SIZE OF BABIES OF OBESE MOTHERS RECEIVING NUTRIENT SUPPLEMENTS*

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THE weight and size at birth of babies born to obese mothers is of clinical importance because the overweight patient has an increased likelihood of a long labor and difficult delivery which may be complicated further by a large baby. Consequently, limitation of fetal growth frequently is attempted through severe restriction of prenatal weight gain. Implicit in such a procedure is the belief that prenatal weight gain has a significant effect on the size of the baby and that the low intake of food required to restrict weight gain has no unfavorable effects on the mother or her baby.

Records of obese patients who attended the Nutrition Research Clinic at the Philadelphia Lying-In Hospital from 1947 through 1952, afford data relevant to the problem of birth size and its relation to prenatal weight gain and also on potential benefits to the patient and her baby of a high level of intake of essential nutrients.

The population and procedures of the Nutrition Research Clinic will be described briefly.

All prenatal patients registering at the Philadelphia Lying-In Hospital were referred to the Nutrition Research Clinic if estimated gestation was not more than sixteen weeks, if the patient was married, and if there was no indication of serious chronic disease or syphilis,[2] unless the patient refused to attend clinic in the afternoon. With these exceptions, the patients are

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1 The Milbank Memorial Fund and The Pennsylvania Hospital, respectively.

2 Patients with chronic disease or syphilis referred to the Nutrition Research Clinic were carried but have been excluded from tabulations in this report. Chronic diseases excluded are essential hypertension, chronic heart classified II-a or higher, chronic nephritis, and chronic pyelitis.

an unselected series from the ward service of the hospital.

Patients registered in the Nutrition Research Clinic were assigned seriatim to one of four study groups by the statistical staff in a manner which would maintain comparability among the four groups for color, age, and gravida of patients. The four primary study groups are as follows:

A. Control group, no supplement
B. Vitamin supplemented group[3]
C. Protein supplemented group[3]
D. Vitamin and protein supplemented group

Patients in all groups received throughout their pregnancies the same prenatal care and management. Diet instructions were accomplished by the nutritionist and supported by supervision and direction of the obstetric staff of the clinic. The diet used in the research study was marginal and designed to produce a base-line against which supplementation could be expected to show a differential, if such a differential existed.

It must be pointed out that the maintenance of patients on a marginal dietary intake, to which known amounts of supplements are added, is specifically for the purpose of evaluating the needs for the specific nutrients added. It is not intended to infer that this procedure represents a desirable method of obtaining an optimum nutritional status.

Comparison of Obese Patients and Standard Weight Patients

Obese patients in the Clinic differed from patients whose weight at the beginning of pregnancy was less than 5 per cent above or below the standard or "ideal" weight[4] with respect

[3] The nutrient supplements used in this study are: Therapeutic poly-vitamin concentrate (Upjohn's Zymacaps and E. R. Squibb & Sons' Theragran) three capsules per day; Protein concentrate (Mead Johnson & Company's Protenum), to furnish 50 gms. of protein daily if taken as advised.

[4] Patients were carefully questioned in the clinic as to their immediate pregravid weight and were measured for height without shoes. The standard weight for a specific height and age used is from the Report of the Medico-Actuarial Investigation 1912–1914 up to age 25 years. The average weight at 25 years is extended to older ages and the value used is the mid-point of the weight range

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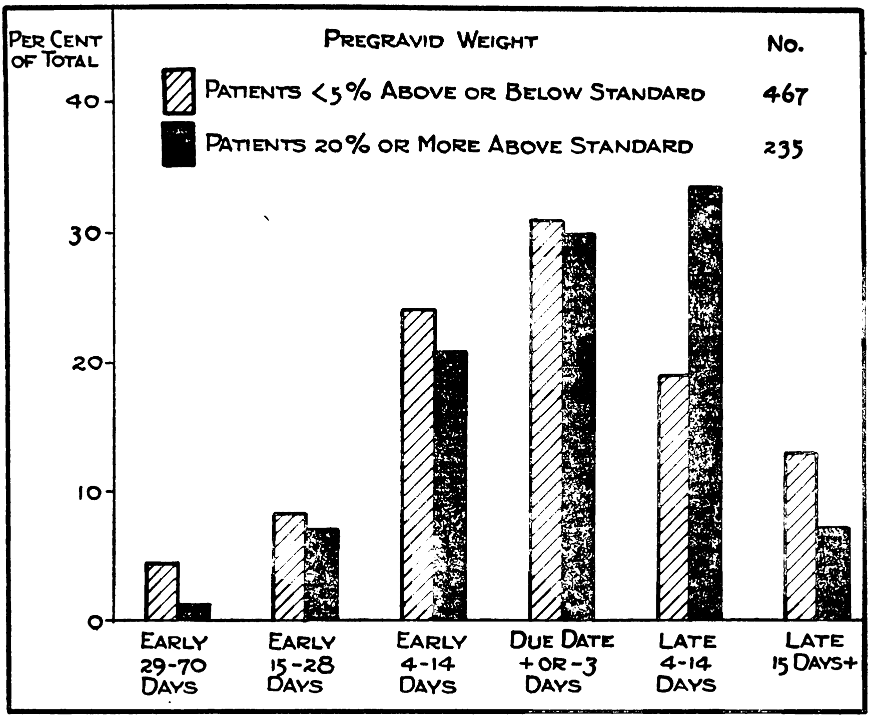

