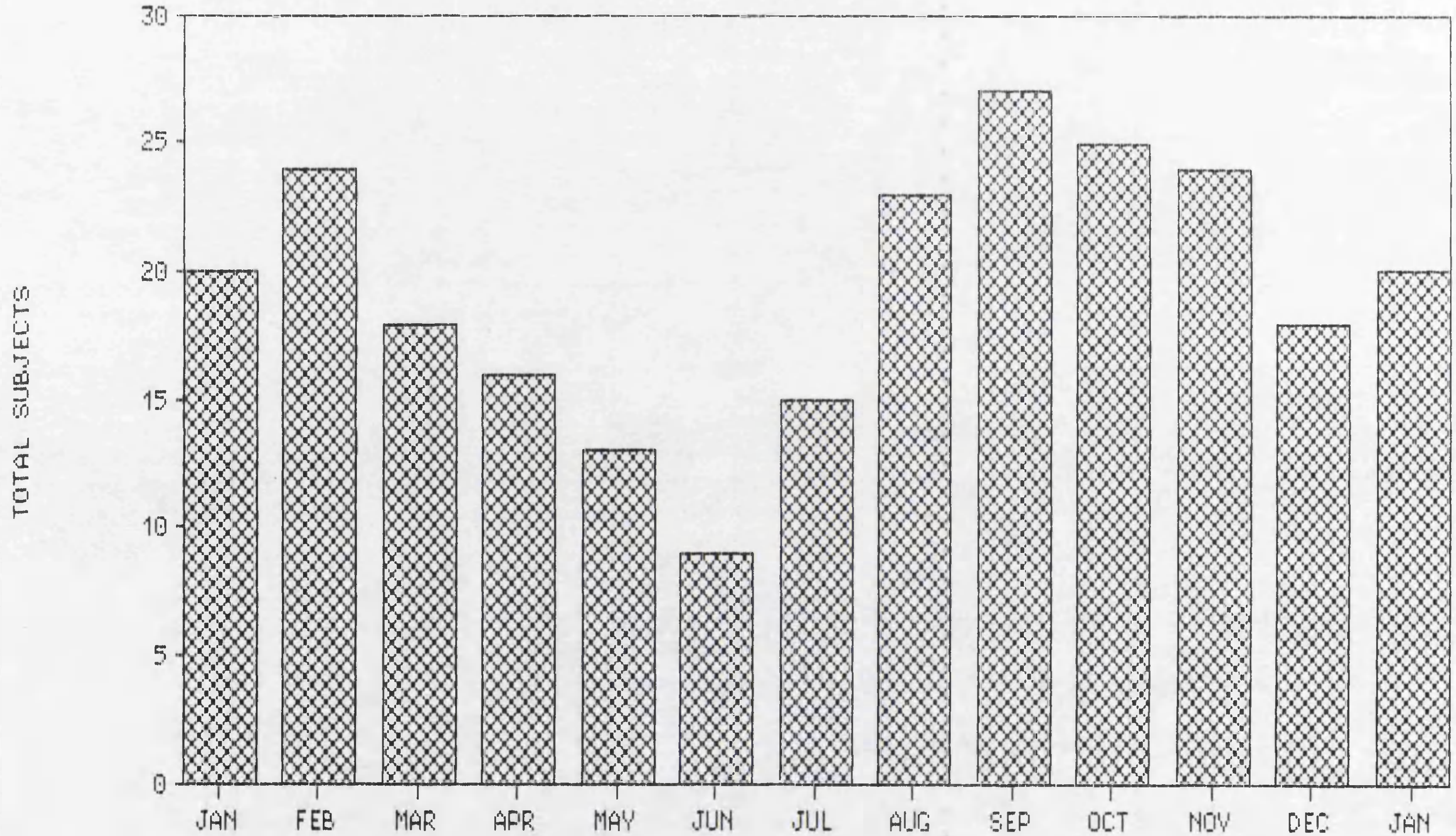


However,if the pattern of energy intake changed by month of the year (**FIG.4.5**) is true, it might be that if the total number of recruited women during non-pregnancy was greater in December (when they worked very hard and had high energy intakes) the initial base-line value of this study might also be high and might affect the over-all result. **FIG.4.6** presents the total number of non-pregnant women recruited by month of the year and shows that the total number of women recruited in December was similar to those of other months and so the average base-line value (2,170 kcal/d or 9.0 MJ/d) is not affected by this.

4.2.5 Uncontrolled influences on food intake

In this longitudinal study, each of the volunteers had food intake measured on about 12 occasions or 60 days during pre-pregnancy and pregnancy. It is possible that there might have been an interaction between the volunteer and the observer which might have influenced food consumption habits. For example, during the first period of measurement both the observer and the volunteer might pay more attention to details of the study which might have altered as the interaction between them progressed. Also increased experience of using the weighing scale might have influenced the data collection. It is difficult, however, to test the effect of observer bias, or error of self weighing. However, it was decided to compare the energy intake of 62 women who had one interview each month for

FIG.4.6 TOTAL NUMBER OF NON PREGNANT WOMEN RECRUITED EACH MONTH



3 consecutive months during the pre-pregnant stage to assess variation in food intake. **TABLE 4.4** shows the average energy intake during each of the 3-period pre-pregnant stages. The mean energy intake of 62 women in the first interview was 2,137±391 kcal/d (8.9±1.6 MJ/d); 2,132±420 kcal/d (8.9±1.7 MJ/d) in the second measurement and 2,137±390 kcal/d (8.9±1.6MJ/d) in the third period. There was no significant difference between the three interviews. It appears that food consumption was probably not affected by the increased experience of the volunteers and the progressive interaction of volunteer and observer.

4.2.6 Energy intake: influence of morning sickness

During the first three months of pregnancy, some women have morning sickness with actual vomiting and loss of appetite, while in others the symptoms are reduced to only a sensation of nausea. The causes of morning sickness are not well understood and it is suspected that it may be related to hormonal imbalance due to changes during this period. Smithells et al.(1977) studied energy intake during the first trimester of 177 pregnant women and grouped the women according to the degree of their symptoms of morning sickness; 1) no nausea or sickness, 2) nausea only, 3) sick not more than 3 days/week and 4) sick more than 3 days/week. They suggested that among the four groups, those who had no morning sickness had the highest energy intake while the fourth group with morning sickness of more than

TABLE 4.4 COMPARISON BETWEEN THE FIRST 3 INTERVIEWS OF INTAKE OF NON-PREGNANT WOMEN

N = 62	kcal/d		MJ/d	
	MEAN	SD	MEAN	SD
1ST PERIOD	2,137	391	8.9	1.6
2ND PERIOD	2,132	420	8.9	1.7
3RD PERIOD	2,137	390	8.9	1.6

3 days/week had the lowest energy intake which was significantly different from the first group. In the present study, it was observed that there was a reduction in energy intake during the first trimester even though there was no obvious recording of morning sickness.

4.3 EFFECT OF ENERGY INTAKE ON INFANT BIRTH WEIGHT

4.3.1 Energy increment and birth weight

According to Hytten & Leitch(1971), the weight of the fetus increases at the maximum by about 55% during the third trimester and so it is interesting to know whether the mother who greatly increases energy intake during this period produces a bigger baby. The pregnant women were divided according to the difference in their average energy intake during the third trimester and the base-line values. The 24 pregnant women who did not have data collected during the pre-pregnant stage were excluded from this analysis. The average energy intake during the third trimester of 63 pregnant women was 76 kcal (318 kJ) higher than the base-line value. The calculated value of the lower quartile (the 25th percentile) and the upper quartile (the 75th percentile) of these pregnant women were found to be -162 kcal (-678kJ) and 346 kcal (1448kJ) respectively. Then, it was decided to compare the outcome of the two groups of mothers: the first group referred to as group A are the mothers whose energy intake increased more than 346 kcal (1,448kJ) and the second group referred to as group B are the mothers who decreased their energy intake during the last trimester more than 162 kcal (678kJ) below the base-line values. **FIG.4.7** confirms that these two groups are completely different in pattern of changes of energy intake. In group A, a marked increase in energy intake was observed during the second and third trimesters while group B showed a sharp reduction of energy intake during the first trimester then increased during the second trimester and during the third trimester energy intake was slightly reduced. **TABLE 4.5** shows that these two groups of mothers who were similar in age and height, became pregnant with differences in their initial body weight in which those in group B were significantly heavier than those in group A ($P<0.001$). The weight at full term of these two groups were the same and the weight gain of group A was about twice more than those of group B. The difference is statistically significant ($P<0.001$). The babies of these two groups were delivered at similar gestation weeks but the babies produced by group A were slightly heavier and slightly increased in length more than the babies produced by group B. These differences are however not statistically significant.

This finding seems to show that the mothers with initial lighter body weight, when they became pregnant

FIG.4.7 CHANGES OF ENERGY INTAKE IN GROUPS WHICH INCREASED AND DECREASED OF ENERGY INTAKE

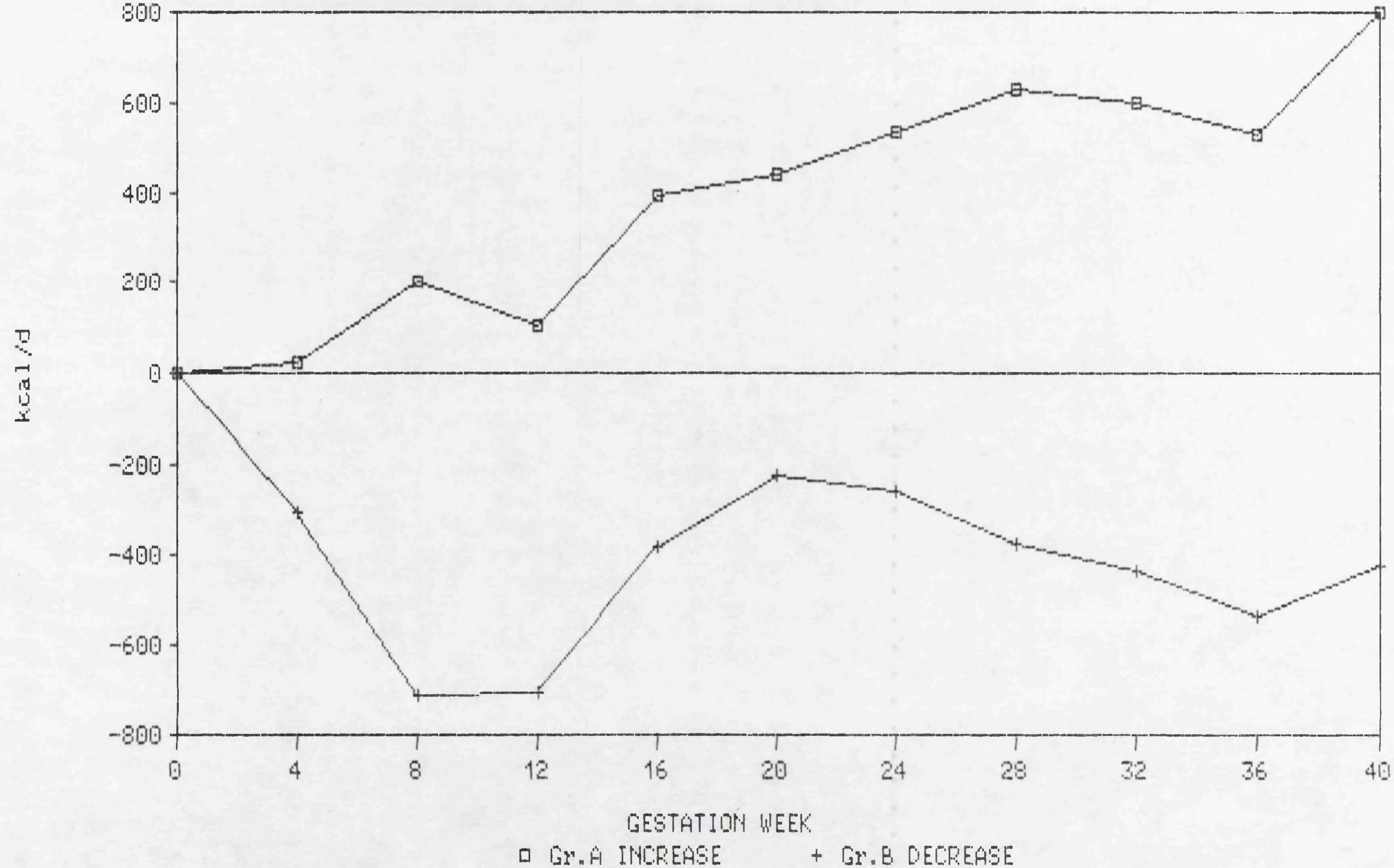


TABLE 4.5 COMPARISON OF GENERAL CHARACTERISTICS AND THE OUTCOME OF PREGNANCY BETWEEN WOMEN WHOSE ENERGY INTAKE INCREASED AND THOSE DECREASED DURING THE 3RD TRIMESTER

	GROUP A INCREASED ENERGY INTAKE		GROUP B DECREASED ENERGY INTAKE	
	MEAN	SD	MEAN	SD
N	16		16	
AGE (yr)	21.5	2.2	22.3	2.4
HEIGHT (m.)	1.53	0.03	1.53	0.03
BODY WEIGHT (kg)				
Base-line*	48.5	4.1	53.5	4.8[a]
At term	59.5	5.3	59.1	4.0
Weight gain	11.0	2.4	5.6	2.2[a]
GESTATION WEEK	39.7	1.5	39.4	4.3
BIRTH WEIGHT(g)	3,099	371	2,997	212
BIRHT LENGTH(cm)	49.8	1.7	49.1	1.4

* average weight before becoming pregnant

[a] significant difference $p < 0.001$

have to consume much more in order to increase their body weight and produce about 3 kg babies while those with initial heavier body weight do not.

Some studies have been carried out to test that energy supplementation during pregnancy has an effect on birth weight. Mora et al., (1979) suggested that food supplementation during the last trimester of pregnancy in women who had high risk of malnutrition had a significant effect on the birth weight of male infants. However, in some population (Prentice, et al., 1983), food supplementation had no beneficial effect on birth weight of Gambian women in dry season but only in the wet season, when the pregnant women were normally in marked negative energy balance due to food shortages and a high agricultural work load, when supplementation improved birth weight.

4.3.2 Are big babies the result of high increment of energy intake?

In this study, 87 pregnant mothers produced babies of an average birth weight of 2.98±0.39 kg (range 2.17 kg to 3.85 kg). It is desired to know whether or not the big babies were produced from the mothers who increased their energy intake during pregnancy. In order to prove this, two distinct groups were compared. The first group were the group of pregnant women who produced birth weight between 3.37 kg (mean +1s.d) and 3.76 kg (mean +2s.d) and the second group were the ones whose baby weight were between 2.59 kg (mean -1s.d) and 2.20 kg (mean -2s.d). These two groups gave different birth weights and baby length ($p<0.001$). **TABLE 4.6** compares the general characteristics of these two groups which were similar in age. Height and weight before becoming pregnant (weight at base-line) of the mothers who produced bigger babies was 1.52±0.04m and 47.5±4.0kg respectively both of which were slightly greater than those of the mothers whose babies were smaller. Moreover, the mothers of bigger babies had more weight gain than the mothers who produced small babies. However, statistically significant difference was observed only in weight at term of which the mothers of bigger babies was about 5kg heavier than that of the mothers who produced small babies($P<0.05$). Their changes of energy intake shown in **FIG.4.8** were similar except for their energy intake during the 4th week. This was a as result of a small number during 4 gestation weeks: only one subject in the group of high birth weight and 5 subjects in low birth weight group.

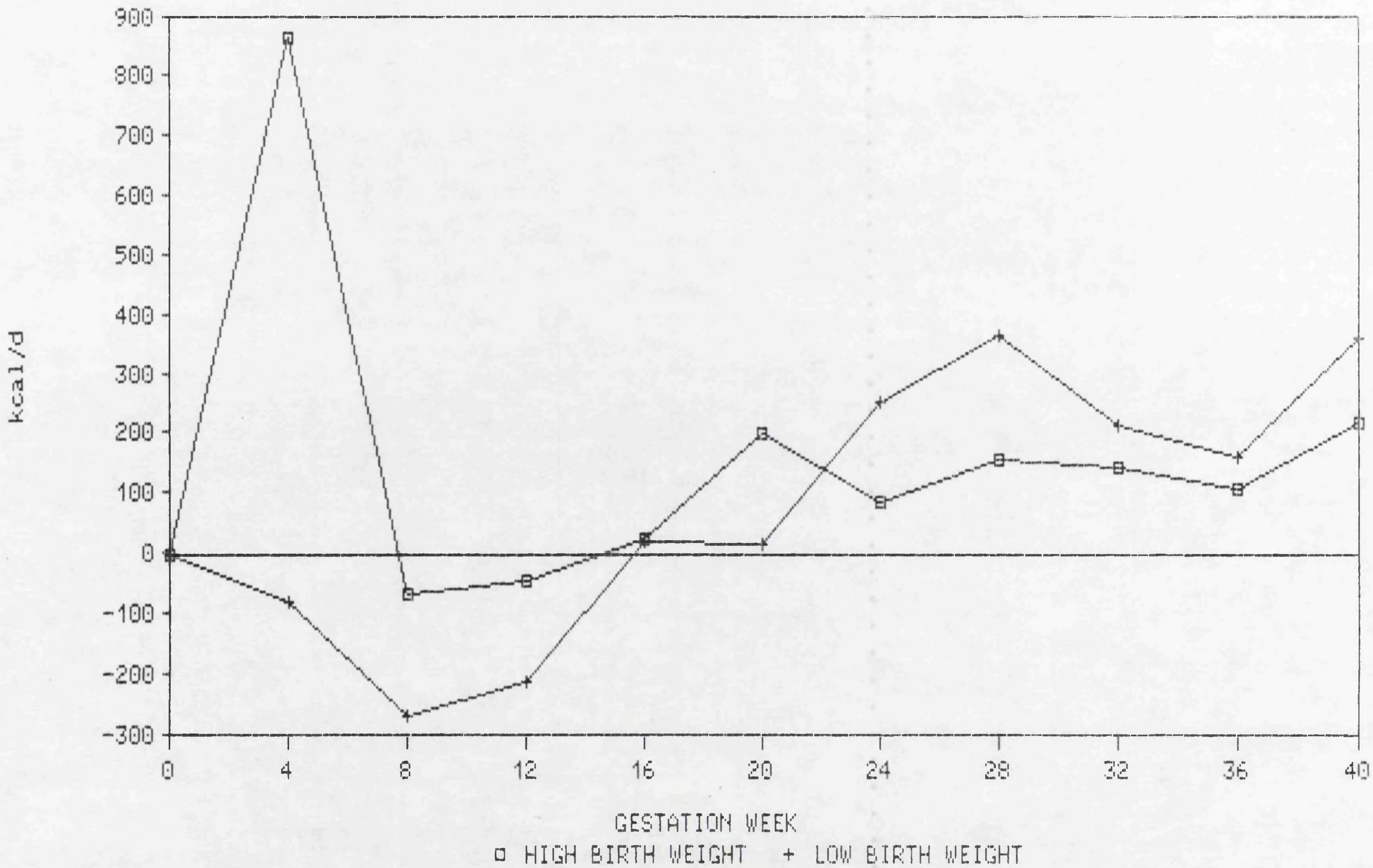
The cause of producing difference in birth weight of these two groups may be of genetic factor. It is reasonable to expect that the bigger mothers would have bigger babies (Hytten and Leitch, 1971). Several studies found a positive relationship between the birth weight and initial maternal body weight (Winikoff and Debrovner, 1981; Abrams and Laros, 1986; Rössner and Öhlin, 1990).

TABLE 4.6 COMPARISON OF GENERAL CHARACTERISTICS BETWEEN THE GROUPS OF THE MOTHERS WHO GAVE HIGH AND LOW BIRTH WEIGHT INFANTS

	MOTHER WHO GAVE			
	HIGH ~~HEIGHT~~ BIRTH WEIGHT (3.37kg-3.76kg)		LOW BIRTH WEIGHT (2.59kg-2.20kg)	
	MEAN	SD	MEAN	SD
N	13		13	
AGE (yr)	23.2	3.2	23.8	2.8
HEGIHT (m)	1.52	0.04	1.51	0.06
BODY WEIGHT(kg)				
At base-line*	47.5	4.0	46.4	6.8
At term	57.0	5.8	52.2	5.5[a]
weight gain	9.5	3.7	7.9	2.4
GESTATION WEEK	39.5	0.9	39.2	1.4
BIRTH WEIGHT (g)	3,550	132	2,452	97[b]
BIRTH LENGTH (cm)	50.6	2.2	46.8	1.3[b]

* average weight before becoming pregnant
a significant difference $p < 0.05$
b significant difference $p < 0.001$

FIG.4.8 CHANGES OF ENERGY INTAKE IN GROUPS WHICH PRODUCED HIGH AND LOW BIRTH WEIGHT OF BABIES



In conclusion, high increment of energy intake during pregnancy may be one of the factors producing big babies but there are also numerous conditions which probably interfere with the interpretation of the result. In this study, there was a great reduction of energy intake during the first trimester. However, it is possible that the extra energy needed for the development may be small. In addition, pregnant women in this period may reduce their activity in order to save their energy. For example, some women who used to migrate to work in the city during dry season stay at home when they become pregnant as it becomes difficult for them to get jobs and also uncomfortable for the pregnant women to go to work in the city. It is thus possible that the energy expenditure is reduced during pregnancy.

CHAPTER 5

MATERNAL BODY COMPOSITION

Anthropometric measurements were used in this study to analyse the outcome of pregnancy. They are presented in terms of body weight and fat-free mass and fat changes. Weight changes during pregnancy were measured by using calibrated scales which were given to every volunteer, and fat changes were estimated by skinfold thickness measurement carried out by a technician. The same technical staff carried out all the skinfold measurements to avoid observer error. One woman who gained 23 kg of weight was excluded from this data analysis because she had signs of mild eclampsia during the third trimester.

RESULTS

5.1 WEIGHT

5.1.1 Weight changes

The pattern of weight changes is shown in **FIG.5.1** and **TABLE 5.1**. There is a slight drop of body weight during the first trimester. By the twelfth week of gestation the average weight loss was about 1.4 kg which is an unusual finding. This will be explained in the discussion. There was a rapid increase in weight from the 16th to the 28th

FIG. 5.1 CHANGES OF BODY WEIGHT
MEAN (kg)

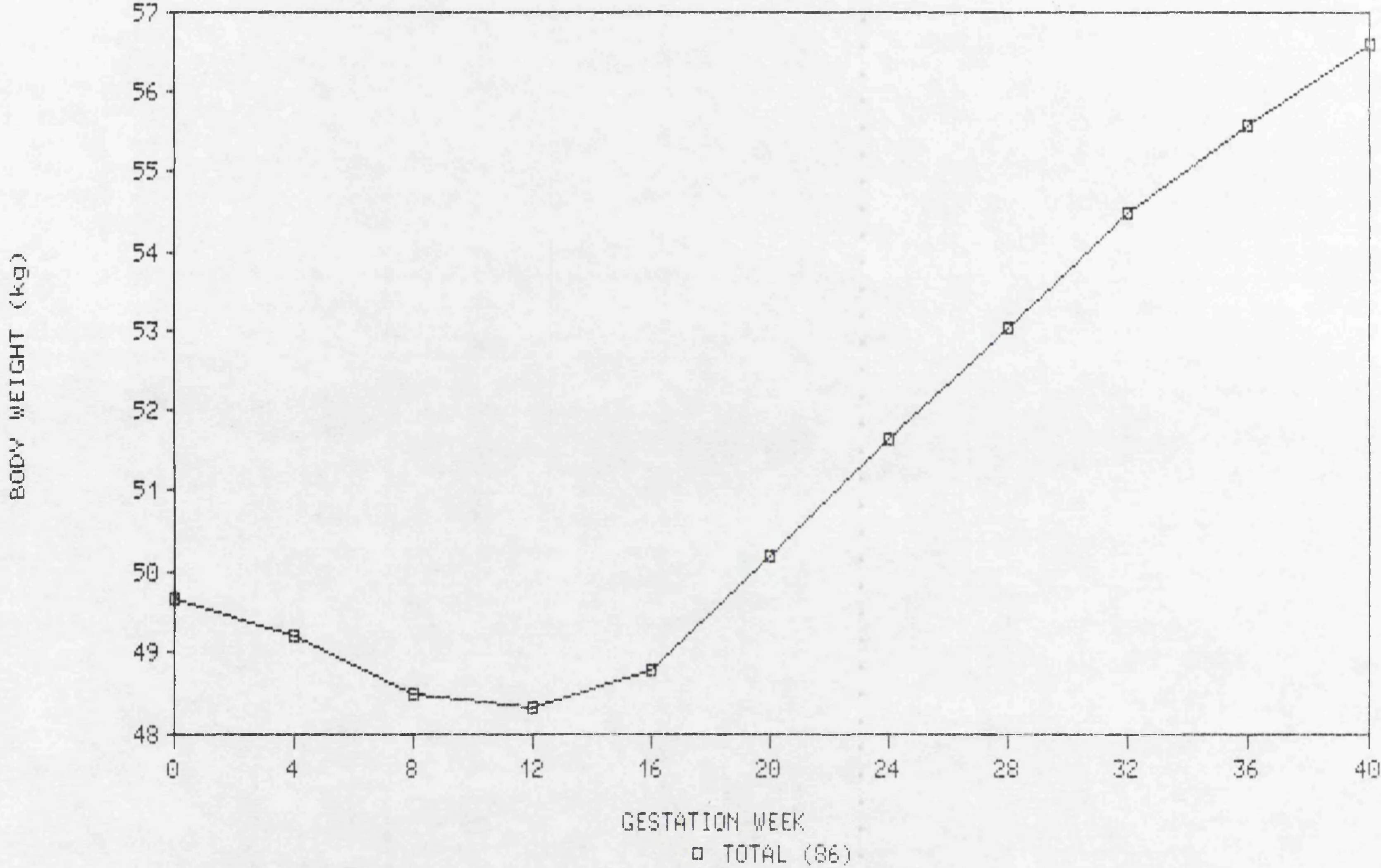


TABLE 5.1 MATERNAL WEIGHT CHANGES (kg)