Fig. 1. Percentages of patients delivered within various periods relative to expected time of delivery among patients who were obese and whose weight was approximately normal at the beginning of pregnancy.

to weight and size of their babies and also with respect to length of gestation.

Length of Gestation. There is a marked tendency for more of the obese patients than of normal weight patients to deliver later than the estimated time. In Figure 1, the time of delivery relative to the date due for 235 patients 20 per cent or more overweight is compared with that for 467 patients whose weight at the beginning of pregnancy differed from the standard weight by less than 5 per cent. Although the percentage for delivery within three days of the date due is nearly the same for the two groups, a much larger percentage of obese

for women of medium frame published by the Metropolitan Life Insurance Company. One inch was subtracted from heights in published tables to adjust for height without shoes. Although reported weights undoubtedly may be in error a few pounds and height alone is not always an adequate criterion for "ideal" weight, comparisons of groups of patients differing in pregravid weight status should give valid results.

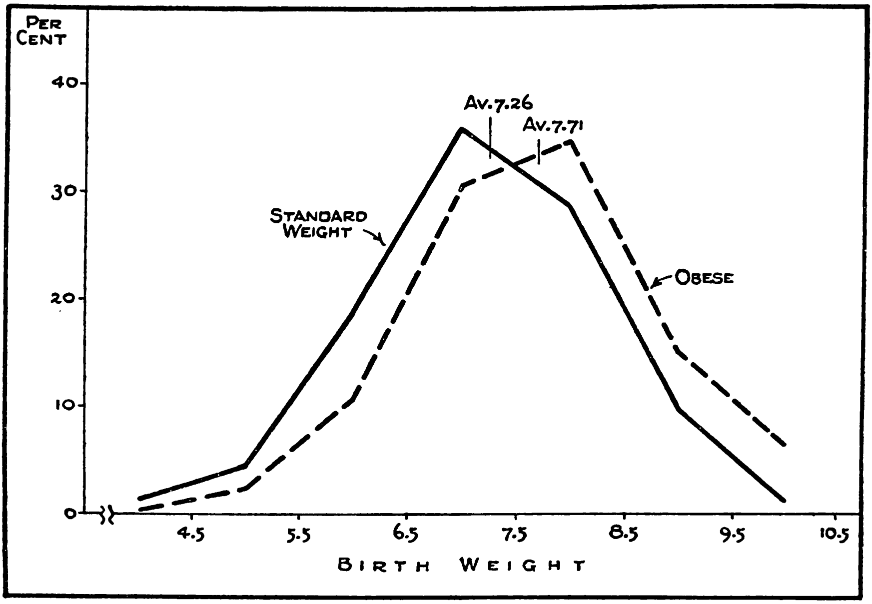

Fig. 2. Percentage distributions for birth weights of babies born to obese patients and to those of normal weight at beginning of pregnancy.

patients delivered late and a smaller percentage delivered early than for patients of standard weight.

The difference in these two distributions of patients by time of delivery is highly significant statistically.[5] It may be assumed that errors in reporting date of last menstrual period are approximately equal in the two groups. Obesity, therefore, apparently has a definite effect on delaying the onset of labor.

Birth Weight. The effect of weight status of the patient at the beginning of pregnancy on the weight of her baby is shown in Figure 2. Data are for single births of at least twenty-eight weeks of gestation.