GESTATION WEEK	N	BODY WEIGHT	SD.	CV%
0	63	49.7	5.9	11.9
1 - 4	32	49.2	6.2	12.6
5 - 8	70	48.3	5.7	11.8
9 - 12	81	48.3	6.0	12.4
13 - 16	83	48.8	5.6	11.5
17 - 20	82	50.2	5.6	11.2
21 - 24	86	51.6[a]	5.7	9.9
25 - 28	86	53.0[b]	5.6	10.6
29 - 32	86	54.5[c]	5.7	10.4
33 - 36	86	55.6[c]	5.7	10.2
37 AND ABOVE	62	56.7[c]	6.1	10.8

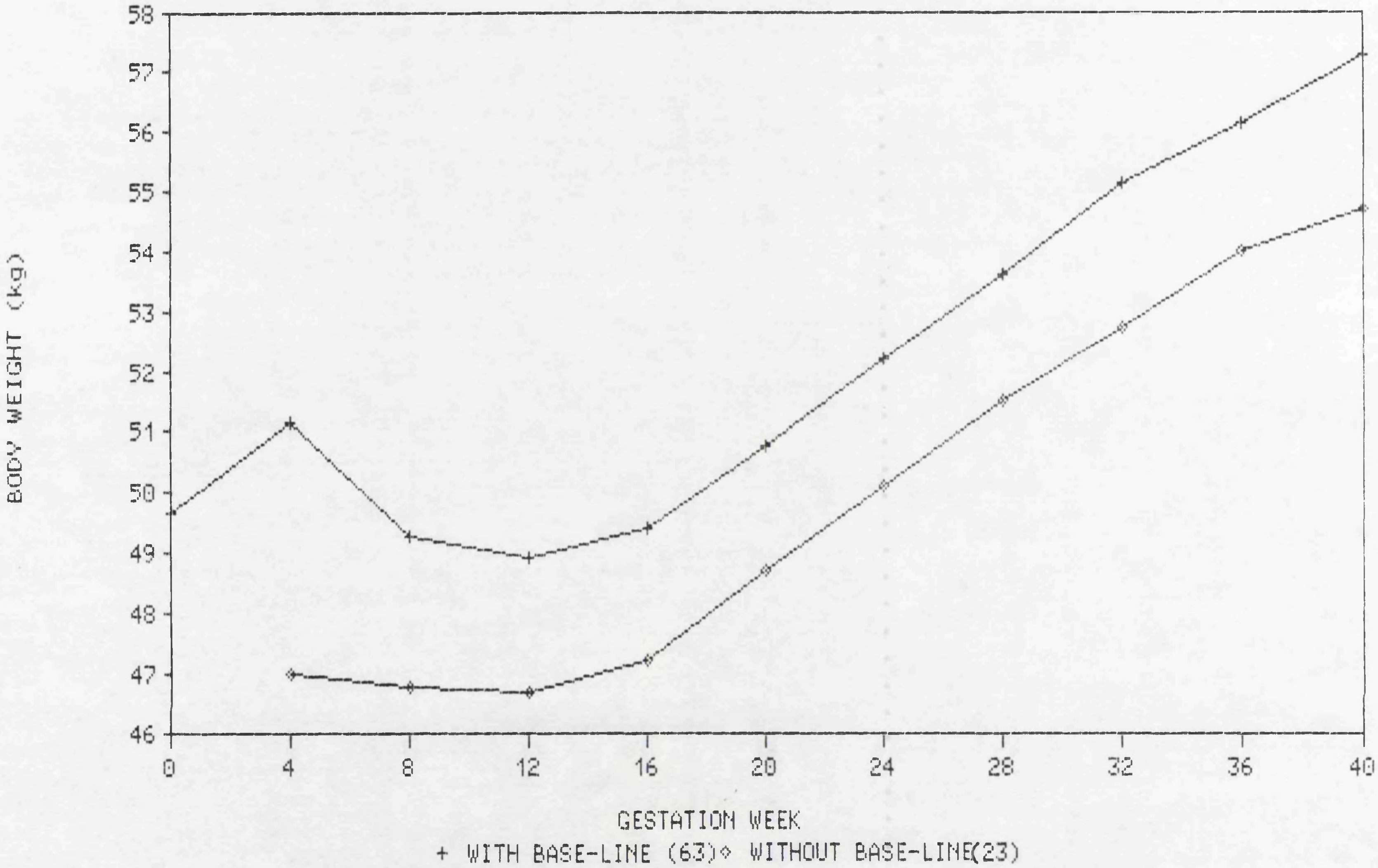
a significant difference from 0 wk $p < 0.05$
b significant difference from 0 wk $p < 0.005$
c significant difference fron 0 wk $p < 0.001$

week when the weight increase was at the maximum rate of about 0.36 kg per week. Thereafter the rate of weight gain decreased to about 0.28 kg per week from the 32nd to the 40th week of gestation. Only after the week 20 were there significant differences from weight at pre-conception.

5.1.2 Weight gain

The average weight before becoming pregnant of 63 women was 49.7±6.0 kg and the average weight at full term all of women was 56.7±6.1 kg. Therefore, the weight gain in this study could be calculated by the difference between the average weight at full term and the average weight at pre-conception (56.7-49.7) which was found to be 7.0 kg. However, a variation of body weight between individuals which was calculated by coefficient of variation (CV% from **TABLE 5.1**) was found to range from 10%-13%. This shows that this weight gain (7.0 kg) may be over- or under-estimated because of some missing base-line values of 23 pregnant women. **FIG. 5.2** compares the changes of body weight between 63 pregnant women who had base-line values (weight at pre-conception) and 23 pregnant women who had no base-line values. These two groups had similar pattern of changes of body weight. There was a peak of body weight of the group of 63 pregnant women during the 4th week of gestation which may be the result of small number of samples (only 16 pregnant women). **FIG. 5.2** also shows that the group of 63 pregnant women who had base-line values

FIG.5.2 COMPARISON OF BODY WEIGHT BETWEEN WOMEN WHO HAD BASE-LINE VALUES AND THOSE WHO HAD NO BASE-LINE VALUES



were heavier than the group of 23 pregnant women who had no base-line values and so this average weight before becoming pregnant (49.7 kg) was probably rather too high for the total 86 pregnant women in this study. It was more accurate to calculate the weight gain in this study by calculating the mean individual differences of body weight from weight at pre-conception and weight at full term of 63 pregnant women. As a result the average weight gain of these pregnant women was found to be 7.8±3.5 kg. It was found that the range of weight gain in this study was wide, from 1 kg to 17 kg.

5.2 FAT

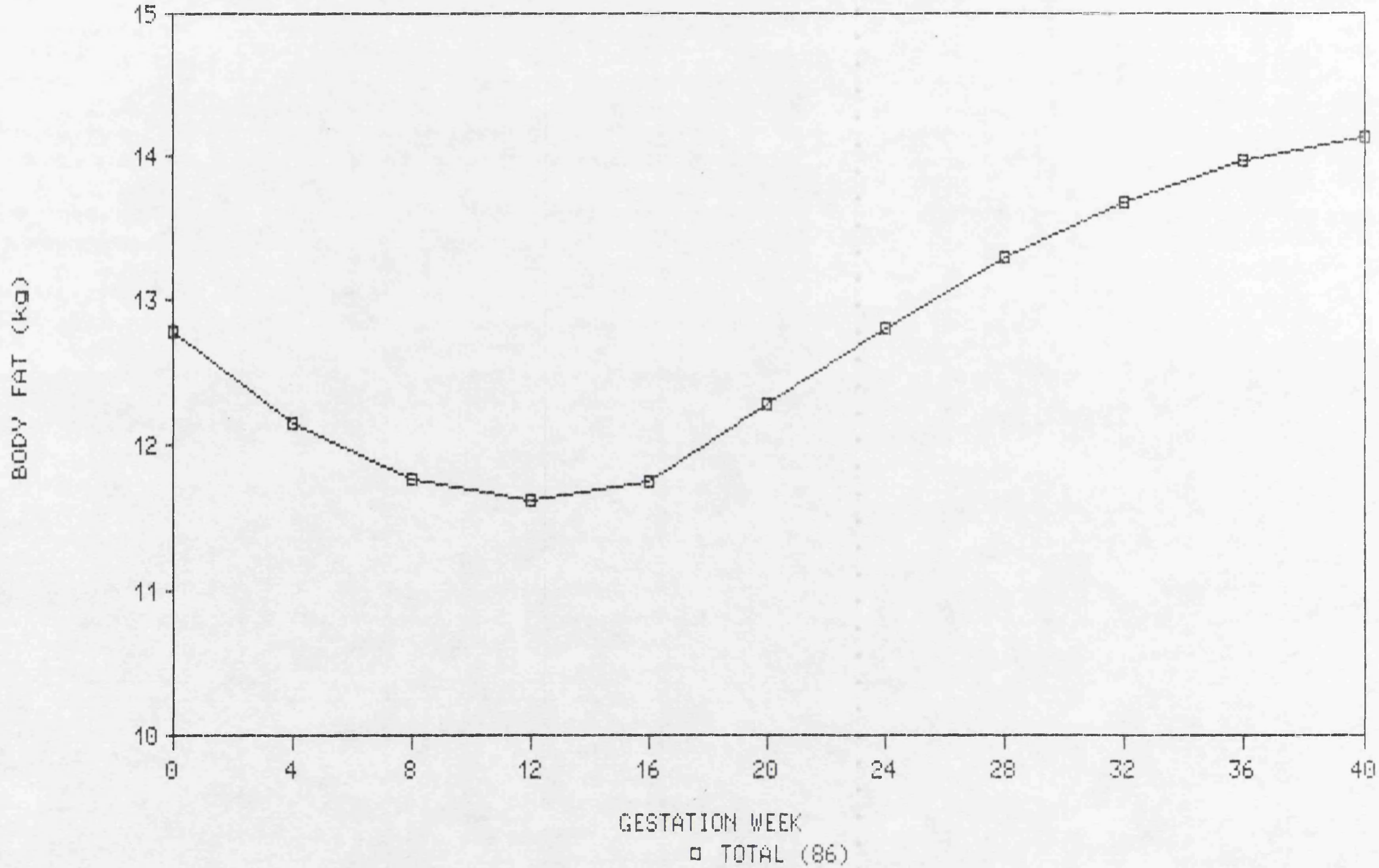
5.2.1 Fat changes

The results of body fat are presented in **TABLE 5.2** and the trends of fat change are quite similar to the pattern of the weight change as shown in **FIG.5.3**. The average body fat at pre-conception which is referred to as the body fat at 0 week in **TABLE 5.2**, is 12.8±3.3 kg. These pregnant women lost about 1.2 kg of body fat during the first trimester because of reasons which will be examined in the discussion. Body fat dropped to the lowest at the week 12 and then increased throughout the rest of pregnancy. However, there were no statistically significant changes in body fat which are as a result of high standard deviation and the calculated coefficient of variation (CV% from **TABLE 5.2**) which was found to range from 22- 29%.

TABLE 5.2 MEAN MATERNAL FAT CHANGES (kg)

GESTATION WEEK	N	BODY FAT(Kg)	SD	CV%
0	63	12.8	3.3	25.8
1 - 4	32	12.2	3.6	29.5
5 - 8	70	11.8	3.2	27.1
9 - 12	81	11.6	3.3	28.4
13 - 16	83	11.8	3.0	25.4
17 - 20	82	12.3	2.9	23.6
21 - 24	86	12.8	3.1	24.2
25 - 28	86	13.3	3.0	22.6
29 - 32	86	13.7	3.1	22.6
33 - 36	86	14.0	3.1	22.1
37 AND ABOVE	62	14.1	3.3	23.4

FIG. 5.3 CHANGES OF BODY FAT
MEAN (kg)



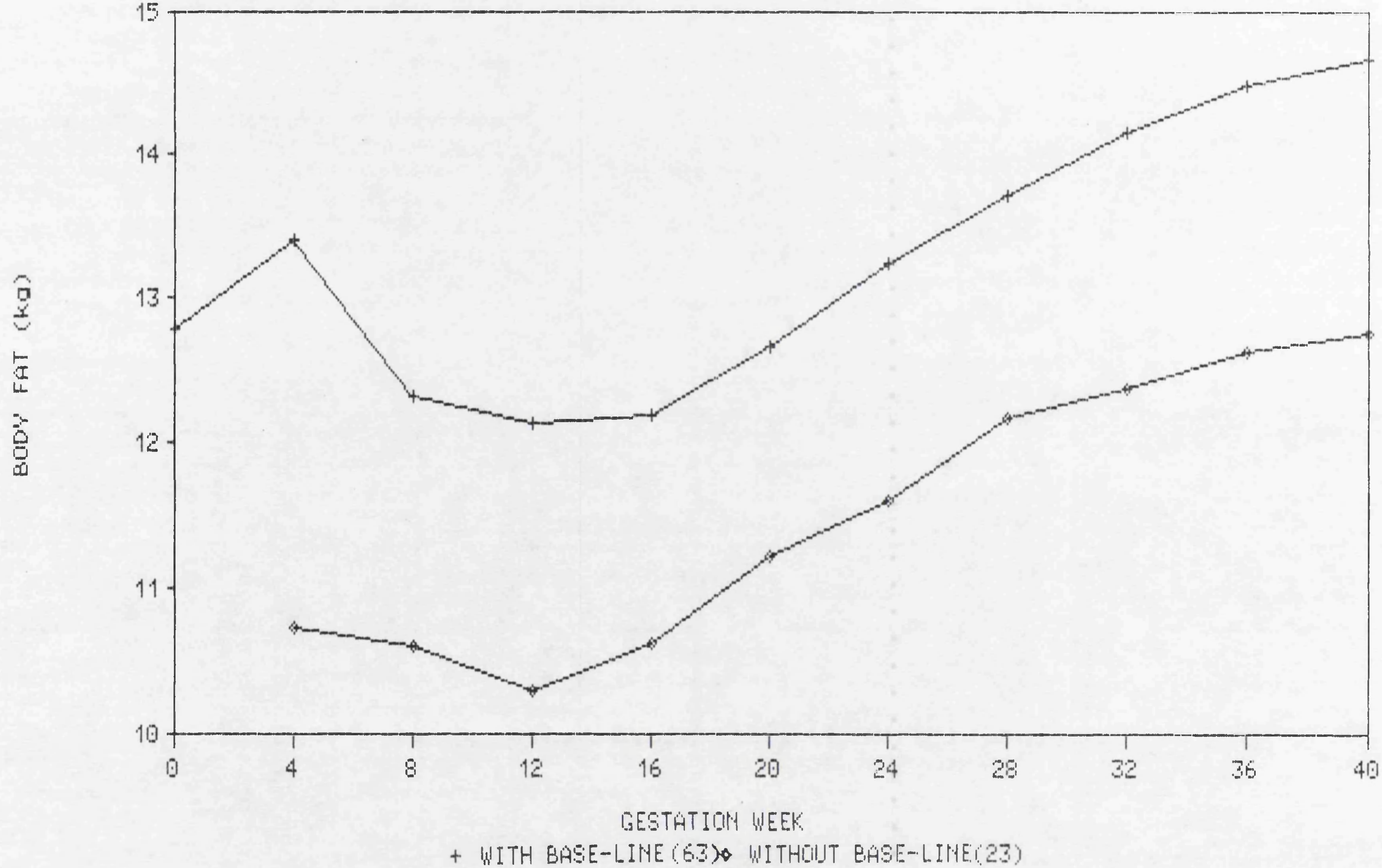
5.2.2 Some missing values

There were 23 pregnant women who had no data recorded before becoming pregnant. **FIGs 5.2** and **5.4** show the body weight and body fat of the group of 63 pregnant women who had base-line values and the other group of 23 pregnant women who had no base-line values. These seem to show that the 23 pregnant women who had no base line measurements have low fat and low weight compared to the other 63 pregnant women who had base-line measurements. In addition, there were large variations between individuals as the reason mentioned above and so they might have apparently higher values before conception. In order to reduce this error it is necessary to estimate some missing values.

5.2.2.1 Estimated base-line values (pre-conception values)

There were 23 pregnant women who had no base-line values and started the first interview in different gestation weeks: 15 pregnant women started from the fourth week of gestation while the other 8 pregnant women started from the week 8. By using the pattern of changes from the ones who had base-line values, it was decided to estimate the base-line values as follows:

FIG.5.4 COMPARISON OF BODY FAT BETWEEN WOMEN WHO HAD BASE-LINE VALUES AND THOSE WHO HAD NO BASE-LINE VALUES



- The 15 pregnant women

There were 15 women who had no pre-conception measurements. In order to assign missing values for them, data were used from 17 pregnant women who had measurements at week 0 (at pre-conception) and week 4. The mean individual differences between these period was calculated. The results show that weight at 4 weeks was 0.4 kg higher than at week 0 while fat at the 4th week was 0.1 kg lower than week 0. The apparent increase in body weight of 0.4 kg may be a result of day to day fluctuation in body fluid and the small sample size. The apparent reduction in body fat of 0.1 kg is small enough to be the result of variability between and within individuals and also the result of methodological error. These 15 pregnant women, therefore had their weight at pre-conception estimated by subtracting 0.4 kg from their value at week 4 and their fat at pre-conception by adding 0.1 kg to their value at week 4 of gestation.

- The 8 pregnant women

There were 8 pregnant women who were first interviewed at the 8th week, Their missing values at pre-conception stage were estimated from 48 pregnant women who had weight and fat recording at week 0 and week 8 of gestation. Calculations of mean individual differences of weight and fat between pre-conception and the 8th week of gestation were performed. The results show that both weight and fat at 8 weeks of gestation were 0.5 kg lower than at pre-conception. The estimated base-line values of these 8 pregnant women therefore, were calculated by adding 0.5 kg to each value of weight and fat at the 8th week of gestation.

TABLE 5.3 summarizes the methods used to estimate the base-line values of 23 pregnant women. The average of weight and fat of 86 pregnant women which were calculated from 63 pregnant women and 23 estimated values are shown in **TABLE 5.4**. The average estimated weight and fat of 86 pregnant women are 48.9±6.1kg and 12.3±3.3 kg respectively which are slightly lower than the average values from 63 pregnant women who had values before becoming pregnant. It is probably more accurate to use the estimated base-line value rather than the base-line value from the 63 pregnant women as mentioned above.

5.2.2.2 Estimated values at 4-6 weeks post-partum

The other points which are important in estimating fat gain are body weight and body fat at 4-6 weeks post-partum. Follow up study was only possible in 51 lactating mothers; the other 35 mothers were lost to follow up after 1-2 days post-partum. The average of weight and fat at full term of all pregnant women in this study was 56.7±6.1 kg and 14.1±3.3 kg respectively while those of 51 pregnant women who had data during 4-6 weeks post-partum was 56.6±5.6 kg and 14.1±3.1 kg respectively. This shows that weight and

TABLE 5.3 METHOD USED TO ESTIMATE MISSING VALUES

EQUATION FOR ESTIMATED MISSING VALUES

ESTIMATED BASE-LINE VALUES OF 23 PREGNANT WOMEN

15 PREGNANT WOMEN WHO STARTED AT 4 WEEK

Mean wt (at 4wk - at 0wk) = + 0.4 (n = 17)
Estimated wt at 0wk = wt(at 4wk) - 0.4

Mean fat (at 4wk - at 0wk) = - 0.1 (n = 17)
Estimated fat at 0wk = fat(at 4wk) + 0.1

8 PREGNANT WOMEN WHO STARTED AT 8 WEEK

Mean wt (at 8wk - at 0wk) = - 0.5 (n = 48)
Estimated wt at 0wk = wt(at 8wk) + 0.5

Mean fat (at 8wk - at 0wk) = - 0.5 (n = 48)
Estimated fat at 0wk = fat(at 8wk) + 0.5

ESTIMATED VALUES AT 4-6 WK POST-PARTUM OF 35 LACTATING MOTHERS

Mean wt(at 4-6wk postpartum - at 1-2d postpartum) = 2.2 (n =51)
Estimated wt at 4-6wk postpartum = wt(at 1-2d postpartum)-2.2

Mean fat(at 4-6wk postpartum - at 1-2d postpartum) = 0.6 (n =51)
Estimated fat at 4-6wk postpartum = fat(at 1-2d postpartum)-0.6

TABLE 5.4 ESTIMATED VALUES COMPARED WITH MEASUREMENT VALUES

	BODY WEIGHT (kg) MEAN	SD	BODY FAT (kg) MEAN	SD
AT PRE-CONCEPTION				
GROUP OF 63 PREGNANT WOMEN	49.7	5.9	12.8	3.3
ESTIMATED VALUES (n = 86)[a]	48.9	6.1	12.3	3.3
GROUP OF COMPLETED DATA (n = 35)[b]	49.8	5.6	12.9	3.3
AT 4-6 WEEKS POSTPARTUM				
GROUP OF 51 LACTATING MOTHERS	49.1	5.4	11.8	2.7
ESTIMATED VALUES (n = 86)[c]	48.9	5.4	12.1	2.8
GROUP OF COMPLETED DATA (n = 35)[b]	50.1	5.4	12.5	2.8

a = The average of weight or fat of 86 pregnant women which was calculated from 63 actual values and 23 estimated values

b = The average of weight or fat of 35 women who had data collected both during pre-conception and at 4-6 weeks post-partum

c = The average of weight or fat of 86 lactating women which was calculated from 51 actual values and 23 estimated values fat of these 51 women was slightly less than those of the total group of 86 women. Moreover, the weight and fat at 1-2 days post-partum of 51 women was 51.3±5.3 kg and 12.5±2.8kg respectively both of which were also less than those of 86 women who had weight and fat these time of 51.8±5.4kg and 12.7±2.9 kg respectively. The estimated fat gain in the later part which were calculated from the differences of weight and fat between at 4-6 weeks post-partum and at pre-conception, may not be accurate if these values at 4-6 weeks post-partum were averaged just from only 51 women. It is therefore, important to estimate the missing values of weight and fat at 4-6 weeks post-partum of the 35 women who were not possible to follow up. To estimate the missing values of the 35 lactating mothers, mean individual differences of weight and fat between 1-2 days post-partum and at 4-6 weeks post-partum of 51 lactating mothers were calculated. The average differences of weight and fat between 1-2 days post-partum and at 4-6 weeks post-partum were found to be 2.2 kg and 0.6 kg respectively in which the values at 1-2 days post-partum were higher than the values at 4-6 weeks post-partum as shown in **TABLE 5.3**. As a result of these, the missing values of 35 lactating mothers were estimated by subtracting 2.2 kg from their weight and 0.6 from their fat at 1-2 days post-partum. The average weight and fat of all the 86 lactating mothers are presented in **TABLE 5.4** and are found to be 49.8±5.4 kg and 12.1±2.8 kg respectively. These values were slightly more than those of the 51 women which are reasonable as mentioned above that the group of

51 women were rather smaller than the total group of 86 women.

In order to prove whether or not the estimated values are accurate, the 35 women who had complete data from pre-conception till 4-6 weeks post-partum were extracted from the total 86 women. **TABLE 5.4** shows that all estimated values compare well with the values from the 35 women. The weight and fat at pre-conception stage of all the 86 pregnant women which were averaged from 63 values of pregnant women who had base-line values and 23 estimated base-line values, were found to be 48.9±6.1kg and 12.3 ±3.3 kg respectively while these average values of the 35 pregnant women were 49.9±5.6 kg and 12.9±3.3 kg respectively. At 4-6 weeks post-partum, the estimated values of weight and fat of the 86 mothers which were averaged from 51 values of lactating mothers who were followed up and 35 estimated values, were 49.8±5.4 kg and 12.1±2.8 kg respectively while the average weight and fat of 35 lactating mothers who had complete data were 50.1±5.4 Kg and 12.5±2.8 kg respectively. **FIG.5.5** and **FIG. 5.6** show the pattern of changes of weight and fat during pregnancy of 86 women which were estimated from base-line values (at 0 week) compared with the group of 35 pregnant women who had complete values at base-line stage and 4-6 weeks post-partum. These two groups show the same pattern and the peak during the 4th week of gestation of 35 pregnant women may be as a result of a small number (n = 9).