Patients who were obese had heavier babies than those whose weight differed from the standard weight by less than 5 per cent. On the average, the difference is about 7 ounces (0.45 lbs.). There is a striking difference in the percentage distributions of birth weights of the babies of obese and stand-

[5] The chi square test of the two distributions gives the following: $X^2 = 24.176$, Degree of Freedom 5, $P < .001$.

ard weight patients, as shown in Figure 2. For the obese patients, 21 per cent of the babies weighed more than 8.5 lbs. compared with 11 per cent for the patients of standard weight. Also, only 3 per cent of the infants of obese patients weighed 5.5 lbs. or less compared with 5.8 per cent for normal weight patients.

The greater weight at birth of babies of obese patients than of the normal weight patients is not due to the greater proportion of late deliveries among obese patients. If the comparison is restricted to babies delivered within seven days of the estimated time for delivery, the average birth weight for 131 babies of obese patients is 7.91 lbs. and for 249 babies of normal weight patients is 7.45 lbs., and the difference is the same as for the total groups, i.e., 0.46 lbs.

Length of Babies. The greater weight at birth of infants of obese patients is associated with a statistically significant difference in total length between infants of obese patients and those of patients whose weight differed from the standard weight less than 5 per cent.

Most of the babies were measured one to five days after birth and the average crown-sole lengths are shown in Table 1. Infants of obese patients were nearly one centimeter longer than those of the patients of standard weight.

Thus, the greater weight at birth of the babies of obese patients is due to their greater length and is not the result of greater mass of soft tissue relative to skeletal size.

Table 1. Average crown-sole length at one to six days after birth for babies of obese and standard-weight patients.

Weight Status At Beginning of Pregnancy	Number of Babies Measured	Average Cms.	Standard Error of Average
Above Standard Weight 20 Per Cent or More	184	50.65	0.152
Standard Weight + or − Less Than 5 Per Cent	386	49.72	0.109
Difference	0.93 ± 0.190	$P < .001$	

In summary, it seems clear that large, heavy babies are definitely characteristic of obese women. This tendency for big babies, though not the result of delayed onset of labor, frequently is accompanied by delayed labor. These facts, together with the long labor and inertia that are well-known complications in the obese patient, emphasize a need for evidence concerning the relation of prenatal weight gain and size of baby.

Prenatal Gain in Weight and Size of Baby

Association between prenatal weight gain and the weight and length of the infant is found to be very slight for this series of obese patients.

Coefficients of correlation are shown in Table 2 for prenatal weight gain and birth weight, and for gain and crown-sole length. For these correlations, patients were selected who had no definite prenatal complications and had no apparent edema or only slight edema of the ankles at one or two visits. Also,

Table 2. Correlation of prenatal weight gain of "normal" obese patients with birth weight and with crown-sole length of babies.

Variates Correlated	Number	Coef. of Correlation	Significance P
Birth Weight Correlated With:			
Total Weight Gain from Minimum Before 17 Weeks to Maximum Last Month	144	+.280	<.01
Gain Minimum to Maximum *Minus* Birth Weight	144	+.153	>.05
Gain from Pregravid Weight to Maximum Last Month *Minus* Birth Weight	144	+.184	.02–.05
Male Babies	79	+.230	.02–.05
Female Babies	65	+.127	>.30
Crown-Sole Length Correlated With:			
Gain from Minimum Weight Before 17 Weeks to Maximum *Minus* Birth Weight	114	+.157	.10
Gain from Pregravid Weight to Maximum *Minus* Birth Weight	114	+.122	>.10
Male Babies	64	+.177	>.10
Female Babies	50	+.007	>.90

only patients weighed in the clinic within three weeks of delivery are included. Weight gain is computed for two periods: (1) gain from the reported pregravid weight to the maximum weight in the last month, and (2) gain from the first visit to clinic or the minimum weight in the first sixteen weeks of gestation to the maximum weight. Errors in the pregravid weight may increase or reduce the true net gain, and an early weight loss, actual or exaggerated by error in reporting, will be deducted from the gain later in pregnancy, when gain is computed from pregravid weight. In addition, the observed maximum gain represents the period for which the physician has an opportunity to influence factors which affect the patient's prenatal gain in weight.

Since birth weight is a part of the patient's weight gain, weight of the fetus will affect the patient's gain and this association may produce a positive correlation which does not have any real meaning with respect to the influence of prenatal gain on birth weight. In order to avoid this "spurious" correlation, birth weight has been subtracted from the total gain and the remainder correlated with birth weight.

Most of the coefficients of correlation in Table 2 are less than 0.20. In no case is the relationship of a level that would give any support to a concept that size or weight of the baby can be predicted by weight gain or can be kept at a minimum by limiting weight gain. A similar lack of correlation between weight gain and birth weight was reported by Beilly and Kurland (1) who obtained an r of 0.1849 for the correlation of weight gain of 979 patients with birth weight. These authors also found that the babies of obese patients were heavier than average regardless of the amount of prenatal gain.

Effects of Supplements on Delivery Time and Size of Baby

The influence of an improved nutritional status on the obese patients as a result of vitamin therapy, supplemental protein, or both, has been examined with reference to delivery relative

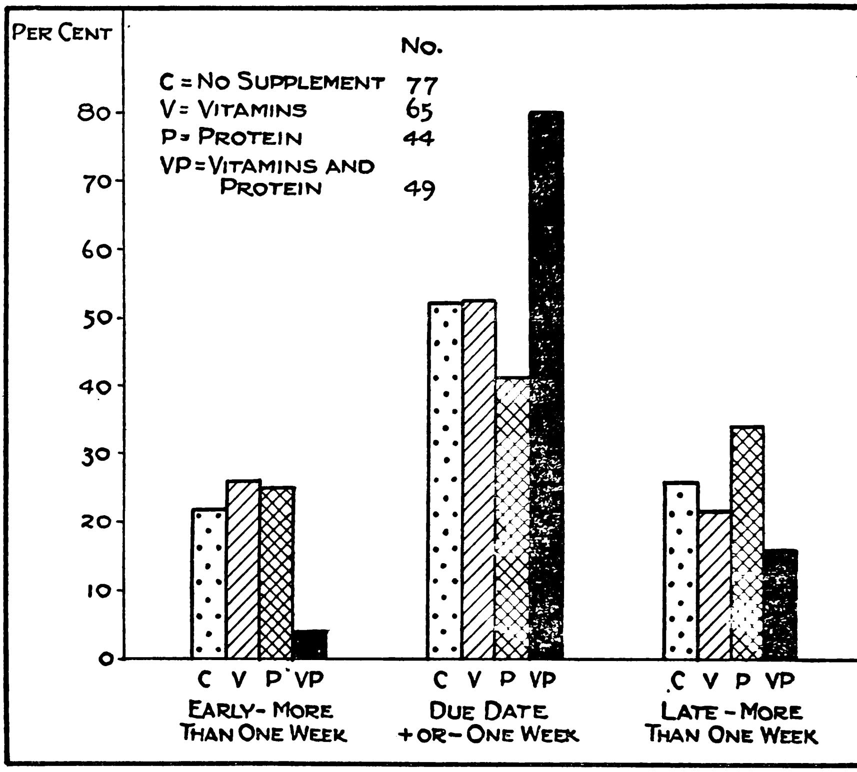

Fig. 3. Percentages of obese patients who received different nutrient supplements that delivered within one week of expected time or more than one week early or late.

to expected time, and the size and development of the babies.

Delivery Time. Comparison of the four study groups[6] with respect to time of delivery is shown in Figure 3.

The very sharp difference in the time of delivery for the patients who received both vitamin and protein supplementation is very evident. Eighty per cent of the patients in this group delivered within one week of the expected date of delivery compared with 41 to 52 per cent of patients in the other three groups. The experience of the vitamin-protein supplemented patients is significantly different from the total obese

[6] Percentage distributions of patients in each of the Study Groups by color, age, and para are given in Appendix Table 1. The groups are quite comparable in most respects; the greatest difference is found for the group given vitamins only in which a smaller percentage of patients were under 25 years of age and also a smaller percentage were having a first baby.

group (P .02–.05) and none of the other three groups differed significantly.

However, it is important to note that the relatively high percentage of vitamin-protein supplemented patients that delivered within one week of the expected delivery time is due chiefly to a much smaller percentage of early deliveries among this group. Only 4 per cent of the vitamin-protein supplemented patients delivered more than one week early compared with 22 to 26 per cent in the other groups. Although the percentage of late deliveries was somewhat smaller, 16 per cent among vitamin-protein supplemented patients compared with 22 to 34 per cent for other groups, the difference is not statistically significant.