FIG. 5.5 CHANGES OF BODY WEIGHT
MEAN (kg)

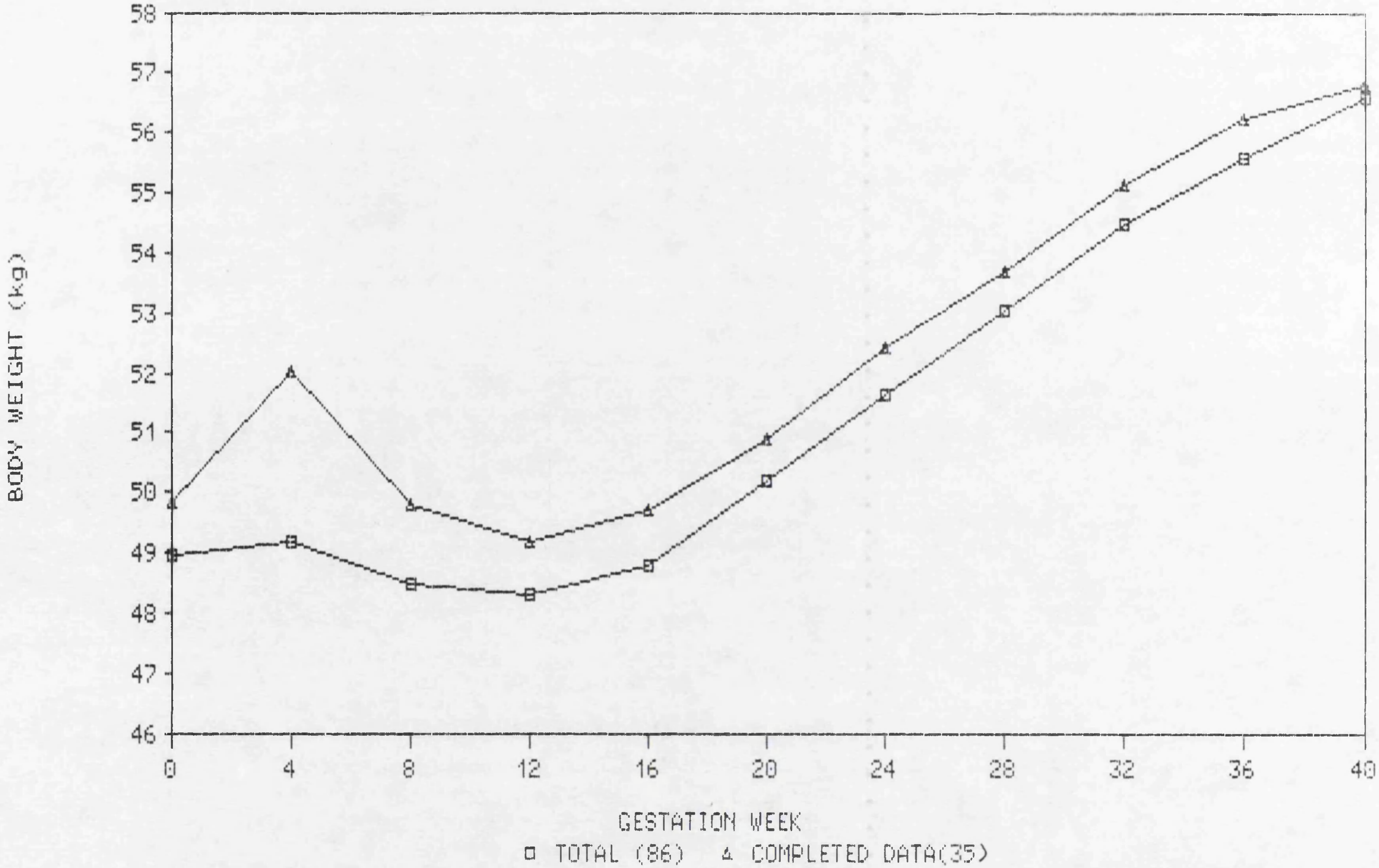
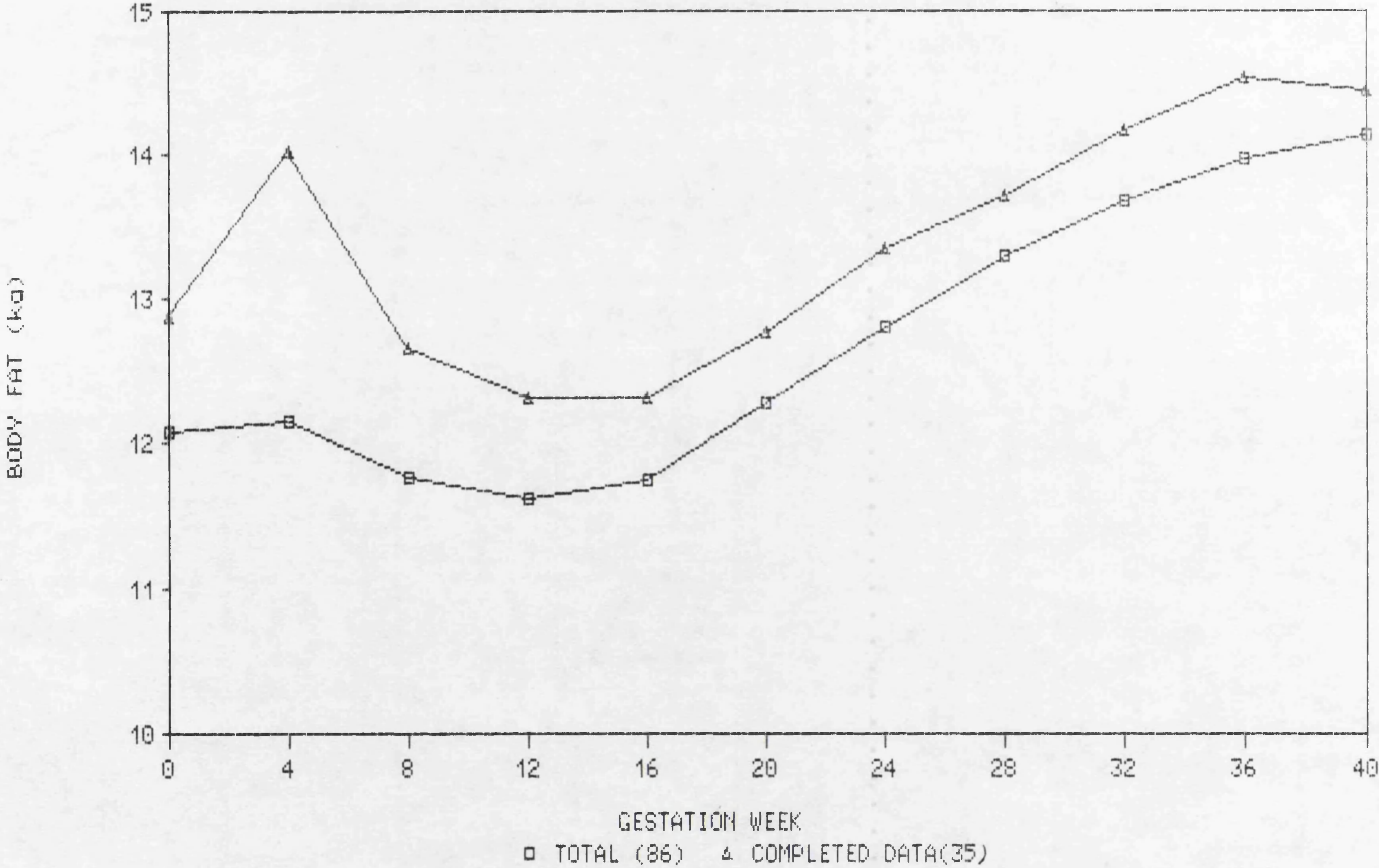


FIG. 5.6 CHANGES OF BODY FAT
MEAN (kg)



5.2.3 Fat gain estimation

Fat gain during pregnancy can not simply be calculated from the differences in weight gain between the values at term and before conception. The problem is due to the fact that body fat estimated at term might not be accurate enough because of water retention in the last trimester which might alter the density of fat free mass (Durning and Mckillop, 1988), leading to error of the calculation of body fat. Therefore, three indirect methods were used to calculate the changes of body fat during pregnancy as follows:

5.2.3.1 Estimation by the difference in fat at pre-pregnant and at 4-6 weeks post-partum

In this study, the logarithms of the summation of 4 sites of skinfold thicknesses (biceps, triceps, subscapular and suprailliac) were used to predict body density by the formula from the study of Durning and Womersley (1974) and then Siri's equation (1956) was used to estimate percentage of body fat. However, estimated fat during pregnancy, especially estimated fat at full term, might not be accurate because water retention during pregnancy might affect the density and percentage of body fat estimated by Siri's equation. In order to know the amount of fat gained during pregnancy, it was decided to calculate by the difference of body fat between pre-conception and 4-6 weeks post-partum.

The study of Pipe et al.(1979) showed that total body water of 27 lactating women return to early levels by 6-15 weeks post-partum. It is found that there was a rapid weight loss between 4 and 10 days post-partum which could be fluid (Lawrence et al.,1988) and the total amount of weight loss by 2 weeks post-partum was due to the combined weight of the fetus, placenta, extra blood and fluid as estimated by Hytten and Leitch (1971). In the third and fourth weeks weight loss was much more gradual. It was therefore assumed that the mother's body has returned more or less to normal at 4-6 weeks post-partum. At this time, the extra fluid and other reproductive tissues which may affect the skinfold equation, would have returned to the non-pregnant condition. Therefore it is assumed that the difference of fat between the pre-pregnant stage and 4-6 weeks post-partum may represent the fat store during pregnancy(Durnin and Mckillop,1988; Lawrence et al.,1988). The mean of estimated fatmass at the pre-pregnant stage is 12.3 kg and at 4-6 weeks post-partum the fatmass, as calculated from skinfolds measurements, is 12.1 kg (**TABLE 5.4**). The result of this study shows that these women lost 0.2 kg of their body fat throughout pregnancy: the reasons will be discussed later. The standard deviation for this fatmass change was however very high. In fact, there were 44 mothers who lost fatmass during pregnancy with the highest value being 5.3 kg; on the other hand, 42 mothers gained fatmass from 0.1 to 5.2 kg.

5.2.3.2 Estimation by the difference in weight at pre-pregnant and at 4-6 weeks post-partum

Calculation of the fatmass can be made from body weight at preconception and body weight at 4-6 weeks postpartum, when it is assumed that the total body water or the blood volume would have returned to the preconception values (as mentioned above). The difference between the values at preconception and at 4-6 weeks post-partum could be due to the increase in adipose tissue and breast tissue. According to Hytten and Leitch (1971), the increase in the mammary gland is about 0.4 kg and so subtraction of this value from the difference in weight at pre-conception and weight at 4-6 weeks post-partum will give the weight of adipose tissue.

From **TABLE 5.4**, it is shown that the estimated body weight at pre-conception of all the 86 pregnant women was 48.9 kg and at 4-6 weeks post-partum it was 49.8 kg. The mean individual of these two values is found to be 0.9 kg which means that this final extra weight is as a result of increase in adipose tissue and mammary gland. The adipose tissue weight is then estimated by subtracting the mammary gland weight increase (0.4 kg) from the difference between the weight at preconception and at 4-6 weeks postpartum which was found to be 0.5 kg (0.9-0.4). Adipose tissue consists of about 80% fat (Keys and Brozek, 1953) and so maternal fat store during pregnancy can be calculated by multiplying 0.8 with the weight of adipose tissue. The estimated fat gain by this method is therefore 0.4 kg of fat mass.

5.2.3.3 The factorial method

The factorial method of Hytten & Leitch (1971) can be used to calculate the increase in the fatmass by subtracting weights of all components of reproductive tissue during pregnancy such as, fetus, placenta, increase in size of uterus and breasts, volume of amniotic fluid, increase of blood volume ,etc, from weight gain during pregnancy, the difference being due to gain in adipose tissue.