Thus the evidence strongly suggests that when high vitamin therapy was taken and the diet was supplemented with a high biologic protein, there was an improvement in the nutritional status of the obese patient which was reflected in the duration of gestation. Protein alone or vitamin therapy alone did not modify the duration of gestation.

Prematurity. Since the percentage of patients delivered early is smaller for those who received both protein and vitamins, it would be expected that this group would have fewer babies classified as premature on the basis of birth weight of 5.5 lbs. or less. There was a total of only seven premature births by the conventional standard of 5.5 lbs. or less, and these were distributed among the study groups as follows: three in the control group; two in the vitamin supplemented group; none in the protein supplemented group; and two in the vitamin and protein supplemented group. All of these babies were less than thirty-eight weeks gestation except one of the two in the vitamin-protein group which was born at term to a patient having a very extensively calcified placenta. There is no statistical significance to the distribution of these prematures among the four study groups. However, it is suggestive that if the one small term birth is excluded there were five prematures, 3.5 per cent, among those in the control and

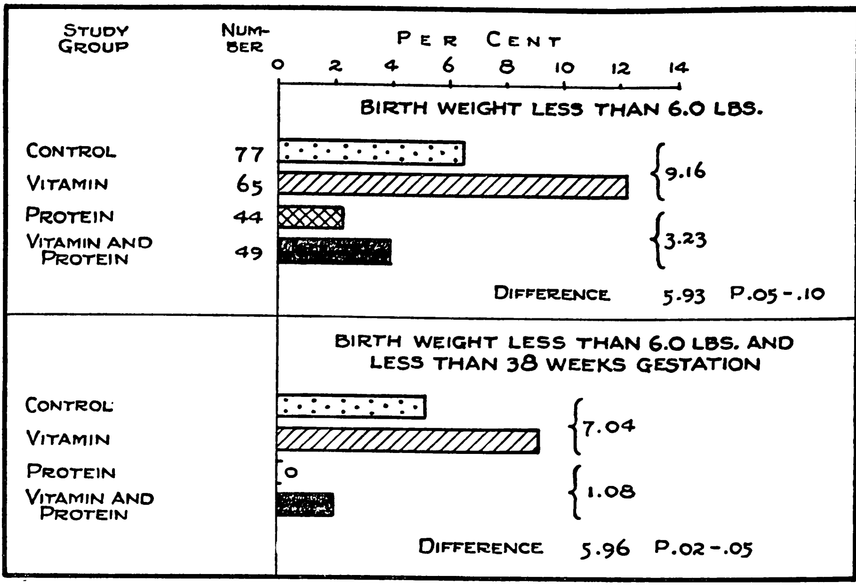

Fig. 4. Incidence of births of less than 6.0 lbs. of any estimated gestation and of less than 38 weeks gestation among obese patients who received different nutrient supplements.

vitamin supplemented groups and only one, 1.1 per cent, among those in the two protein supplemented groups.

Since infants of obese patients are heavier on the average than those of normal weight patients, the probability is high that those weighing slightly more than 5.5 lbs. are as premature or immature as lighter babies born to patients of normal weight. Therefore, an arbitrary criterion of less than 6.0 lbs. was taken for prematurity, which increases the usual criterion of 5.5 lbs. or less by an amount equal to the difference in the average weights at birth for infants of obese patients and normal weight patients. By the criterion of less than 6.0 lbs. there was a total of sixteen premature babies among the obese patients (6.8 per cent), and eleven (4.7 per cent) were also of less than thirty-eight weeks gestation. The frequency of premature infants by this weight standard among patients in each of the four study groups is shown in Figure 4.

It is evident in Figure 4 that high vitamin therapy did not prevent babies of less than 6.0 lbs. among obese patients. The rate is higher than for patients who received no supplements, but the difference is not statistically significant. There is a marked decrease, however, in the frequency of such small babies for the patients who took protein or protein and vitamin supplements. As there is no significant difference in the rates for the two groups of patients who received protein supplements, these have been combined and compared with patients in the control group and vitamin therapy group. Although the incidence of babies under 6.0 lbs. is much lower for patients who took protein supplements than for the others, the difference is not statistically significant when weight alone is considered. When both weight and gestation are used, the difference is increased relatively and is moderately significant.

These data support a general conclusion that supplementation of the usual diets of these obese patients with high biological protein resulted in a reduced frequency of very small babies which were very probably premature.

Birth Weight. The average birth weight for all babies in each of the study groups is shown in Table 3. It is clear that a statistically significant difference in the birth weights did not occur. This is important clinically in that it indicates that an improvement in the status of these obese patients through supplementation did not increase the hazard of a heavier baby as compared with non-supplemented patients.

Skeletal Size. The average length and average chest circumference of babies in each of the study groups is given in Table 4. The differences among the groups are small both for

Table 3. Birth weight in relation to type of supplement given to patients 20 per cent or more overweight at beginning of pregnancy.

Type of Supplement	Number of Babies	Average Birth Weight	St. Error of Average
Total	234	7.73	0.074
No Supplement[1]	76	7.77	0.139
Vitamins	65	7.57	0.133
Protein	44	7.58	0.139
Vit. + Protein	49	7.99	0.170

[1] Excludes one infant weighing 3.2 lbs. at birth.

Supplement Group	Number Measured	Length-Cms.		Chest-Cms.	
		Average	St. Error	Average	St. Error
Total[1]	184	50.65	0.152	32.95	0.127
No Supplement	60	50.48	0.246	33.01	0.216
Vitamins	51	50.41	0.315	32.81	0.282
Protein	36	50.58	0.344	32.85	0.266
Vit. + Protein	37	51.35	0.322	33.16	0.244

[1] Babies weighing less than 5.5 lbs. at birth are not included since very few were measured.

Table 4. Crown-sole length and chest circumference of babies of obese patients in relation to type of supplement.

crown-sole length and chest circumference. However, the crown-sole length of babies of the patients who took both vitamins and protein supplements is nearly one centimeter greater than the average for each of the other three groups. This difference is moderately significant (P .01–.05) when the three groups are combined.

This greater length of babies of patients taking vitamin and protein supplements is due chiefly to the very small percentage of patients in this group who were delivered more than one week before the estimated time of delivery. The average length of babies delivered not more than one week early or late is 51.31 cms. for the vitamin and protein group compared

Table 5. Difference of actual birth weight from expected weight estimated from length and chest circumference in relation to type of supplement given to patients 20 per cent or more overweight at beginning of pregnancy.

Type of Supplement	Number	Average Difference in Pounds	Standard Error of Average
All Babies	184	+.033	.0386
No Supplement	60	+.075	.0735
Vitamins	51	−.025	.0638
Protein	36	−.108	.0782
Vit. + Protein	37	+.184	.0915

Analysis of variance for 4 groups, 3 degrees of freedom: F value is 2.28 and P > .05

Analysis of variance for vitamin + protein group and all others, 1 degree of freedom: F value is 3.89, and P is .05

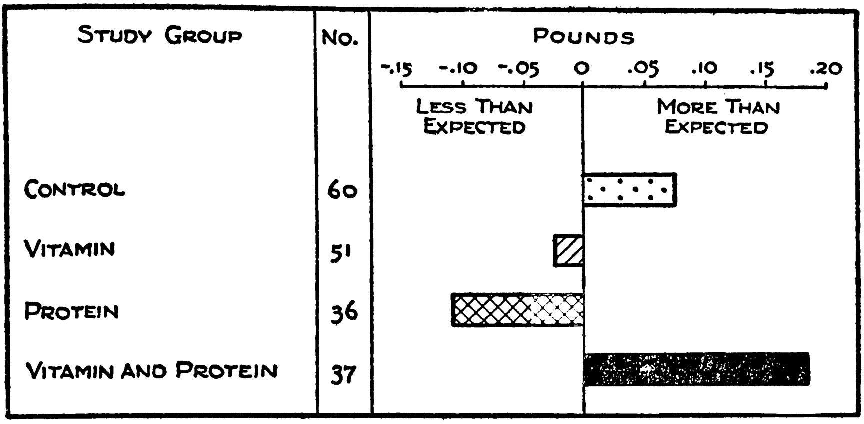

Fig. 5. Average differences between birth weight and a predicted weight for length and chest circumference for babies of obese patients who received different nutrient supplements.

with 50.87 cms. for the other three groups. This difference is not significant.

Birth Weight Relative to Body Build. Further evidence as to infant status is available when the birth weight of the baby is related to its body build.