In this study, it was not possible to estimate the weight of some of components of reproductive tissue; for example, uterus, mammary gland, extracellular and extravascular fluid which are used to estimate fat gain based on the factorial method. The work of Hytten & Leitch (1971) was carried out among women who are bigger in size and height than the average of Thai women and so a factor was used in the Thai study as follows: Since the average preconception weight of theoretical women is 56.0 kg (Hytten & Leitch,1971) and that for Thai women from this study is 48.9 kg a calculation factor of 48.9÷56.0 i.e 0.87 was therefore used to estimate the values of those components which could not be weighted in this study. Similarly the birth weights and placental weights from Hytten & Leitch (1971) and from this study were used to check the validity of this assumed calculation factor. From

Hytten and Leitch (1971) the average birth weight is 3.4 kg and placenta weight is 0.65 kg while from this study the values are 2.98 kg and 0.55 kg respectively. The calculation factor is thus $(2.98+0.55)\div(3.40+0.63)$ i.e. 0.87 which is similar to the calculation factor from the maternal weight at preconception. **TABLE 5.5** summarizes the estimated fat gain by the factorial method.

It is possible to estimate amniotic fluid and blood volume by the difference between maternal weight at term and weight at 1 day after delivery. This difference in maternal weight is due to the weight of fetus, placenta, amniotic fluid and blood and so amniotic fluid and blood volume can be estimated by subtracting the weight of the fetus and placental weight from the difference in maternal weight, thus weight of amniotic fluid + blood volume = weight at term - (weight at 1-2 days postpartum + weight of fetus + weight of placenta). This is estimated as 1.57 Kg by this method (**TABLE 5.5**)

Finally, the total weight of the components of reproductive tissue is 7.758 kg. This is 0.042 kg that less than the maternal weight gain of 7.8 kg. The 0.042 kg, which is unaccounted for is assumed to be adipose tissue (Hytten & Leitch, 1971), of which 80% is assumed to be fatmass. Therefore the fat gain estimated by this method is 0.042 multiplying with 0.8 or 0.033kg. Fat gain estimated by the factorial method may be less accurate compared to the other two methods because most of the products of conception were estimated based on the values from Hytten

TABLE 5.5 ESTIMATED FAT GAIN BY THE FACTORIAL METHOD

	THE THEORY (g)		THIS STUDY* (g)
FETUS	3.40		2.980
PLACENTA	0.65		0.550
AMINOTIC FLUID	0.800		5.1-2.98-.55 = 1.57
BLOOD	1.250		
UTERUS	0.970		
MAMMARY GLAND	0.405	3.055	2.658
EXTRA CELLULAR & EXTRA VASCULAR FLUID	1.680		
TOTAL	9.155		7.758
WEIGHT GAIN	12.500		7.800
WEIGHT UNACCOUNTED FOR	3.345		0.042
EQUIVALENT TO FAT GAIN	2.676		0.0336

* based on Hytten & Leitch (1971)

and Leitch (1971) and these may be too inaccurate to detect small fat gains. However, the results using this method did not affect the overall result of estimated fat gain because it was in between those of the first two methods.

The average value of fatmass from these three methods as shown in **TABLE 5.6** was 0.08 kg. This value is far less than the value of Hytten and Leitch (1971).

DISCUSSION

It needs to be recommended that pregnant women restrict their weight gain as much as possible by limiting dietary intake to permit an easy delivery since this helps to reduce fetal size. As medical health care improved and the risk of delivery became reduced, pregnant women were advised to increase food intake to improve fetal nutrition. An acceptable weight gain for normal well nourished pregnant women during pregnancy is about 12.5 kg (Hytten and Leitch, 1971). In the review of Hytten and Leitch (1971) maternal weight change during pregnancy was quoted to vary from weight reduction to a weight gain of up to 23 kg. Most of the pregnant women in developed countries increased their body weight by about 20% from initial body weight (Whitehead et al.,1981; Durnin et al., 1985; van Raaij et al., 1987) whereas weight gain was found to be 16% in the present study. This weight gain is similar to those reported from developing countries such as India (Venkatachalam et al.,1960), Taiwan (McDonald et al., 1981) and the Gambia (Lawrence et al., 1984).

TABLE 5.6 FAT GAIN ESTIMATION

METHOD	kg	ESTIMATED FAT GAIN(kg)
1 DIFFERENCE IN FAT		
FAT AT 4-6WK POST-PARTUM	12.1	
FAT AT PRE-CONCEPTION	12.3	
fat gain		-0.2
2 DIFFERENCE IN WEIGHT		
WEIGHT AT 4-6WK POST-PARTUM	49.8	
WEIGHT AT PRE-CONCEPTION	48.9	
adipose tissue + mammary gland[a]	0.9	
adipose tissue	0.9-0.4[a] = 0.5[b]	0.4
3 THE FACTORIAL METHOD		
WEIGHT GAIN	7.800	
TOTAL WT. OF PRODUCTS OF CONCEPTION	7.758[c]	
adipose tissue	.042[b]	0.033
AVERAGE OF MATERNAL FAT STORE		0.077

a mammary gland assumed to be 0.4 kg (Hytten & Lietch,1971)
b 80 % of adipose tissue assumed to be fat
c from TABLE 5.5

The amount of fat gain during pregnancy was assessed by Hytten and Leitch (1971) to be about 3.5 kg. The results of this study showed that the women seemed to have no increase in fat store during pregnancy. The other studies which used the same method as this study to estimate maternal fat store also found lower values of fatmass than those of Hytten and Leitch (1971): Two studies from developed countries (Scotland and the Netherlands), showed an increase of 2.1 Kg and 2.5 kg respectively (Durnin et al., 1987; van Raaij et al., 1987). Three studies from developing countries (the Philippines, the Gambia and Thailand) showed an increase of 1.3, 0.6 and 1.3 kg respectively (Tuazon et al., 1987; Lawrence et al., 1987 and Thongprasert et al., 1987). It is therefore, possible that the average maternal fat gain suggested by Hytten and Leitch (1971) may be too high, even for developed countries.

The average weight gain during pregnancy in this study was 7.8 kg and the estimated weight of the products of conception was found to be 7.758 kg (from TABLE 5.5). This means that about 99% of weight gain appeared to be as a result of the weight of products of conception. However, these estimated weights of the products of conception were based on assumptions by Hytten and Leitch (1971) which may not be applicable to this Thai population.

It was found in this study that there were wide variations in weight gain; some pregnant women had an increase in fat store while others lost their fatmass. It is of interest to know if these have any effect on birth weight or if these variables are the result of changes of energy intake during pregnancy.

5.3 WHY WAS THERE A REDUCTION OF WEIGHT AND OF FAT DURING THE FIRST TRIMESTER?

It was found that these pregnant women lost about 1.4 kg of body weight and about 1.2 kg of fat during the first trimester. It is also important to note that during this period their energy intake was also greatly reduced. It is therefore possible that the loss in weight and fat may be due to energy supply during the first trimester when they could not increase their energy intake. The estimated energy which these pregnant women got from their reduction of weight and fat is shown in **TABLE 5.7**. The weight loss (1.4 kg) during the first trimester may be represented as adipose tissue weight which gives about 10,080 kcal or 42.17 MJ (80% adipose tissue is fatmass and 1kg of fat = 9 kcal). The fat loss (1.2 kg) during this period would supply about 10,800 kcal or 45.19 MJ (1kg of fat = 9 kcal). It is probable that these pregnant women got an extra energy supply from the fat stored before becoming pregnant (equivalent to about 10,440 kcal or 43.68 MJ) i.e. about 125 kcal/d (525 kJ/d). This extra energy supply was

TABLE 5.7 ENERGY SUPPLY FROM WEIGHT AND FAT LOSS DURING THE FIRST TRIMESTER

SORUCE OF ENERGY	kg	FAT LOSS	ENERGY SUPPLY	
WEIGHT LOSS			kcal	MJ
Weight at pre-conception	49.7			
Weight at 12 wk	48.3			
adipose tissue	1.4[a]	1.12	10,080[b]	42.17
FAT LOSS				
Fat at pre-conception	12.8			
Fat at 12 wk	11.6	1.20	10,800	45.19
average energy supply			10,440	43.68

[a] 80 % of adipose tissue assumed to be fat
[b] 1 kg of fat = 9,000kcal

not equal to the negative energy intake during the first trimester. The reduction of energy during the first trimester was found to be 142 kcal/d (595 kJ/d) and an extra energy supply from fat loss gave about 125 kcal/d (595 kJ/d). However, the difference in the reduction of energy intake and the extra energy supply from the fat loss was only about 17 kcal/d which is less than the value for the standard deviation. Therefore, no definitive information can be obtained from these data about positive or negative energy balance.

5.4 RELATIONSHIP BETWEEN WEIGHT GAIN AND BIRTH WEIGHT

Weight gain during pregnancy is recognised as one of the factors known to influence birth weight. Hytten and Leitch (1971) reviewed from published data that mothers who gain little weight produce smaller babies than those who gained more weight. Simpson et al.(1975) reviewed the influence of weight before pregnancy and weight gain during pregnancy and showed that as pre-pregnant weight increased, there was an associated increase in birth weight whether the weight gain was small or large. This suggests a genetic influence. The results from Brown (1981) suggested that total weight gain during pregnancy has a strong influence on infant birth weight. Women who become pregnant at very low weight or moderately underweight delivered infants at a younger gestational age and of lower birth weight than did normal weight women who gained the same amount of weight during pregnancy. In addition, the findings from Kirksey et al.(1991) clearly support strongly the view that body weight in early pregnancy and weight gain during pregnancy were the factors, other than length of gestation, that influence birth weight.

The average weight gain in this study was found to be 7.8±3.5 kg which ranged from 1 to 17 kg. It was decided to compare energy intake and birth weight of the group of mothers who gained greatest weight during pregnancy with the other group who gained least weight. There were 12 mothers who gained weight of between 11.3 to 14.6 kg (mean +1sd and mean +2sd) and 12 mothers who gained weight of between 4.7 to 1.4 kg (mean -1sd and mean -2sd). Both of these two groups were significantly different in weight gain ($p<.001$). **TABLE 5.8** presents the general characteristics of these two groups which are similar in terms of age and height but their BMI and their initial weight and fat (at pre-conception) were not the same. **TABLE 5.8** shows that BMI, initial weight and fat of the first group whose weight gain was greater were 20.1±1.6 kg/m^2, 48.1±3.7 kg and 11.5±2.8 kg respectively which were significantly less than the second group ($p<.001$). The 12 mothers who had a greater weight gain(11.3-14.6 kg) during pregnancy produced bigger babies than the other 12 mothers whose weight gain during pregnancy was lower ($p<.025$). This finding suggested that total weight gain has a positive

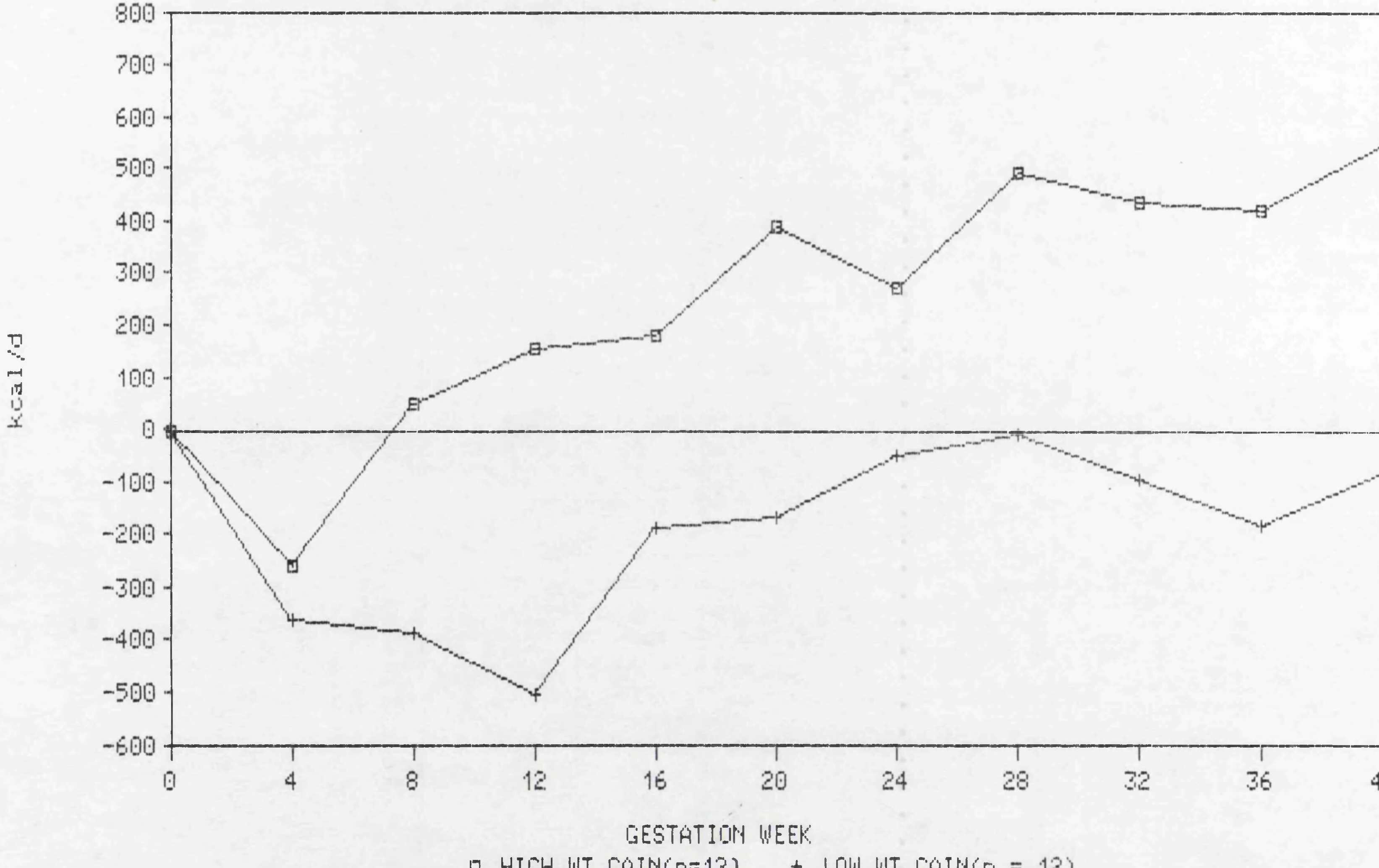
TABLE 5.8 GENERAL CHARACTERISTICS AND THE OUTCOME OF PREGNANCY OF GROUPS WITH HIGH (11.3-14.6)AND LOW (1.4-4.7) WEIGHT GAIN

	HIGH WEIGHT GAIN (11.3-14.6KG)		LOW WEIGHT GAIN (1.4-4.7KG)	
	MEAN	SD	MEAN	SD
N	12		12	
AGE (yr)	23.6	2.9	22.8	3.2
HEIGHT (m)	1.54	0.04	1.55	0.06
BMI (kg/m2)	20.1	1.6	22.8	1.5[a]
BODY WEIGHT (kg)				
At base-line(0wk)	48.1	3.7	54.7	5.9[b]
At term	60.5	3.4	58.0	6.0
WEIHGT GAIN	12.7	1.1	3.3	0.9[a]
FATMASS at 0 wk (kg)	11.5	2.8	15.9	2.3[b]
INTAKE at 0 wk(kcal/d)	1,984	278	2,277	350[c]
BIRTH WEIGHT (g)	3,198	431	2,870	288[c]
HEIGTH (cm)	49.7	1.8	48.2	1.7[c]

a significant difference $p < 0.001$
b significant difference $p < 0.005$
c significant difference $p < 0.05$

relationship on birth weight. **FIG. 5.7** shows the comparison of pattern of changes of energy intake of these two groups. The results show that after the 4th week of gestation, the group with a greater weight gain greatly increased their energy intake until full term; their energy intake was about 500 kcal/d (2.1MJ/d) higher than the base-line value(0 week). On the other hand, the group of lower weight gain reduced their energy intake during the first trimester and increased during the second and the third trimesters but these increment were not enough to give an extra energy during pregnancy. This seems to show that the first group who gained more weight and produced bigger babies than the second group, was as a result of having more increment of energy intake during pregnancy. However, it could not be used to predict that the mother who has high increment of energy intake during pregnancy would produce a bigger baby than that mother who has not much increment of energy intake as discussed in the previous Chapter (see part of 4.3.1). The mothers whose increment of energy intake was completely higher than the other group who could not increase energy intake during pregnancy, produced slightly heavier babies with 100g.(but no significant difference) than the other mothers. It is also shown in the chapter 4 (part 4.3.2) that the energy intake was similar in mothers who produced big babies to those who produced small babies.

FIG 5.7 CHANGES OF ENERGY INTAKE IN GROUPS WITH
HIGH AND LOW WEIGHT GAIN



5.5 RELATIONSHIP BETWEEN FAT GAIN AND ENERGY INTAKE

There were 44 mothers who lost fatmass during pregnancy while the other 42 mothers gained fatmass. It is interesting to know what makes the difference between these two groups. **FIG. 5.8** shows the comparison of energy intake of the 44 mothers who lost fatmass during pregnancy and the other 42 mothers who gained fatmass. As shown in this figure the pattern of energy intake is similar in both groups, the difference being only in the amount of energy intake at pre-conception. Energy intake during pre-conception stage of 44 mothers who lost fatmass was 2,299±446 kcal/d(9.6±1.9MJ/d). When they became pregnant, there was obviously a reduction of energy intake during the first trimester but this returned to the same level as their base-line stage (0 week) during the second and the third trimesters. On the other hand, 42 mothers who gained fatmass had lower energy intake during non-pregnant stage than the first group with a significant difference (see **TABLE 5.9**). The energy intake then slightly dropped during the 8th week of gestation and thereafter it increased throughout the rest of pregnancy.

Comparing the initial body weight and fat between the two groups from **TABLE 5.9**, the group which gained fatmass had lower body weight and fat than the other group which lost fatmass ($p<.001$). The body fat was however similar in the two groups at 4-6 weeks postpartum and so these made the

FIG.5.8 CHANGES OF ENERGY INTAKE IN GROUPS WITH GAIN AND LOSS OF FATMASS

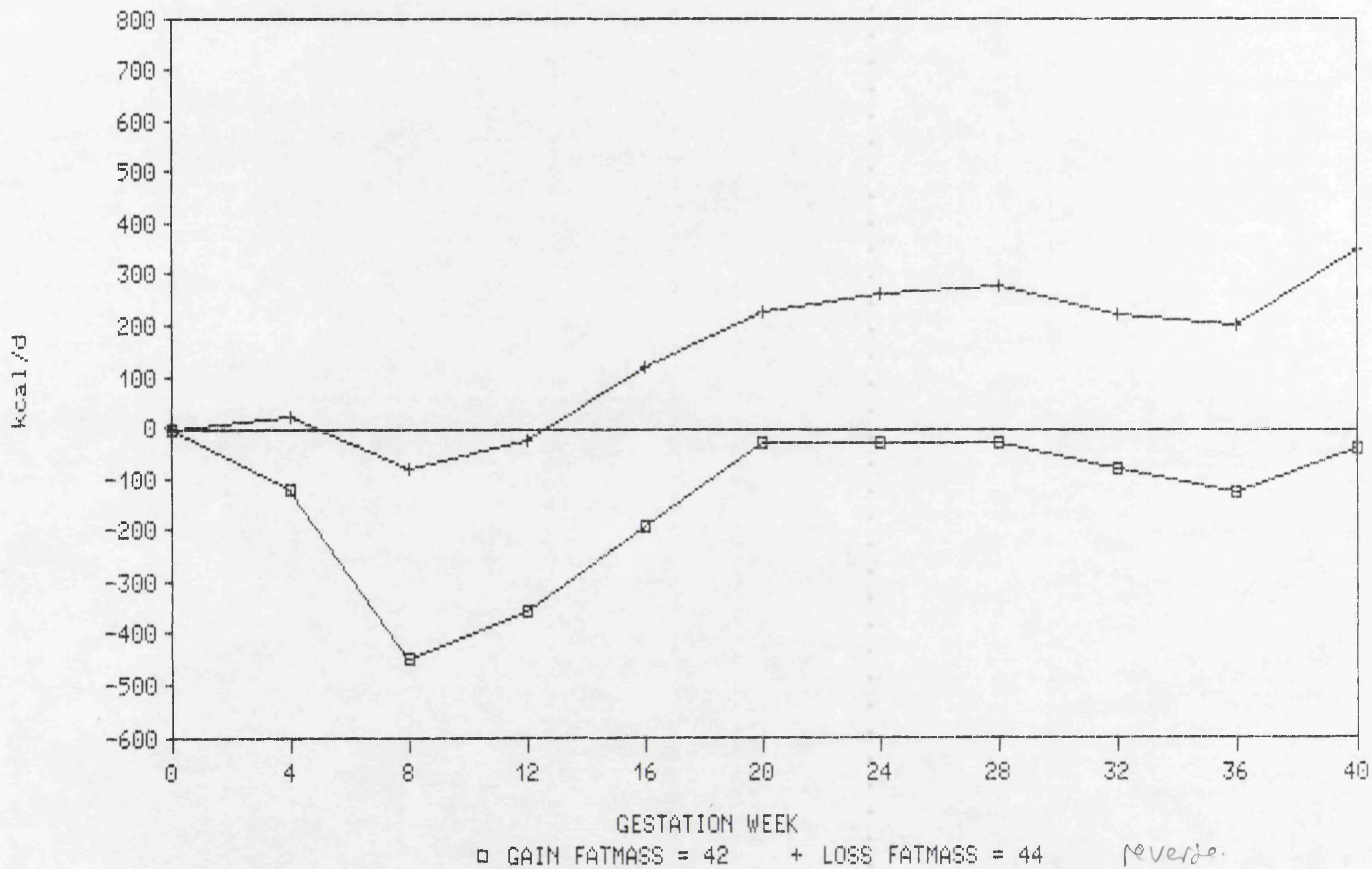


TABLE 5.9 GENERAL CHARACTERISTIC AND THE OUTCOME OF GROUPS WHICH GAINED AND LOST FATMASS

	GROUP LOSS FATMASS		GROUP GAIN FATMASS	
	MEAN	SD	MEAN	SD
N	44		42	
AGE (yr)	22.7	3.0	22.7	2.7
HEIGHT (m)	1.53	0.09	1.52	0.03
BODY WEIGHT(kg)				
At base-line	51.2	6.0	46.6	4.5[a]
At term	57.3	5.6	56.5	5.5
Weight gain	6.1	2.6	9.9	2.9[a]
Fatmass (kg)				
At base-line	13.8	3.5	10.8	2.2[a]
At 4-6wk postpartum	12.0	2.8	12.2	2.8
INTAKE 0 WK (kcal/d)	2299	446	2010	353[b]
GESTATION WEEK	39.5	1.2	39.3	1.4
BIRTH WEIGHT(g)	3002	366	2952	406
BIRTH HEIGHT(cm)	48.9	2.0	48.6	2.0

a significant difference $p < 0.001$
b significant difference $p < 0.01$

difference of fat gain of these two groups. This table also shows that the group which gained fatmass had greater weight gain than the other group (p<.001). The birth weight and length of babies were also similar in both groups.

It is important to note that the energy intake at pre-conception of the 44 mothers who lost fatmass was high (2,299kcal/d or 9.6MJ/d). These energy intake may be high enough to result in a positive energy balance and the accumulation of a store of body fat which could be used to supply extra energy during pregnancy. The calculated fat loss of the 44 mothers was found to be 1.8 kg. The estimated energy supply from fat loss can be done by multiplying fat loss by 9,000 kcal (1 kg of fat = 9,000 kcal) so this group of mothers could get about 16,200 kcal (67.8MJ). This means that these 44 mothers would get an extra energy supply of about 193 kcal/d (810kJ/d) during the first 12 weeks then the deficit of energy during this period may disappear. This may be an adaptation in pregnant women when maternal intake is probably not enough for development of the fetus; they could use their fat store for supplying energy to the babies.

In the case of the 42 mothers who gained fatmass during pregnancy, their energy intake during pre-pregnancy stage was much lower than the first group (44 mothers who lost fatmass) but just only the first 4 weeks then they could increase their energy intake to similar level to those of 44 mothers who lost fatmass (see **FIGURE 5.8**).

This increase in energy intake of the 42 mothers therefore, may cause an increase in body fat 4-6 weeks post-partum. As a result these 42 mothers could gain fatmass during pregnancy.

The mean of weight gain in this study was 7.8 kg and it was found that the mothers who gained most weight produced bigger babies. Several studies have also suggested that weight gain during pregnancy is positively correlated with infant birth weight (Rankaleio and Hartikainen-Sorro,1981; Rössner and Öhin, 1990). However, there has been much controversy on the definition of optimal weight gain during pregnancy. The study of Naeye (1979) showed that a mother's optimal weight gain in pregnancy seemed to depend on her body build. Optimal weight gain for an overweight mother was about half of that for a very thin one. Some studies reported that the positive correlation between weight gain and birth weight was reduced as prepregnant weight increased (Eastman & Jackson, 1968; Brown et al., 1981; Abram & Laros, 1986).