The weight of the baby at birth is a function of its skeletal build and amount of soft tissue. It is reasonable to postulate that the nutritional status of the baby may be judged by its weight in relation to body size, just as is done throughout infancy and childhood. Using total length and chest circumference, a predicted weight was calculated for each baby[7] and the difference between this expected weight and the birth weight was determined. A minus difference indicated the baby was less than the expected weight and a plus difference indicated greater than the expected weight. These differences are shown in Table 5 and Figure 5.

[7] These calculations were made from multiple regression formulae as follows: (L = crown-sole length and Ch. = chest circumference.)
Whites, male and female:
Expected weight = .236 cms. L + .286 cms. Ch. −13.59
Colored, male and female:
Expected weight = .133 cms. L + .420 cms. Ch. −12.68
The formulae are based on data for babies born to patients of any pregravid weight status that were rated excellent or good in the first week of life by the pediatricians for the Nutrition Research Clinic.

Babies born to patients who received both vitamin and protein supplements were, on the average, about three ounces heavier than the predicted weight. The other groups ranged from about one ounce heavier (the control group) to a little less than two ounces lighter (the protein only group).

Individual differences from the expected weight varied over a wide range, from minus 1.4 lbs. to a plus 1.5 lbs. and are influenced greatly by errors in measurement of chest circumference and length as well as actual differences in amount of soft tissue. This wide variation for individual differences from expected weight applied to all study groups and an analysis of statistical significance using four groups gives a probability greater than 5 per cent for the observed variation in averages of the groups. However, if the vitamin and protein supplemented group is compared with the total experience of the other three groups, statistical significance is borderline at 5 per cent probability.

This finding for the metabolic efficiency of mothers who received both vitamin and protein supplements is consistent with that shown for expected time of delivery relative to date due.

That the babies of patients who received only protein had the poorest record for weight relative to body size may appear somewhat inconsistent with the previous finding that only one baby in this group weighed less than 6 lbs. However, examination of the individual records of the patients taking protein supplement only shows that the poor weight status of babies of a few patients, who took less than half of the intended amount of the protein supplement, was responsible for the low average weight for the entire group. Babies of patients who took more than half of the protein supplement had an average deviation from the expected weight of approximately zero (+.015). Thus, although small immature babies did not occur in this group, the general developmental status was not equal to that of babies whose mothers received both vitamins and protein.

Summary

A comparison of 235 obese patients (20 per cent or more above standard weight for height) with 467 patients less than 5 per cent above or below standard weight at the beginning of pregnancy showed (1) a much larger percentage of obese patients delivered late and a smaller percentage delivered early than among normal weight patients; (2) babies of obese patients were, on the average, about seven ounces heavier, and nearly one centimeter longer.

Correlation of prenatal weight gain with birth weight and with crown-sole length at birth was very low and gives no indication that maternal weight gain has an important effect on size of baby.

Obese patients who supplemented their diets with high vitamin capsules and a protein concentrate showed benefits as compared with obese patients who had no nutrient supplement or took only vitamins or only protein with respect to several criteria:

1. A significantly larger percentage delivered within one week of the expected time of delivery;
2. The average crown-sole length of babies was greater as a result of fewer premature deliveries;
3. The birth weight relative to length and chest circumference indicated better development.

Obese patients who received the protein supplement and vitamins or only protein had fewer "premature" babies on the basis of birth weight less than 6.0 lbs. and less than thirty-eight weeks of gestation.

Acknowledgments

Acknowledgment is made Josephine Perlingiero Randall, M.D. and Alexander Randall IV, M.D., pediatric fellows to the Nutrition Research Clinic, who evaluated and measured almost all of the babies.

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Appendix Table 1. Color, age, and para of obese women in each of the four study groups.

Classification	Number of Women in Specified Group				Per Cent of Total for Specified Group			
	Control	Vitamin	Protein	Vit.+ Prot.	Control	Vitamin	Protein	Vit. + Prot.
Total	77	65	44	49	100.0	100.0	100.0	100.0
White	53	47	34	36	68.8	72.3	77.3	73.5
Colored	24	18	10	13	31.2	27.7	22.7	26.5
Under 25 Years	30	16	16	18	39.0	24.6	36.4	36.7
25–34	36	41	25	23	46.7	63.1	56.8	46.9
35 Years +	11	8	3	8	14.3	12.3	6.8	16.3
First Birth	31	17	16	18	40.3	26.2	36.4	36.7
Second or Later	46	48	28	31	59.7	73.8	63.6	63.3