Birth weight is affected by many other factors such as genetic influence, maternal age, parity, smoking habits, illness and disease. Maternal status before becoming pregnant is also important for fetal development. In this study, the mother who had an adequate fat store when she became pregnant seemed to use this fat store as an extra energy supply for the growth of the fetus. This may be a form of maternal adaptation to protect against maternal energy imbalance.

CHAPTER 6

CONCLUSION

6.1 ENERGY COST OF PREGNANCY

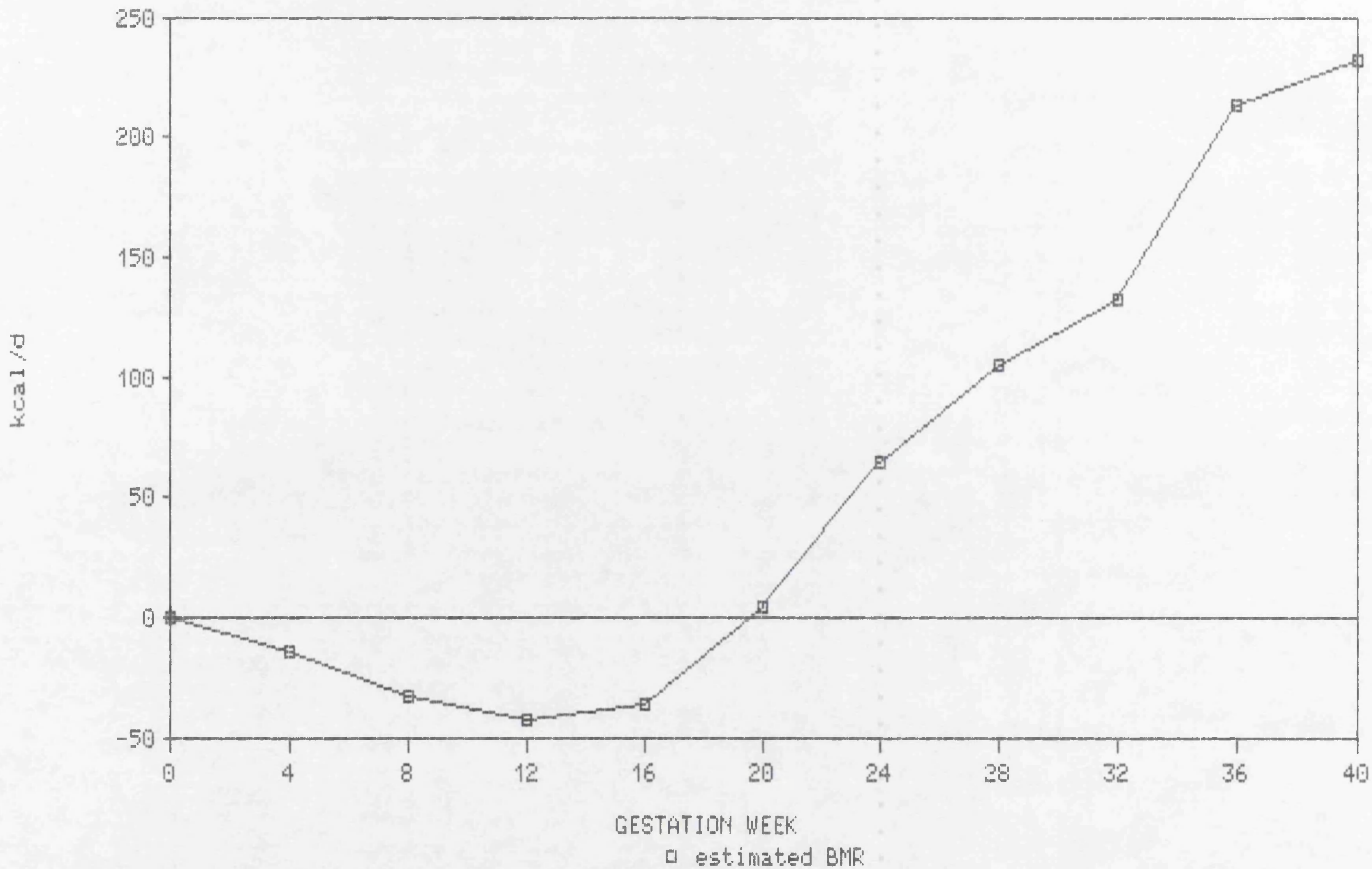
There are three important components of the estimated energy cost of pregnancy : increase in the BMR, increase in maternal fat store and the products of conception. Although, this study did not measure the changes of the BMR during pregnancy, nevertherless, it is possible to estimate the BMR values of these pregnant women by the BMR equation from FAO/WHO/UNU (1985) where BMR varies roughly proportionately to body weight (BMR = 14.7wt + 496). From this equation, the estimated BMR of the women in this study would be 1,226 kcal/d (5.1 MJ/d) at preconception. However, the FAO/WHO/UNU equation has been shown to under-estimate the BMR of Thai women (Lawrence et al, 1988) and at full term the estimated BMR of these pregnant women would give only about 103 kcal (0.4 MJ) higher than the value at pre-conception in contrast to the result from the study of Thongprasert et al.(1987) who found this to be 289 kcal (1.2MJ) higher than the base-line value at 10 weeks. Therefore, the BMR estimated by the BMR equation from FAO/WHO/UNU (1985) may not accurately predict the changes of the BMR in these pregnant women. It was decided to estimate the BMR increment during pregnancy in this study by using the changes of BMR per body weight from the study of Thongprasert et al.(1987) and then multiplying with the changes of body weight during pregnancy from this study to estimate the changes of BMR. It is assumed that the BMR during pre-conception and during early pregnancy were similar so the estimated BMR during pre-conception and the 8th week of gestation should also be similar to the value of BMR/kg at 10 weeks from the study of Thongprasert et al.(1987). **FIG 6.1** shows the changes of estimated BMR of the women in this study and the calculated increment of BMR throughout pregnancy was estimated at 14,336 kcal (59.8 MJ). This estimated value was less than that from Thongprasert et al.(1987) because there was a reduction of body weight during the first 12 weeks in this study and so caused the higher BMR value at pre-conception than that value at 12 weeks of gestation. In this study, the average of maternal fat store during pregnancy which was estimated by three methods was 0.08 kg which is equivalent to 720 kcal (3 MJ). The last part of energy cost of pregnancy, products of conception, is calculated by using the figures from Hytten and Leitch (1971). The total cost of products of conception and maternal tissue is 10,124 kcal (42.3 MJ) as shown in **TABLE 6.1**. Finally, the estimate of energy cost of pregnancy in this study was 25,180 kcal (106MJ) which is shown in **TABLE 6.1**. This finding is much less than the value from the study of Thongprasert et al.(1987), which had higher values of the BMR increment and maternal fat store than this study as a result of a reduction of body weight and fat during the first 12 weeks of gestation as mentioned above.

TABLE 6.1 ENERGY COST OF PREGNANCY

CONTENTS	FAT (kg)	PROTEIN (kg)	ENERGY EQUIVALENT (kcal)	(MJ)
1 INCREASE IN THE BMR[a]			14,336	59.8
2 MATERNAL FAT STORE	0.08		720	3.0
3 PRODUCTS OF CONCEPTION[b]				
Fetus = 2.98 kg	0.385	0.385	6,930	30.0
Placenta = 0.55 kg	0.003	0.085	628	2.6
Increase in uterus, blood etc.= 4.228kg	0.321	0.029	2.566	10.7
		TOTAL	25,180	106.1

a estimated BMR based on FAO/WHO/UNU(1985)
b assumed from Hytten and Leitch(1971)

FIG. 6.1 CHANGES OF ESTIMATED BMR



6.2 WAYS TO MEET ENERGY COST OF PREGNANCY

The energy cost of pregnancy could be met by an increase in energy intake or a reduction of energy expenditure or by a combination of both. In the previous study (Thongprasert et al.,1987) there was an increase of energy of about 56,900 kcal(238.1 MJ) which covered the extra needed energy during pregnancy of about 47,200 kcal (197.5 MJ). The finding from this study on the other hand is in contrast with the study from Thongprasert et al.(1987); there were only a small increment of energy intake during pregnancy. The difference between the two studies is as a result of the difference in base-line values. In the study of Thongprasert et al. (1987), the base-line was taken as the value at 10 weeks gestation, while in this study the base-line value was taken at pre-conception and was found to be high compared with the previous study. However, the pregnant women in this study could produce healthy babies similar to those in the previous study (Thongprasert et al., 1987) even though there was little extra energy intake in this study. It is difficult to explain this finding if we only take into account the increment of energy intake. These pregnant women would probably meet the costs of pregnancy by a combination of two conditions. Firstly, by fat loss during the first trimester; the energy from their fat loss would have supplied energy of about 10,440 kcal(43.7KJ) during the first trimester, when they did not increase their intake. Secondly, increase by an increased energy intake during the third trimester; it was found that these pregnant women increased energy intake during the third trimester (the last 16 weeks of gestation) by about 105 kcal/d (441 kJ/d), which provided 11,760 kcal (49.2 MJ). With the combination of these two conditions, these pregnant women would have total extra energy of about 22,260 kcal (92.9 MJ) as shown in **TABLE 6.2**. However, this extra energy was still less than the total estimated energy cost of pregnancy of about 2,920 kcal (13.0 MJ) which caused an energy deficit of about 10.4 kcal/d (43 kJ/d) throughout pregnancy. It is possible that during pregnancy these pregnant women might save their energy by reduction of energy expenditure, for example, increasing the sitting period by half an hour per day and reducing the period of walking by half an hour.

6.3 ENERGY REQUIREMENTS FOR RURAL PREGNANT THAI WOMEN

This study seems to suggest that well-nourished pregnant Thai women increase their energy intake by about 105 kcal/d (441 kJ/d) only during the third trimester to cover the overall energy cost of pregnancy. However, all the volunteers in this study were healthy with no under-weight mother so only increase of energy intake during the third trimester may not be enough for an under-weight mother or the mother who were very thin because they might have inadequate fat stores to supply energy during the first trimester. In this study the thinner or lighter mothers when they became pregnant increased their energy intake during pregnancy much more than the fatter and heavier mothers in order to produce similar babies.

TABLE 6.2 MEETING THE ENERGY COST OF PREGNANCY

SOURCE OF ENERGY	kcal	MJ
1 DURING THE FIRST TRIMESTER		
Fat loss	10,440	43.7
2 DURING THE THIRD TRIMESTER		
Increase energy intake 105kacl/d	11,760*	49.2
Total reserved energy	22,260	93.0

* 105 x 112 days (the last 16 weeks)

There are several factors which influence the birth weight of the babies. Many studies found that as maternal weight increases during pregnancy, there was an associated increase in birth weight of the babies (Harrison et al., 1980; Luke et al., 1981). However, others report that as pre-pregnancy weight increases the importance of maternal weight gain was reduced (Eastman and Jackson, 1968; Winikoff and Debrovner, 1981; Abrams and Lavo, 1986). In conclusion, maternal status before becoming pregnant may be the first indicator to predict the success of pregnancy. An under-weight mother or woman who is very thin may be at risk to produce low birth weight baby (<2.5 kg).

Low birth weight (<2.5 kg) infants is a nutrition problem in Thailand of which about 12% were recorded by Health statistics Department(1989) and Division of Nutrition(1991) in Bangkok, Thailand with rather high prevalence in the north-eastern part of Thailand where Ubon is located. The nutritional survey (Dhanamitta et al., 1978) showed that both protein and energy of pregnant women in rural Thai villages, were far below the FAO/WHO recommended daily allowance. Their diet was not well balanced with the majority of total calories from carbohydrates of about 83 to 86%. Some studies (Chaiyavatana, 1979 and Jaiyavat, 1980) also indicate poor maternal protein and fat status in these pregnant women. In addition, there are some food beliefs and taboos which also contribute to the reduced energy intake especially during pregnancy. So food supplementation and nutrition education in these population may be of benefit.

The relationship of maternal nutrition to the development and fetal growth has been the subject of several studies. Dietary supplementation of pregnant women were found to improve fetal growth only in some condition (Mora et al., 1979; Prentice et al., 1983). In healthy mothers increment in energy intake during pregnancy affected maternal fat gain rather than progress of fetal growth (Lawrence et al., 1991).

Although in this study we did not have under-weight mother it is shown that the group of small birth weight babies were produced from small mothers and as such, Maternal health care in Thailand which has a limited budget would be more effective if more attention is paid to the target group such as under-weight women and smaller mothers who are at a higher risk of producing small babies.

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